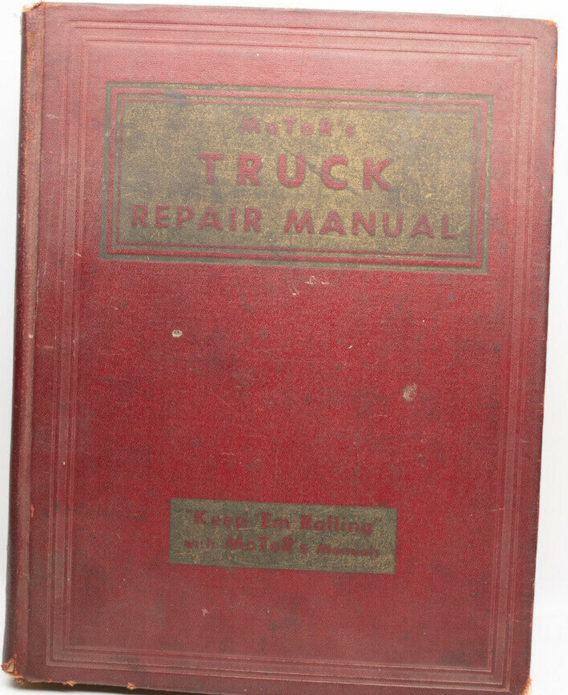

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REPAIR MANUAL

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Be Sure to Read This:—

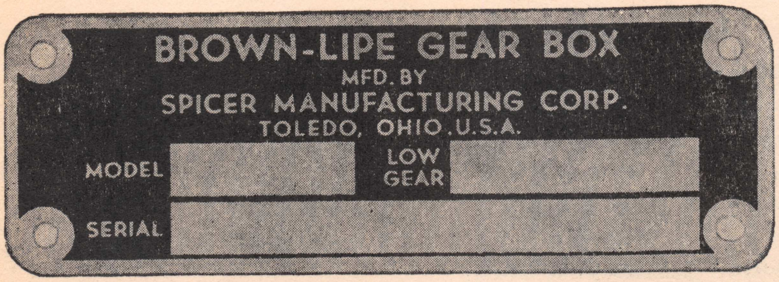
DIRECTIONS When servicing any truck engine, transmission, generator, distributor, starting motor, etc., first look at the name plate or tag attached to the unit to identify the manufacturer's name and its model number (four typical name plates are shown). Then turn to the pages which give service instructions on this make and model.

In servicing a transmission having no name plate, locate the serial number stamped on the case, then consult your dealer as to its model.

In some cases, such as brakes, universals and axles, where the model number may not be attached to the unit, all that is necessary to service the unit is to match the illustrations in this book with the unit you are servicing and proceed as directed in the text.

Although this manual is primarily concerned with the servicing of trucks, many of the engines, transmissions, clutches, axles, and almost every other piece of equipment covered in this book may also be found on busses, industrial units, generating plants, road building machinery, farm tractors, fire engines, etc. See inside back cover for details.

For units developed since 1942, see index on page 915. For 1943 to 1946 units which are the same as 1942, see CONTENTS, page 1.


BROWN-LIPE GEAR BOX
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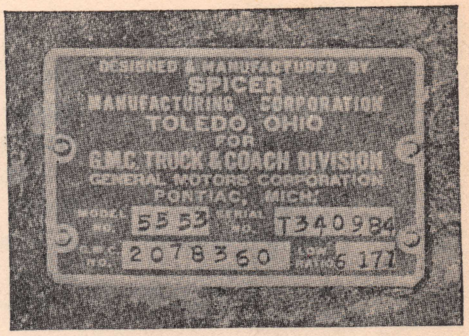
SPICER MANUFACTURING CORP.
TOLEDO, OHIO, U.S.A.
MODEL
LOW GEAR
SERIAL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SPICER
MANUFACTURING CORPORATION
TOLEDO, OHIO
FOR
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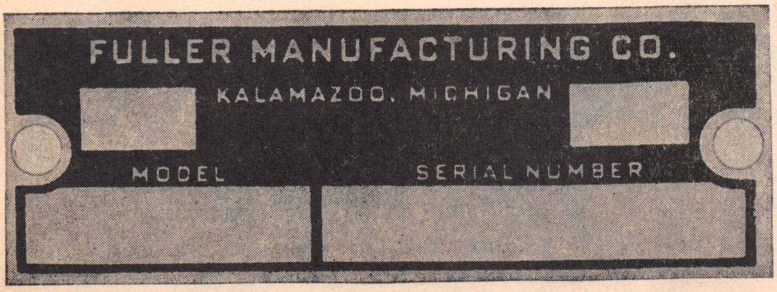
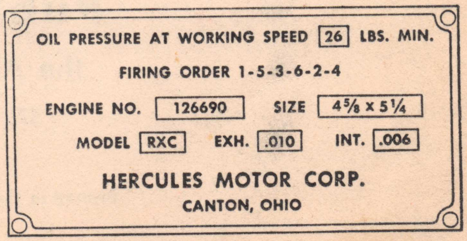
GENERAL MOTORS CORPORATION
PONTIAC, MICH.
5553
T340984
2078360
6 171


FULLER MANUFACTURING CO.
KALAMAZOO, MICHIGAN
MODEL
SERIAL NUMBER


OIL PRESSURE AT WORKING SPEED 26 LBS. MIN.
FIRING ORDER 1-5-3-6-2-4
ENGINE NO. 126690
SIZE 4⅝ x 5¼
MODEL RXC
EXH. .010
INT. .006
HERCULES MOTOR CORP.
CANTON, OHIO

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ARMLEDER, 1936	Continental Hercules	32 99	Borg & Beck	704	Fuller Warner	717 717	Timken Wisconsin	777 777	Lockheed	853
AUTOCAR, 1936-46	Autocar Cummins (D) Hercules	6 236 99	Long W. C. Lipe	712 710	Autocar Brown-Lipe Clark Fuller	717 717 717 717	Autocar Eaton Timken	777 777 777	Bendix Lockheed Timken Westinghouse	845 853 854 862
AVAILABLE, 1936-46	Buda (D) Cummins (D) Waukesha Waukesha-Hesselman	222 236 186 338	Borg & Beck Long W. C. Lipe	704 712 710	Brown-Lipe Fuller Warner	717 717 717	Timken	777	Lockheed Timken Westinghouse	853 854 862
BIEDERMAN, 1936-46	Continental Hercules Waukesha	32 99 186	Borg & Beck W. C. Lipe	704 710	Fuller Warner	717 717	Clark Timken Wisconsin	777 777 777	Lockheed Timken Westinghouse	853 854 862
BROCKWAY, 1936-46	Brockway Continental	32 32	Borg & Beck Brown-Lipe W. C. Lipe	704 707 710	Brown-Lipe Fuller Warner	717 717 717	Eaton Timken Wisconsin	777 777 777	Bendix Lockheed Timken Westinghouse	845 853 854 862
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DART, 1936-46	Buda (D) Cummins (D) Hercules Hercules (D) Waukesha	222 236 99 304 186	Fuller W. C. Lipe	708 710	Brown-Lipe Fuller	717 717	Timken	777	Lockheed Timken Westinghouse	853 854 862
DAY-ELDER, 1936-38	Hercules	99	Borg & Beck Fuller W. C. Lipe	704 708 710	Fuller Warner	717 717	Timken	777	Lockheed Timken Westinghouse	853 854 862
DIAMOND T, 1936-46	Cummins (D) Hercules Hercules (D)	236 99 304	Borg & Beck W. C. Lipe	704 710	Brown-Lipe Clark Warner	717 717 717	Clark Eaton Timken Wisconsin	777 777 777 777	Lockheed Westinghouse	853 862
DIVCO TWIN, 1936-46	Continental	32	Long	712	Clark Warner	717 717	Timken Spicer	777 777	Lockheed	853

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ESCO, 1936-38	Continental	32	Borg & Beck	704	Clark Fuller	717 717	Clark	777	Lockheed Timken Westinghouse	853 854 862
FAGEOL, 1936-38	Cummins (D) Waukesha	236 186	Long	712	Brown-Lipe Fuller Warner	717 717 717	Timken	777	Lockheed Timken Westinghouse	853 854 862
FARGO, 1936-46	Dodge Dodge (D)	45 267	Borg & Beck	704	Clark New Process Warner	717 717 717	Dodge Eaton Timken	777 777 777	Lockheed	853
FEDERAL, 1936-46	Continental Hercules Waukesha	32 99 186	Borg & Beck W. C. Lipe	704 710	Brown-Lipe Clark Warner	717 717 717	Eaton Timken Wisconsin	777 777 777	Bendix Lockheed Timken Westinghouse	845 853 854 862
FORD, 1936-46	Ford Four Ford Six Ford V8	64 64 64	Long	712	Ford	717	Ford Eaton	777 777	Ford Lockheed	851 853
FWD, 1936-46	Cummins (D) Hercules Waukesha	236 99 186	W. C. Lipe	710	Brown-Lipe Fuller FWD	717 717 717	Timken Wisconsin	777 777	Bendix Lockheed Timken Westinghouse	845 853 854 862
GMC, 1936-46	GMC GMC (D)	77 278	Borg & Beck Long Rockford W. C. Lipe	704 712 716A 710	Brown-Lipe Clark Fuller GMC Warner	717 717 717 717 717	Eaton GMC Timken Spicer	777 777 777 777	Huck Lockheed Timken Westinghouse	852 853 854 862
GRAMM, 1936-46	Buda (D) Continental Cummins (D) Hercules Hercules (D) Waukesha	222 32 236 99 304 186	Borg & Beck	704	Clark Fuller Warner	717 717 717	Clark Timken Wisconsin	777 777 777	Lockheed Timken Westinghouse	853 854 862
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HAHN, 1936-46	Hercules Waukesha	99 186	Borg & Beck	704	Fuller Warner	717 717	Clark Timken Wisconsin	777 777 777	Bendix Lockheed Timken Westinghouse	845 853 854 862
HENDRICKSON, 1936-46	Cummins (D) Waukesha	236 186	Borg & Beck W. C. Lipe	704 710	Brown-Lipe Fuller	717 717	Clark Eaton Timken	777 777 777	Lockheed Timken Westinghouse	853 854 862
HUG, 1936-46	Buda (D) Cummins (D) Hercules Waukesha	222 236 99 186	Borg & Beck W. C. Lipe	704 710	Brown-Lipe Clark Fuller	717 717 717	Clark Timken Wisconsin	777 777 777	Bendix Lockheed Timken Westinghouse	845 853 854 862

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INTERNATIONAL, 1936-46	Buda Cummins (D) International Waukesha	12 236 113 186	Long Rockford	712 716A	Clark Fuller International Warner	717 717 717 717	Eaton International Timken	777 777 777	Lockheed Westinghouse	853 862
KENWORTH, 1936-46	Buda Cummins (D) Hercules Waukesha	12 236 99 186	Long W. C. Lipe	712 710	Brown-Lipe Fuller	717 717	Timken Wisconsin	777 777	Bendix Lockheed Timken Westinghouse	845 853 854 862
KLEIBER, 1936-37	Continental Cummins (D) Hercules	32 236 99	Borg & Beck	704	Brown-Lipe	717	Timken	777	Lockheed Timken Westinghouse	853 854 862
LA FRANCE-REPUBLIC, 1936-46	Cummins (D) Waukesha	236 186	W. C. Lipe	710	Brown-Lipe Fuller Warner	717 717 717	Timken Wisconsin	777 777	Lockheed Timken Westinghouse	853 854 862
LE MOON, 1936-38	Continental Cummins (D) Waukesha	32 236 186	Borg & Beck	704	Brown-Lipe Clark Warner	717 717 717	Timken	777	Lockheed Timken Westinghouse	853 854 862
MACK, 1936-46	Buda (D) Continental Cummins (D) Mack Mack (D)	222 32 236 138 325	Borg & Beck Mack W. C. Lipe	704 716 710	Brown-Lipe Clark Mack Warner	717 717 717 717	Eaton Timken Mack	777 777 777	Bendix Lockheed Timken Westinghouse	845 853 854 862
MACK, JR., 1936-38	Continental Mack Jr.	32 152	Borg & Beck Long	704 712	Mack Jr. Warner	717 717	Timken	777	Lockheed Timken Westinghouse	853 854 862
MARMON-HERRINGTON, 1936-46	Ford V8 Hercules Hercules (D)	64 99 304	Borg & Beck Long W. C. Lipe	704 712 710	Brown-Lipe Ford Fuller Warner	717 717 717 717	Eaton Ford Timken Wisconsin	777 777 777 777	Bendix Lockheed Timken Westinghouse	845 853 854 862
MAXIM	Ford V8 Hercules	64 99	Long	712	Brown-Lipe Warner	717 717	Timken	777	Lockheed	853
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MORELAND, 1936-39	Continental Cummins (D) Hercules Waukesha	32 236 99 186	Borg & Beck W. C. Lipe	704 710	Brown-Lipe Fuller Warner	717 717 717	Timken	777	Lockheed Timken Westinghouse	853 854 862
NETCO, 1936-38	Waukesha	186	Borg & Beck W. C. Lipe	704 710	Brown-Lipe	717	Timken	777	Lockheed Timken Westinghouse	853 854 862
OSHKOSH, 1936-46	Cummins (D) Hercules GMC (D)	236 99 278	Borg & Beck W. C. Lipe	704 710	Brown-Lipe Fuller	717 717	Timken	777	Lockheed Timken	853 854
PAK-AGE-CAR, 1936-42	Hercules	99	Borg & Beck (Stutz) Long (Diamond T)	704 712	Stutz Diamond T	717 717	Pak-Age-Car	777	Bendix Lockheed	845 853

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SCHACHT, 1936-39	Continental Hercules	32 99	Borg & Beck	704	Fuller Warner	717 717	Timken	777	Bendix Lockheed Timken Westinghouse	845 853 854 862
STERLING, 1936-46	Buda (D) Cummins (D) Waukesha Hesselman	222 236 186 338	W. C. Lipe	710	Brown-Lipe Fuller Warner	717 717 717	Timken Wisconsin	777 777	Bendix Lockheed Timken Westinghouse	845 853 854 862
STEWART, 1936-42	Continental Waukesha	32 186	Borg & Beck Brown-Lipe W. C. Lipe	704 707 710	Brown-Lipe Fuller Warner	717 717 717	Clark Eaton Spicer Timken	777 777 777 777	Bendix Timken Westinghouse	845 854 862
STUDEBAKER, 1936-46	Hercules Studebaker Waukesha	99 173 186	Borg & Beck Long W. C. Lipe	704 712 710	Clark Warner	717 717	Clark Spicer Timken	777 777 777	Bendix Lockheed Timken Westinghouse	845 853 854 862
TRUCKSTELL	Chevrolet Ford V8	22 64	Borg & Beck Long	704 712	Chevrolet Ford	717 717	Chevrolet Eaton Ford	777 777 777	Ford Huck Lockheed	851 852 853
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WARFORD	Chevrolet Ford V8	22 64	Borg & Beck Long	704 712	Chevrolet Ford	717 717	Chevrolet Ford Timken	777 777 777	Ford Huck Lockheed	851 852 853
WHITE, 1936-46	Cummins (D) Hercules Hercules (D) White	236 99 304 198	W. C. Lipe Long Rockford	710 712 716A	Brown-Lipe Clark Fuller Warner White	717 717 717 717 717	Eaton Timken White	777 777 777	Bendix Lockheed Timken Westinghouse	845 853 854 862
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(D) DIESEL

ENGINES

GASOLINE

AUTOCAR

Year	Engine Model	Number Cylinders and Valve Arrangement	Bore and Stroke	Displacement Cubic Inches	Compression Ratio	Taxable H. P.	Brake H. P. at R. P. M.	Maximum Torque at R. P. M. Pounds Feet	Oil Capacity Quarts
1936-40	315	6-L	3¾x4¾	315	5.90	33.70	90@2600	230@1100	10
1936-40	358	6-L	4 x4¾	358	6.00	38.40	100@2500	268@1100	10
1936-38	404	6-L	4¼x4¾	404	5.50	43.40	97@2200	295@800	12
1936-38	453	6-L	4½x4¾	453	5.50	48.60	108@2200	333@800	12
1936-46	501	6-L	4½x5¼	501	5.70	48.60	130@2400	370@1000	12
1939-46	408	6-L	4¹⁄₁₆x5¼	408	5.70	39.62	114@2400	292@1100	12
1939-46	447	6-L	4¼x5¼	447	5.70	43.35	118@2400	330@1100	12
1941-46	331	6-L	3¾x5	331	5.75	33.70	101@2600	252@1100	10
1941-46	377	6-L	4x5	387	6.00	38.40	112@2600	290@1100	10

TUNE UP CHART

Year	Engine Model	Firing Order	Spark Plug Gap	Breaker Gap	Cam Angle, Degrees	Timing Mark Location	Spark Timing, Degrees	Tappet Clearance For Running, Hot Int.	Tappet Clearance For Running, Hot Exh.	Tappet Clearance For Timing, Intake	Battery Terminal Grounded
1936-40	315	153624	.018-.023	.018-.024	36	Flywheel	9BTDC	.015	.018	.020	Positive
1936-40	358	153624	.018-.023	.018-.024	36	Flywheel	8½BTDC	.015	.018	.020	Positive
1936-38	404	153624	.018-.023	.018-.024	36	Flywheel	2BTDC	.015	.018	.020	Positive
1936-38	453	153624	.018-.023	.018-.024	36	Flywheel	2BTDC	.015	.018	.020	Positive
1936-46	501	153624	.018-.023	.018-.024	36	Flywheel	2BTDC	.015	.018	.020	Positive
1939-46	408	153624	.018-.023	.018-.024	36	Flywheel	2BTDC	.015	.018	.020	Positive
1939-46	447	153624	.018-.023	.018-.024	36	Flywheel	2BTDC	.015	.018	.020	Positive
1941-46	331	153624	.018-.023	.018-.024	36	Flywheel	6BTDC	.015	.018	.020	Positive
1941-46	377	153624	.018-.023	.018-.024	36	Flywheel	2BTDC	.015	.018	.020	Positive

ENGINE BEARING SPECIFICATIONS

Year	Engine Model	Camshaft Journal Diameter	Camshaft Clearance	Connecting Rod Journal Diameter	Connecting Rod Clearance	Connecting Rod Bearing Bolt Tension Lb. Ft.	Mains Journal Diameter	Mains Clearance	Mains Bearing Bolt Tension Lb. Ft.	Mains Thrust on No.	Mains End-play
1936-40	315	①	.003-.005	2.249-2.250	.002-.003	85-90	2.999-3.000	.003-.0045	130-140	4	.005-.008
1936-40	358	②	.003-.005	2.249-2.250	.002-.003	85-90	2.999-3.000	.003-.0045	130-140	4	.005-.008
1936-38	404		.003-.005	2.499-2.500	.002-.003	85-90	3.2455-3.2465	.003-.0045	130-140	4	.005-.008
1936-38	453	③	.003-.005	2.499-2.500	.002-.003	85-90	3.2455-3.2465	.003-.0045	130-140	4	.005-.008
1936-46	501	③	.003-.005	2.499-2.500	.002-.003	85-90	3.2455-3.2465	④	130-140	4	.005-.008
1939-46	408	③	.003-.005	2.499-2.500	.002-.003	85-90	3.2455-3.2465	④	130-140	4	.005-.008
1939-46	447	③	.003-.005	2.499-2.500	.002-.003	85-90	3.2455-3.2465	④	130-140	4	.005-.008
1941-46	331	①	.003-.005	2.374-2.375	.002-.003	85-90	3.2455-3.2465	④	130-140	4	.005-.008
1941-46	377	①	.003-.005	2.374-2.375	.002-.003	85-90	3.2455-3.2465	④	130-140	4	.005-.008

① No. 1—2.435″. No. 2—2.405″. No. 3—2.373″. No. 4—1.748″.

② No. 1—2.435″. Nos. 2, 3 and 4—2.405″. No. 5—1.748″.

③ No. 1—2.435″. No. 2—2.405″. No. 3—2.388″. No. 4—2.373″. No. 5—1.748″.

④ Clearance for cadmium silver and antimony bearings, .003″ to .0045″; for copper lead bearings, .004″ to .005″.

VALVE SYSTEM

Year	Engine Model	Stem Clearance		Tappet Guide Clearance	Tappet Clearance				Valve Spring Pressure Test		Valve Seat Angle Degrees
					Running Hot		Timing				
		Intake	Exhaust		In-take	Ex-haust	In-take	Ex-haust	Free Length, Inches	Pounds at Inches, Length	
1936-40	315	.0035-.005	.0035-.005	.0025-.005	.015	.018	.020	.023	3 11/32	64@2 5/8	45
1936-40	358	.0035-.005	.0035-.005	.0025-.005	.015	.018	.020	.023	3 11/32	64@2 5/8	45
1936-38	404	.0035-.005	.0035-.005	.0025-.005	.015	.018	.020	.023	3 11/32	64@2 5/8	45
1936-38	453	.0035-.005	.0035-.005	.0025-.005	.015	.018	.020	.023	3 11/32	64@2 5/8	45
1936-46	501	.0035-.005	.0035-.005	.0025-.005	.015	.018	.020	.023	3 11/32	64@2 5/8	45
1939-46	408	.0035-.005	.0035-.005	.0225-.005	.015	.018	.020	.023	3 11/32	64@2 5/8	45
1939-46	447	.0035-.005	.0035-.005	.0025-.005	.015	.018	.020	.023	3 11/32	64@2 5/8	45
1941-46	331	.0035-.005	.0035-.005	.0025-.005	.015	.018	.020	.023	3 11/32	64@2 5/8	Int. 30 Ex. 45
1941-46	377	.0035-.005	.0035-.005	.0025-.005	.015	.018	.020	.023	3 11/32	64@2 5/8	45

PISTON AND RING CLEARANCES

Year	Engine Model	Piston Skirt, Inches		Fitting Pistons with Shim and Spring Scale		Ring End Gap, Inch ①		Ring and Groove, Inch	
		Top	Bottom	Shim Thickness	Pounds Pull on Scale	Com-pression	Oil	Com-pression	Oil
1936-40	315	②	.003	.003	4 to 6	.018-.022	.018-.022	.002-.003	.002-.003
1936-40	358	②	.003	.003	4 to 6	.018-.022	.018-.022	.002-.003	.002-.003
1936-38	404	②	.003	.003	4 to 6	.018-.022	.018-.022	.002-.003	.002-.003
1936-38	453	②	.003	.003	4 to 6	.018-.022	.018-.022	.002-.003	.002-.003
1936-46	501	②	.003	.033	4 to 6	.018-.022	.018-.022	.002-.003	.002-.003
1939-46	408	②	.003	.003	4 to 6	.018-.022	.018-.022	.002-.003	.002-.003
1939-46	447	②	.003	.003	4 to 6	.018-.022	.018-.022	.002-.003	.002-.003
1941-46	331	②	.003	.003	4 to 6	.018-.022	.018-.022	.002-.003	.002-.003
1941-46	377	②	.003	.003	4 to 6	.018-.022	.018-.022	.002-.003	.002-.003

① Ring end gap clearances are for cylinder bores without taper. Fit rings in tapered bores with not less than the maximum figure given in the table.

② Pistons are larger in diameter at the bottom of the skirt and taper .002" smaller toward the ring grooves. Measure the clearance at the bottom of the skirt only.

ENGINE

CYLINDER HEAD

1936-46 ALL: As no particular tightening sequence is recommended by the manufacturer, the head should be tightened down, starting from the center, working outward toward the sides and to the ends. Draw down the nuts evenly and repeat the operation until all are normally tight. After the engine has been run sufficiently long to bring all the parts to normal operating temperature, a final tightening should be made. When using a torque indicating wrench, the final tightening should be from 80 to 85 pounds feet.

NOTE—When using a torque wrench, be sure the nuts and studs are free from rust or dirt, otherwise a false reading will be obtained due to the increased friction.

EXHAUST VALVE SEAT INSERTS

1936-46 ALL: Since these inserts are too hard to reface by the ordinary grinding methods, a high-speed grinding stone or a special lapping tool should be used to perform this operation. When using this equipment, be sure valve guides are clean and that the valve guide pilot is a snug fit in order to assure a concentric finish. Finished seats should be checked with a dial indicator and run-out should not exceed .0005".

To remove an insert, use a drill which is smaller in diameter than the insert width and drill two holes at opposite sides, but not all the way through. Cut through the undrilled portion of the insert with a sharp chisel and remove the two pieces.

To install an insert, pack in "dry ice" for at least fifteen minutes to allow the metal to contract, and heat the exhaust valve port area gradually, to permit this material to expand. Then use a suitable driver to install the insert into the cylinder block, using extreme care to see that it is not cocked or misaligned. When installed, finish the seats with the grinding or lapping equipment already mentioned.

VALVE STEM GUIDES

1936-46 ALL: When necessary to replace guides, run the tappet adjusting screw all the way down and crank the engine to bring the tappet on the low point of the cam. Then use a suitable drift, preferably one having a pilot the same size as the valve stem, to drive out the guide. If the guide comes in contact with the tappet before it is all the way out, break off the lower portion.

NOTE—Install one guide at a time and measure the position of one which has not been removed to determine the correct depth of the guide being installed. When installed, ream to provide a clearance within the limits given in the VALVE SYSTEM table.

VALVE TAPPETS & GUIDES

1936-46 ALL: Tappets must be a free fit in their guides without excessive side play. If the fit is too loose, remove the guide cluster from the engine, take out the loose tappet, ream the guide hole and install an oversize tappet, being sure the tappet is provided with a clearance within the limits given in the VALVE SYSTEM table.

NOTE—If all or most of the tappets are too loose a fit, install a new guide cluster and standard size tappets.

VALVE TIMING

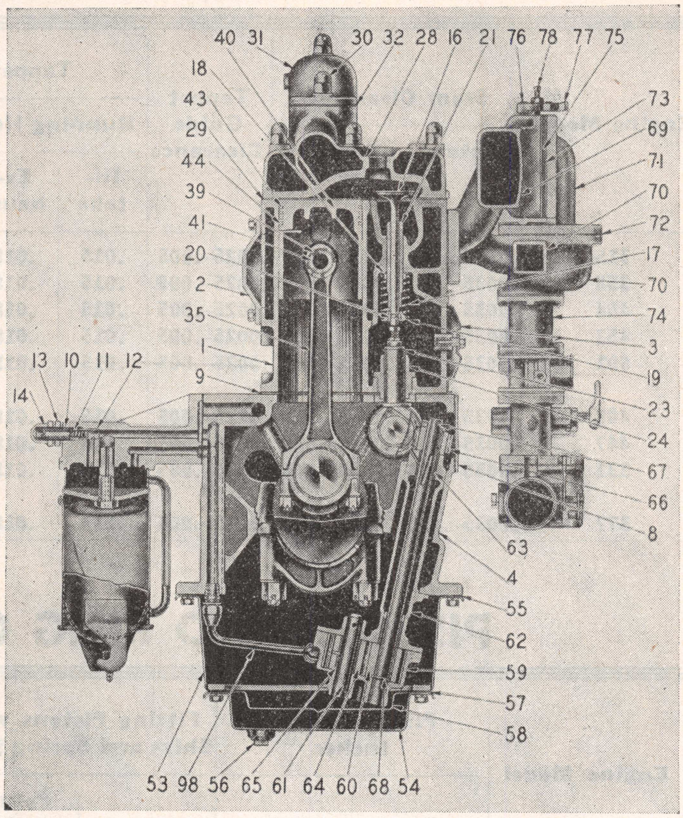
1936-46 ALL: With the engine at normal room temperature and No. 1 intake valve tappet set to the clearance for timing as given in the VALVE SYSTEM table, crank the engine until the first long line on the scale (on flywheel) adjacent to the "1—DEAD CENTER" mark for 331 and 377 engines, or the first long line next to the "INLET OPEN" mark on all other engines, is in line with the indicator on the flywheel housing. In this position, No. 1 intake valve should be just starting to open.

This may be checked by placing a very narrow feeler gauge between the tappet and the valve stem. If the feeler is pinched, the timing is correct; if the feeler is not pinched, check again to be sure the piston is on the intake stroke and not on the power stroke. If on the power stroke, turn the engine one complete revolution and check again with the feeler. If the feeler is still not pinched, the timing is incorrect, in which case, the gear cover will have to be removed and the valves retimed.

NOTE—The following data are for use when the engine has been entirely disassembled and, either the timing gear marks or the flywheel marks have been obliterated, or if they are not legible. On all engines, intake opens at TDC. Exhaust closes at TDC on 315, 331, 358 and 377 engines, while on engines 404, 408, 447, 453 and 501, exhaust closes 2½ degrees after TDC.

TIMING GEARS

1936-46 ALL: Timing gear backlash should not exceed .004". If gears are to be removed and the same gears replaced, make sure the timing marks are legible. The camshaft gear is fastened to the camshaft by means of four bolts, one bolt position being slightly offset to prevent the gear from being installed incorrectly.



MODELS 358 and 377. Rear Sectional View.

When installing a new crankshaft gear, it is advisable to heat the gear in boiling water to expand the metal, and coat the shaft with white lead to make assembly easier. Before replacing the gear cover, be sure the valve timing is correct which is when the marks on the camshaft, idler and crankshaft gears are meshed.

CAMSHAFT AND BEARINGS

1936-46 ALL: When necessary to renew camshaft bearings, they should be pressed in place and line-reamed to provide a clearance within the limits given in the ENGINE BEARING SPECIFICATIONS table.

NOTE—To assure proper camshaft fit, camshaft bearings should be reamed **after** the cylinder block is bolted to the crankcase. Be sure that the oil holes in the camshaft bearings are lined up with the oil holes in the crankcase, and that these holes are clean and open.

Camshaft end thrust is controlled by a fibre washer at the front end of the shaft. At long intervals, or when the engine has been disassembled for repairs, the end play should be checked and if in excess of about .006", install a new washer.

PISTONS AND RODS, REMOVE

1936-46 ALL: Piston and connecting rod assemblies are removed from the top of the block. Although regular production rods are generally marked with the cylinder number in which they are installed, replacement rods are not; therefore, unmarked rods should be suitably identified with punch marks, as removed.

PISTON AND ROD, ASSEMBLE

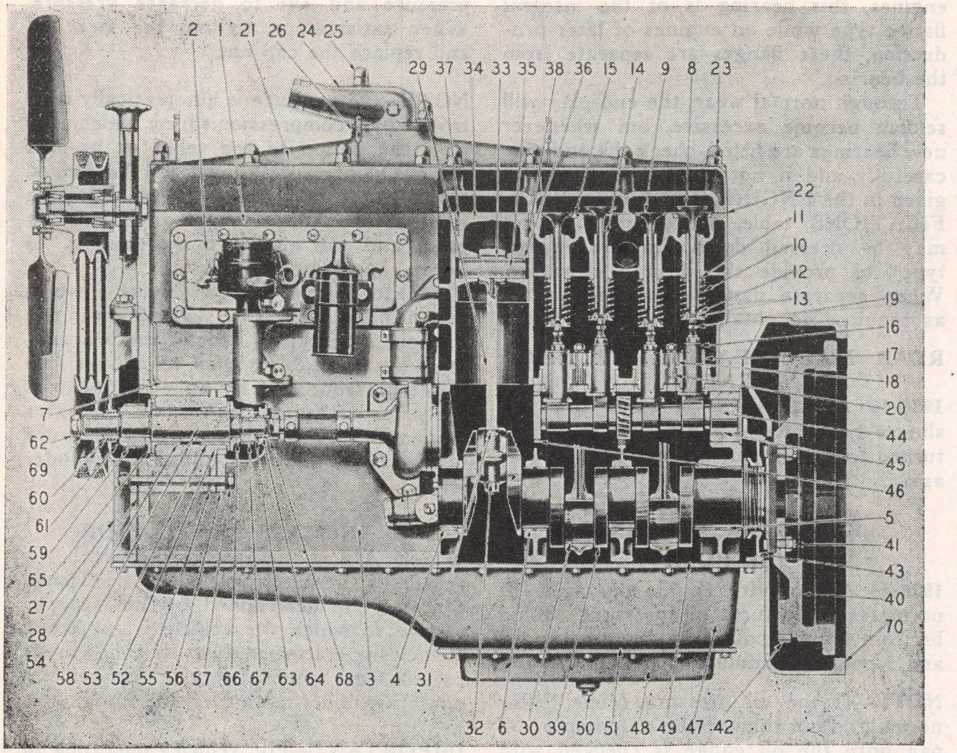
1936-46 ALL: Aluminum pistons should be assembled to the rods so that when installed in the cylinder bores, the slotted side of the piston is facing opposite to the camshaft. Regular production rods are marked with the cylinder number in which they are installed. These marks must also face away from the camshaft.

PISTONS, RENEW

1936-46 ALL: NOTE—A variation of 10 degrees between the temperature of the pistons and cylinder bores is sufficient to produce a difference of .0005". Therefore, both the pistons and cylinder bores should be at normal room temperature (about 70 degrees) when fitting pistons. This is particularly important because the clearances given in the PISTON & RING CLEARANCES table are minimum and pistons must not be fitted with less than specified.

Before any attempt is made to fit new pistons, cylinder bores should be carefully indicated and refinished. If bores do not require refinishing, be sure to remove the ridge at the top of each bore. If refinishing is required, it is good practice to do so in alternate cylinders due to the localized temperature build-up. Cylinder bores should not be out-of-round or tapered more than .0005".

Before fitting pistons, wipe the cylinder walls and pistons to remove all chips, dirt or other foreign matter. The feeler ribbon used to check piston fit should be about



MODEL 377. Side Sectional View.

12" long and ½" wide. Consult the PISTON & RING CLEARANCES table for the thickness of shim to use, as well as the recommended pounds pull on a spring scale required to withdraw the feeler ribbon past the piston.

Insert the piston in the bore upside down and in its running position (see PISTON & ROD, ASSEMBLE). Place the feeler ribbon between the cylinder wall and the thrust side of the piston (opposite slotted side) in a position at right angles to the piston pin hole.

After assembling the piston to the connecting rod, check the assembly for alignment on a suitable jig.

PISTON RINGS, RENEW

1936-46 ALL: NOTE—To prevent the possibility of bending or breaking the second ring land—thus ruining the piston—the ridge at the top of the cylinder bore should be cut away before removing the piston and rod assemblies. If the available ridge reamer has no provision to control the depth of the cut, it is good practice to bring the piston far enough up into the cylinder to allow the reamer to rest on top of the piston. This will serve to prevent cutting down into the ring travel area.

CAUTION—Never cut down into the ring travel area more than 1/32"—or more than half the depth of the top ring.

New rings should be fitted with end gaps and groove clearances as given in the PISTON & RING CLEARANCES table. Ring grooves must be clean and free from carbon, and must show no perceptible wear.

NOTE—Ring end gaps given in the PISTON & RING CLEARANCES table are for cylinder bores without taper. Fit rings in tapered bores with not less than the maximum dimension given. If rings other than standard are being installed, pay particular attention to the installation instructions which usually are included in the ring package. This applies to clearances, position in grooves, etc.

When rings are properly fitted to the pistons, be sure to stagger the ring gaps so they are spaced equal distances around the circumference of the piston. However, see that no gaps are over the piston pins.

PISTON PINS, RENEW

1936-46 ALL: Piston pin bosses should be reamed to provide a hand push fit of the pin. However, since the pressure of the hand may vary to some extent, the piston may be heated in water to approximately 170 degrees, after which, the pin should enter the piston easily.

Use a pair of long-nosed pliers to contract the snap ring keepers and install in the grooves of the piston bosses. When installed properly, it should not be possible to turn the rings with the fingers.

PISTON PIN BUSHINGS, RENEW

1936-46 ALL: New bushings should be pressed in place and reamed to provide a hand push fit of the pin at normal room temperature. When installed, be sure the oil hole in the bushing lines up with the hole in the connecting rod.

CONNECTING ROD BEARINGS, RENEW

1936-46 ALL: When bearings become worn, they can be replaced without removing the rod by simply taking off the bearing cap and replacing the upper and lower halves. Bearings should be replaced in sets and under no circumstances should rods or caps be filed, altered or mutilated in any way in an attempt to obtain proper bearing fit.

NOTE—Before replacing bearings, make sure that the crankpins are not nicked or scored. Use care also, to see that all parts are thoroughly clean. This is particularly important because one small particle of metal, carbon or other foreign matter, lodged between the back of the bearing and the rod, or between the face of the bearing and the crankpin, will very likely cause a hot spot due to the elimination of the oil clearance at that point, eventually resulting in a bearing failure or a scored crankpin.

CAUTION—These engines employ shims between the bearing cap and rod ONLY on the side opposite the bearing lock notch. Never use more than a .006" shim pack to obtain proper bearing fit. Clearance can be reduced for example, by substituting a .002" shim for a .003" shim. Use any combination of these shims to obtain proper clearance.

To check the fit of new bearings, use a piece of brass shim stock ¼" wide, the length of which should be ¼" less than the length of the bearing, while the thickness should be about the same as the minimum allowable clearance.

CAUTION—To avoid damaging the bearing material, smooth down the edges of the shim stock on an oil stone so that no sharp edges remain. Install the shim between the bearing and the crankpin, in the center of the bearing, then tighten the cap bolts to the recommended torque tension. When fitted properly, it should not be possible to move the rod endwise by hand, but a light tap with a hammer should cause the rod to move endwise. Then remove the shim and install the cap again, tightening the cap bolts with the torque wrench, after which, the rod should move endwise by hand. If the rod is too loose with the checking shim in place and all the rod shims removed, then the crankpin should be turned down and undersize bearings fitted.

MAIN BEARINGS, RENEW

1936-46 ALL: NOTE—Before replacing bearings, make sure that the crankshaft journals are not nicked or scored. Use care also, to see that all parts are thoroughly clean. This is particularly important because one small particle of metal, carbon, dirt or other foreign matter, lodged between the back of the bearing and the cap, or between the bearing face and the crankshaft journal, will very likely cause a hot spot due to the elimination of the oil clearance at that point, eventually resulting in a bearing failure or a scored journal.

When bearings become worn, they can be replaced without removing the crankshaft in the following manner: Remove the bearing cap and take out the worn lower shell. A suitable tool can be made to remove the upper shell by using a cotter pin with the rounded end flattened to form a T shape. Insert the T-shaped end of the pin in the oil passage hole in the crankshaft journal and, by rotating the crankshaft in the reverse direction, the T-shaped head will contact the bearing and force it out.

To install, place a new upper shell on the crankshaft journal with the locating notch in the correct position and rotate the shaft to turn the shell in place. Then install the lower shell in the cap and replace the cap, tightening the cap bolts to the recommended torque tension which will be found in the ENGINE BEARING SPECIFICATIONS table.

NOTE—Bearings should be replaced in sets and under no circumstances should any attempt be made to file, alter or otherwise mutilate the bearing caps to obtain proper bearing fit. A .010" shim pack is used on both sides of these bearings and more than this thickness should never be used; nor should these shims project between the edges of the bearings as they will cause the bearings to buckle when the cap bolts are tightened. Main bearing caps are numbered and should be installed so that they correspond with the numbers on the oil pan mounting flange on the upper crankcase.

To check the fit of new bearings, use a piece of brass shim stock ¼" wide, the length of which should be ¼" less than the length of the bearing, while the thickness should be about the same as the minimum allowable clearance.

CAUTION—To avoid damaging the bearing material, smooth down the edges of the shim stock to remove sharp edges or turned over corners. And before inserting it in place, coat the shim on both sides with a light film of engine oil.

Then lay the shim lengthwise in the center of the bearing and install the bearing cap to the crankshaft, tightening the cap bolts to the recommended torque tension which can be found in the ENGINE BEARING SPECIFICATIONS table. Test the fit of the bearing by rocking the flywheel through an arc of 2"—not more than 1" in either direction. The bearing may be considered fitted properly if the shaft is movable with a fairly heavy drag.

NOTE—Remove the checking shim and replace the cap, but do not tighten the cap bolts, as this bearing must be loose in order to check the fit of the other bearings. It is good practice to fit bearings by starting at the center, then the rear bearing, front bearing, and finally, the intermediates.

CRANKSHAFT END THRUST

1936-46 ALL: Crankshaft end thrust is taken on the center main bearing. On early engines, this bearing is of the integral flange type while on engines of later production, these flanges are separate from the bearing.

Through normal wear, the end play will seldom become excessive, but whenever new bearings are fitted, check the end play carefully and if not within the limits as given in the ENGINE BEARING SPECIFICATIONS table, the bearing flanges may be dressed down (integral flange type) to provide the desired clearance. When separate flanges are used, install as required to obtain the desired result.

REAR MAIN BEARING OIL SEAL, RENEW

1936-46 ALL: These engines use the slinger type oil seal and surplus oil is returned to the oil pan through an oil passage.

ENGINE OILING

OIL PUMP

1936-46 ALL: With engine operating at normal temperature, oil pressure should be from 40 to 45 pounds at governed speed and 5 pounds minimum, at idling speed.

NOTE—If the oil pressure drops below normal, do not remove the oil pump or oil pan until the oil gauge is checked with another gauge known to be accurate. Check the oil level and examine the condition of the oil. If the pressure continues to drop, remove and clean the oil pan thoroughly, and disassemble, clean and inspect the pump parts.

The pump is easily removed for inspection or repairs after the oil pan is removed. To disassemble the pump, drive the pin out of the hub of the upper spiral drive gear and pull the gear from the shaft. Take off the oil pump bottom cover and withdraw the gears and shaft.

Clearance between the gears and cover may be checked by placing a steel scale across the face of the housing, and a feeler between the steel scale and gears. If the clearance is excessive, it may be reduced by grinding the face of the housing, using an abrasive compound evenly distributed on a perfectly flat surface.

Examine the oil pump pressure ball check, ball check spring and ball check seat in the bottom cover for evidence of wear. If so, it is important that new parts be installed.

CAUTION—Before replacing the oil pump and oil pan, the oil float, screen and tube should be thoroughly cleaned, being sure that all openings in the screen are free and clean. If the screen has been crushed, it is better to replace it rather than attempt to make a repair. When assembling the pump, dip the gears in fresh engine oil as a means of priming the pump.

OIL PRESSURE REGULATOR

1936-46 ALL: The regulator is located in the upper crankcase below the water pump and when it is desired to make an adjustment, remove the cap nut which covers the adjusting screw. Loosen the lock nut and turn the adjusting screw in to increase pressure and out to decrease pressure. When satisfactory, tighten the lock nut and replace the cap nut.

NOTE—Oil pressure is automatically controlled by a compression spring which controls the action of the relief or by-pass valve. Oil pressure should not be judged too high or too low until it is known whether the proper weight of oil is being used, and the engine is warmed up to normal operating temperature.

As the engine bearings become worn, the oil pressure will be slightly lower due to more oil escaping around the bearings. It is not advisable to try to correct this slight pressure loss by an adjustment of the pressure regulator, because the extra amount of oil being thrown off by the worn bearings is already over-oiling the cylinder walls.

CRANKCASE VENTILATOR

1936-46 ALL: The interval at which the ventilator and air cleaner should be cleaned can only be determined by the type of service to which the vehicle is subjected. Vehicles operating in dusty or sandy areas require more frequent service than vehicles operating under more favorable conditions.

IMPORTANT—For vehicles operating in dust storm areas, cleaner should be cleaned immediately after such storms occur.

The crankcase ventilator breather is fitted with an oil-wetted air cleaner which should be removed and washed at least every 1000 miles. After the cleaner element is washed, blow it dry with compressed air, then dip it in SAE 50 engine oil. The outlet tube should be cleaned every 2000 miles.

OIL FILTER

1936-46 ALL: Filters should be cleaned thoroughly every time the oil is changed and after every thousand miles of operation. If the dip stick shows the oil to be thick and very dirty, it indicates that the filter element requires service.

To remove the filter element, first take out the plug from the base of the filter to allow the oil to drain. Then remove the cover and pull out the element.

NOTE—At frequent intervals, it is good practice to drain the filter to get rid of any solid matter or water which may have settled in the filter sump. Whenever this is done, be sure to add an extra quart of oil to the crankcase to compensate for the oil drained. Of course, this also applies when changing the element.

COOLING SYSTEM

WATER PUMP, OVERHAUL

1936-46 ALL: On early production engines, the water pump is of the centrifugal type, bolted directly to the crankcase and driven at 1½ engine speed by an accessory shaft through a flexible coupling. The pump shaft is supported in the body by two bronze bushings and packed with ring packing.

This type pump is easily disassembled by simply separating the pump housing, and when this is done, the internal parts are accessible and readily removed.

On later production engines, the pumps used are also of the centrifugal type but differ from the early type in that the shaft is supported by two ball bearings. Water sealing is accomplished by a non-adjustable packless seal, requiring no lubrication, being packed with lubricant at the time of manufacture.

To disassemble this type pump, remove the bolts and separate the cover from the pump body. Use a suitable puller to remove the impeller from the shaft. Insert a screwdriver through one of the slots in the impeller hub and press the snap ring out of the groove, after which, take out the seal parts.

Assemble the pump in the reverse order, bearing in mind that the metal ring acts as a seat for the seal spring and presses the rubber seal squarely against the carbon disc. The clamping ring keeps the rubber tight around the shaft.

ENGINE WATER THERMOSTAT

1936-46 ALL: If the thermostat is not functioning properly, remove the assembly from the water outlet and see if the bellows and valve are in good condition. If they are, test its operation by completely submerging it in water, heating the water gradually until it reaches the opening temperature of the thermostat, and then in water heated to the fully opened temperature.

NOTE—When taking temperature readings, agitate the water thoroughly. And if the thermostat fails to function properly, it should be replaced rather than attempt to make a repair. However, before installing the new unit, it should be tested as directed above. The thermostat should start to open at approximately 150 degrees and be fully open at about 170 degrees.

CAUTION—The thermostat should be installed with the thermal spring down or toward the cylinder block.

FUEL SYSTEM

NOTE—For service information on Carburetors, Automatic Chokes, Governors, Fuel Pumps, Air Cleaners and Gasoline Gauges, see the Table of Contents on page 1.

MANIFOLD HEAT CONTROL

1936-46 ALL: To regulate the amount of heat by-passed around the heat riser, the manifold is equipped with a plate mounted between the intake and exhaust manifolds.

During cold weather operation, the plate should be set in the open position, permitting the hot exhaust gases to flow around the intake manifold. During warm weather, the plate may be closed as required.

ELECTRIC SYSTEM

NOTE—For service information on Distributors, Magnetos, Generators, Generator Controls, Starting Motors and Starting Switches, see the Table of Contents on page 1.

IGNITION TIMING

1936-46 ALL: Flywheels are scaled with marks for a distance of 2¼" along the wheels' circumference, graduated in 1/16" divisions. On 331 and 377 engines, the first long line of this scale—next to the "1—DEAD CENTER" mark indicates TDC for No. 1 and 6 cylinders. The ignition advance for these engines is 13/16" and is indicated by a punch mark and white line. On all other engines, the ignition mark is indicated by a white line with black margins.

When timing ignition, adjust the breaker gap to the clearance given in the TUNE UP CHART and crank the engine to bring No. 1 piston up on its compression stroke, stopping when the ignition line (indicated in the foregoing paragraph) is in line with the pointer on the flywheel housing.

Locate No. 1 spark plug wire on the distributor cap, place the cap in position on the distributor, and mark the housing opposite No. 1 terminal so that its relative position will be known when the cap is removed.

Loosen the distributor base clamp bolt and rotate the distributor until the points close. Then rotate the distributor in the opposite direction until the points just begin to open, then tighten the clamp bolt.

NOTE—For best results, use a Neon timing light or a conventional test lamp to check the timing. For best performances and fuel economy, this setting should be one which will provide smooth engine performance with a slight "ping" on wide-open throttle at comparatively low vehicle speed.

ENGINES GASOLINE BUDA

Year	Engine Model	Number Cylinders and Valve Arrangement	Bore and Stroke	Displacement Cubic Inches	Compression Ratio	Taxable H. P.	Brake H. P. at R. P. M.	Maximum Torque at R. P. M. Pounds Feet	Oil Capacity Quarts ①
1936–42	GF-638	6-L	4¾x6	637.9	4.75	54.1	128@1800	407@900	16
1936–46	HP-205	4-L	3 13/16x4½	205.6	4.76	23.2	51@2400	133@1200	5
1936–46	HP-217	4-L	3 13/16x4¾	217	5.50	23.2	55@2400	146@1200	5
1942–46	HP-234	4-L	3 13/16x5⅝	234	5.83	34.88	59@2400	133@1200	6
1936–42	HP-260	6-L	3½x4½	259.9	4.75	29.4	68@2800	164@1100	6
1936–42	HP-298	6-L	3¾x4½	298.2	4.75	33.75	77@2800	190@1100	6
1937–46	HP-326	6-L	3 13/16x4¾	325.4	5.40	34.8	80@2600	220@1000	6
1942–46	HP-351	6-L	3 13/16x5⅝	351.2	5.83	34.8	85@2600	235@1000	6
1936–39	J-214	6-L	3⅜x4	214.7	5.00	27.34	62@3000	135@1000	6
1936–39	K-325	6-L	3 13/16x4¾	325	4.80	34.8	87@2800	203@1100	9
1936–41	K-369	6-L	4 1/16x4¾	369	4.73	39.6	99@2800	234@1100	9
1936–46	K-393	6-L	4 3/16x4¾	393	4.80	42.07	103@2600	260@1200	9
1936–46	K-428	6-L	4⅜x4¾	428	5.33	45.9	107@2600	280@1200	9
1936–40	L-468	6-L	4¼x5½	468	4.75	43.3	106@2400	306@700	9
1936–46	L-525	6-L	4½x5½	524.7	4.75	48.6	113@2400	339@800	9
1937–40	LO-468	6-I	4¼x5½	468	5.00	43.3	120@2400	382@1200	9
1937–46	LO-525	6-I	4½x5½	524.7	5.00	48.6	139@2400	390@1400	9
1937–40	M-707	6-I	5x6	707	5.00	60.0	143@1800	466@1000	12
1937–42	M-766	6-I	5x6½	766	5.00	60.0	156@1800	500@1000	12

① Capacities are approximate and vary with type of oil pan used.

NOTE—See page 912 for Tune Up Chart on these engines.

VALVE SYSTEM

Year	Engine Model	Stem Clearance		Tappet Guide Clearance	Tappet Clearance				Valve Spring Pressure Test		Valve Seat Angle Degrees
					Running, Hot		Timing				
		Intake	Exhaust		Intake	Exhaust	Intake	Exhaust	Free Length, Inches	Pounds at Inches, Length	
1936–42	GF-638	.002–.004	.002–.004	.0005–.001	.010	.016	.010	.016	3 11/16	92–100@2⅞	45
1936–46	HP-205	.002–.004	.002–.004	.0005–.001	.006	.009	.006	.009	2 3/16	96–104@1 19/32	45
1936–46	HP-217	.002–.004	.002–.004	.0005–.001	.006	.009	.006	.009	2 3/16	96–104@1 19/32	45
1942–46	HP-234	.002–.004	.002–.004	.0005–.001	.006	.009	.006	.009	2 3/16	96–104@1 19/32	45
1936–42	HP-260	.002–.004	.002–.004	.0005–.001	.006	.009	.006	.009	2 3/16	96–104@1 19/32	45
1936–42	HP-298	.002–.004	.002–.004	.0005–.001	.006	.009	.006	.009	2 3/16	96–104@1 19/32	45
1937–46	HP-326	.002–.004	.002–.004	.0005–.001	.006	.009	.006	.009	2 3/16	96–104@1 19/32	45
1942–46	HP-351	.002–.004	.002–.004	.0005–.001	.006	.009	.006	.009	2 3/16	96–104@1 19/32	45
1936–39	J-214	.002–.004	.002–.004	.0005–.001	.006	.009	.006	.009	---	--------------	45
1936–39	K-325	.002–.004	.002–.004	.0005–.001	.006	.009	.006	.009	2 9/16	125–138@1 13/16	45
1936–41	K-369	.002–.004	.002–.004	.0005–.001	.006	.009	.006	.009	2 9/16	125–138@1 13/16	45
1936–46	K-393	.002–.004	.002–.004	.0005–.001	.006	.009	.006	.009	2 9/16	125–138@1 13/16	45
1936–46	K-428	.002–.004	.002–.004	.0005–.001	.006	.009	.006	.009	2 9/16	125–138@1 13/16	45
1936–40	L-468	.002–.004	.002–.004	.0005–.001	.006	.009	.006	.009	2 9/16	125–138@1 13/16	45
1936–46	L-525	.002–.004	.002–.004	.0005–.001	.006	.009	.006	.009	2 9/16	125–138@1 13/16	45
1937–40	LO-468	.002–.004	.002–.004	.0005–.001	.009	.018	.009	.018	2 9/16	125–138@1 13/16	45
1937–46	LO-525	.002–.004	.002–.004	.0005–.001	.009	.018	.009	.018	2 9/16	125–138@1 13/16	45
1937–40	M-707	.002–.004	.002–.004	.0005–.001	.010	.016	.010	.016	3⅜	100–110@2 3/16	45
1937–42	M-766	.002–.004	.002–.004	.0005–.001	.010	.016	.010	.016	3⅜	100–110@2 3/16	45

PISTON AND RING CLEARANCES

Year	Engine Model	Piston Skirt, Inches		Fitting Pistons with Shim and Spring Scale		Ring End Gap, Inch ①		Ring and Groove, Inch	
		Top	Bottom	Shim Thickness	Pounds Pull on Scale	Compression	Oil	Compression	Oil
1936–42	GF-638	.006②	.0065③	.006②	.0065③	.024	.012	.0005–.001	.0005–.001
1936–46	HP-205	.005②	.0055③	.005②	.0055③	.017	.009	.0005–.001	.0005–.001
1936–46	HP-217	.005②	.0055③	.005②	.0055③	.017	.009	.0005–.001	.0005–.001
1942–46	HP-234	.005②	.0055③	.005②	.0055③	.017	.009	.0005–.001	.0005–.001
1936–42	HP-260	.0045②	.005③	.0045②	.005③	.014	.007	.0005–.001	.0005–.001
1936–42	HP-298	.005②	.0055③	.005②	.0055③	.016	.008	.0005–.001	.0005–.001
1937–46	HP-326	.005②	.0055③	.005②	.0055③	.017	.009	.0005–.001	.0005–.001
1942–46	HP-351	.005②	.0055③	.005②	.0055③	.017	.009	.0005–.001	.0005–.001
1936–39	J-214	.0045②	.005③	.0045②	.005③	.013	.007	.0005–.001	.0005–.001
1936–39	K-325	.005②	.0055③	.005②	.0055③	.017	.009	.0005–.001	.0005–.001
1936–41	K-369	.0055②	.006③	.0055②	.006③	.022	.011	.0005–.001	.0005–.001
1936–46	K-393	.0055②	.006③	.0055②	.006③	.022	.011	.0005–.001	.0005–.001
1936–46	K-428	.0055②	.006③	.0055②	.006③	.022	.011	.0005–.001	.0005–.001
1936–40	L-468	.0055②	.006③	.0055②	.006③	.022	.011	.0005–.001	.0005–.001
1936–46	L-525	.0058②	.0063③	.0058②	.0063③	.023	.012	.0005–.001	.0005–.001
1937–40	LO-468	.0055②	.006③	.0055②	.006③	.022	.011	.0005–.001	.0005–.001
1937–46	LO-525	.0058②	.0063③	.0058②	.0063③	.023	.012	.0005–.001	.0005–.001
1937–40	M-707	.0065②	.007③	.0065②	.007③	.026	.013	.0005–.001	.0005–.001
1937–42	M-766	.0065②	.007③	.0065②	.007③	.026	.013	.0005–.001	.0005–.001

① End gaps shown in the compression ring column are for the top or fire ring only. All other compression rings should be fitted with end gaps as given in the oil ring column. When taking end gap measurements in tapered cylinder bores, do so with the ring at the narrowest point of the bore.

② Piston should pass on shim thickness shown.

③ Piston should lock on shim thickness shown.

ENGINE BEARING SPECIFICATIONS

Year	Engine Model	Camshaft		Connecting Rod			Mains				
		Journal Diameter	Clearance	Journal Diameter	Clearance	Bearing Bolt Tension Lb. Ft.	Journal Diameter	Clearance ①	Bearing Bolt Tension Lb. Ft.	Thrust on No.	End-play
1936–42	GF-638	②	.002–.0035	2.996–2.997	.002–.004	75– 85	2.996–2.997	.002–.004	210–230	7	.004–.008
1936–46	HP-205	2⅛③	.002–.0035	2.1225–2.1235	.002–.003	75– 85	2.996–2.997	.002–.004	125–135	4	.004–.008
1936–46	HP-217	2⅛③	.002–.0035	2.1225–2.1235	.002–.003	75– 85	2.996–2.997	.002–.004	125–135	4	.004–.008
1942–46	HP-234	2⅛③	.002–.0035	2.1225–2.1235	.002–.003	75– 85	2.996–2.997	.002–.004	125–135	4	.004–.008
1936–42	HP-260	2⅛③	.002–.0035	2.1225–2.1235	.002–.003	75– 85	2.996–2.997	.002–.004	125–135	4	.004–.008
1936–42	HP-298	2⅛③	.002–.0035	2.1225–2.1235	.002–.003	75– 85	2.996–2.997	.002–.004	125–135	7	.004.–008
1937–46	HP-326	2⅛③	.002–.0035	2.1225–2.1235	.002–.003	75– 85	2.996–2.997	.002–.004	125–135	7	.004–.008
1942–46	HP-351	2⅛③	.002–.0035	2.1225–2.1235	.002–.003	75– 85	2.996–2.997	.002–.004	125–135	7	.004–.008
1936–39	J-214	2③	.002–.0035	1.9975–1.9985	.0015–.0025	—	2.496–2.497	.0015–.0035	—	7	.004–.008
1936–39	K-325	2¼③	.002–.0035	2.3725–2.3735	.002–.004	95–105	2.996–2.997	.002–.004	150–160	7	.004–.008

ENGINE BEARING SPECIFICATIONS

Year	Engine Model	Camshaft		Connecting Rod			Mains				
		Journal Diameter	Clearance	Journal Diameter	Clearance	Bearing Bolt Tension Lb. Ft.	Journal Diameter	Clearance ①	Bearing Bolt Tension Lb. Ft.	Thrust on No.	End-play
1936–41	K-369	2¼③	.002–.0035	2.3725–2.3735	.002–.004	95–105	2.996–2.997	.002–.004	150–160	7	.004–.008
1936–46	K-393	2¼③	.002–.0035	2.3725–2.3735	.002–.004	95–105	2.996–2.997	.002–.004	150–160	7	.004–.008
1936–46	K-428	2¼③	.002–.0035	2.3725–2.3735	.002–.004	95–105	2.996–2.997	.002–.004	150–160	7	.004–.008
1936–40	L-468	2¼③	.002–.0035	2.3725–2.3735	.002–.004	95–105	2.996–2.997	.002–.004	150–160	7	.004–.008
1936–46	L-525	2¼③	.002–.0035	2.3725–2.3735	.002–.004	95–105	2.996–2.997	.002–.004	150–160	7	.004–.008
1937–40	LO-468	2¼③	.002–.0035	2.3725–2.3735	.002–.004	95–105	2.996–2.997	.002–.004	150–160	7	.004–.008
1937–46	LO-525	2¼③	.002–.0035	2.3725–2.3735	.002–.004	95–105	2.996–2.997	.002–.004	150–160	7	.004–.008
1937–40	M-707	2½	.002–.0035	3.246–3.247	.003–.005	150–160	3.496–3.497	.0025–.0045	④	7	.004–.008
1937–42	M-766	2½	.002–.0035	3.246–3.247	.003–.005	150–160	3.496–3.497	.0025–.0045	④	7	.004–.008

① On all engines except GF-638, the bearing saddle bore is .002″ larger on the horizontal centerline than on the vertical centerline; therefore the figures given are vertical clearances and the horizontal clearances should be .002″ greater.

② No. 1, 2 1/16″. Nos. 2 and 3, 2 1/32″. No. 4, 1⅝″.

③ No. 4 bearing, 1½″.

④ For ⅝″ bolts, 150–160; for ¾″, 210–230.

ENGINE

NOTE—All engines listed in the tables are "Hivelo" models except GF-638. However, the following service instructions apply to all engines except when specified.

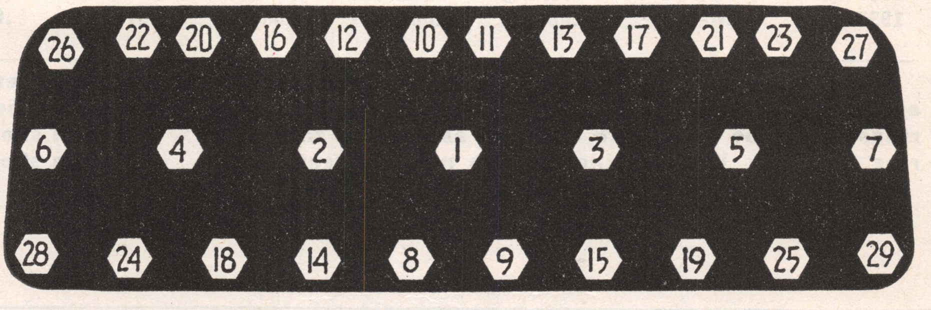
CYLINDER HEAD

1936-46 All: Cylinder heads should be tightened down by starting from the center, working outward toward the sides and to the ends. A typical L-head cylinder head layout is illustrated. Draw down the nuts evenly and repeat the operation until all are normally tight. After the engine has been run sufficiently long to bring all the parts to normal operating temperature, a final tightening should be made.

NOTE—When using a torque indicating wrench, the final tightening should be within the torque values recommended by the wrench manufacturer. If two torque values are shown, use the lower limit for clean and oily threads, and the high limit for clean and dry threads. In any case, the threads should be free from rust or dirt, otherwise a false reading will be obtained due to the increased friction. When the final tightening is made on overhead valve engines, check the valve tappet clearance according to the recommendations given in the VALVE SYSTEM table.

ROCKER ARMS & PUSH RODS

Overhead Valve Engines: When disassembling the rocker shaft assembly, place all parts on the bench in their proper relationship to assure correct assembly. To prevent the possibility of bending or twisting push rods, they should always be removed before taking off the cylinder head, and replaced after the head is installed.



TIGHTENING SEQUENCE. Typical cylinder head layout.

VALVE SEAT INSERTS

1936-46 All: Since these inserts are too hard to reface by the ordinary grinding methods, a high-speed grinding stone or a special lapping tool should be used to perform this operation. When using this equipment, be sure valve guides are clean and the valve guide pilot is a snug fit in order to assure a concentric finish. Finished seats should be checked with a dial indicator and run-out should not exceed .0005″.

To remove and install inserts, special puller and driver equipment is available. However, if these tools are not procurable, the following method may be used:

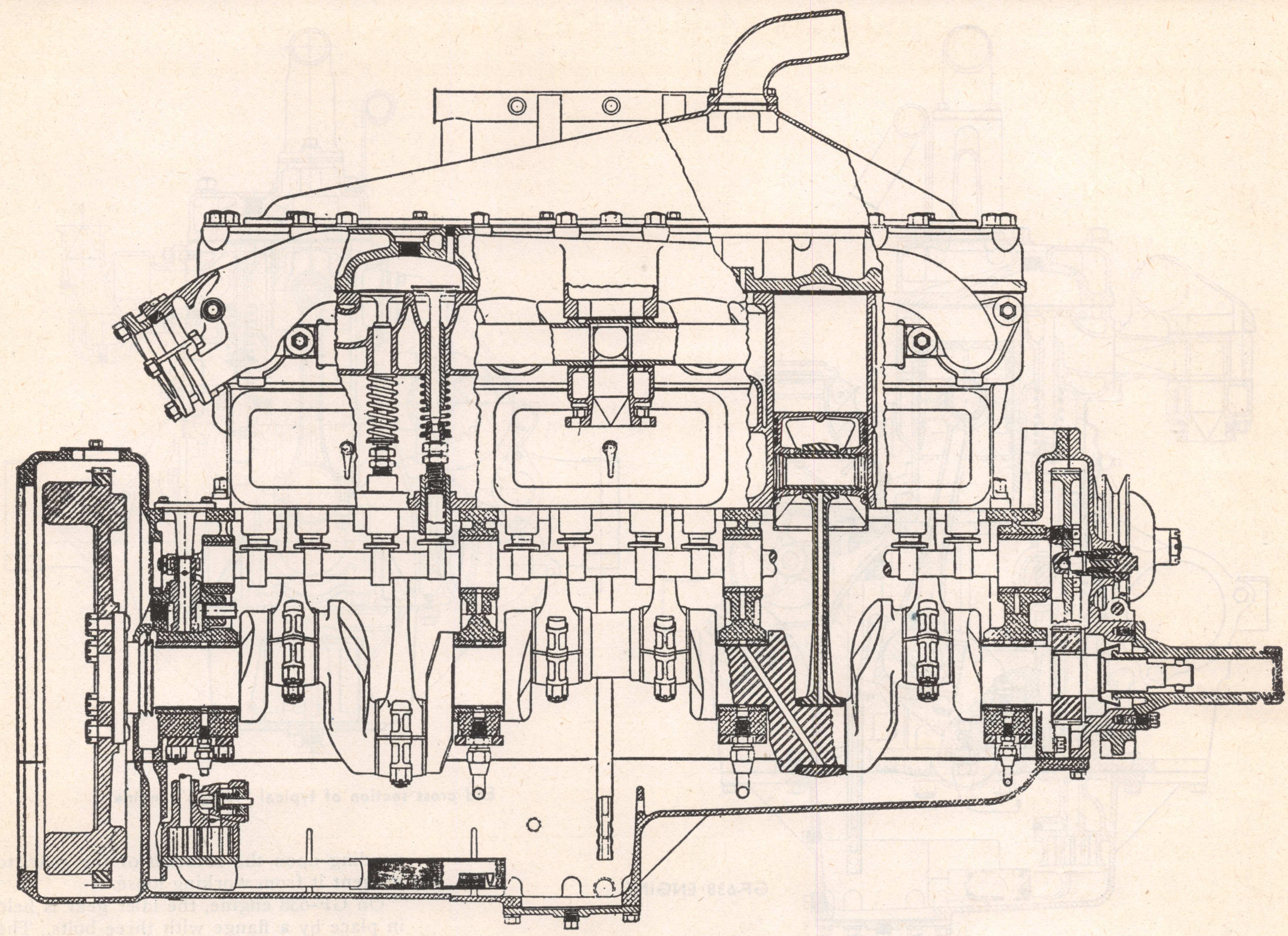
To remove an insert, use a drill which is smaller in diameter than the width of the insert and drill two holes at opposite sides, but not all the way through. Cut through the undrilled portion of the insert with a sharp chisel and remove the two pieces.

To install an insert, pack in "dry ice" for at least fifteen minutes to allow the metal to contract, and heat the valve port area gradually, if necessary, to permit this material to expand. Then press or drive the insert into the cylinder block or head, as the case may be, using extreme care to see that it is not cocked or misaligned. When installed, finish the seats with the grinding or lapping equipment already mentioned.

VALVE SPRINGS, REMOVE

1936-46 All: On L-head engines, when removing the valve spring split tapered locks, care should be used to prevent these locks from dropping into the oil pan.

Overhead Valve Engines: Valve springs can be changed on these engines without removing the cylinder head. When removing any spring, be sure to bring that piston up on top center to prevent the valve from dropping into the cylinder. Depress the end of the rocker arm over the valve until the push rod can be removed from its socket. Then compress the valve spring, remove the spring retainer and lift off the spring.



GF-638 ENGINE.

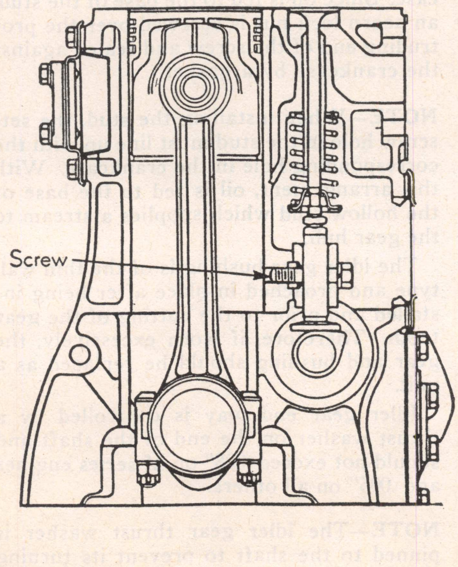
NOTE—To prevent the valve from dropping into the cylinder, as in the case of a broken valve spring or valve stem end, a snap ring is fitted into the groove in the valve stem on late production of these engines.

VALVE STEM GUIDES

1936-46 All: When necessary to replace **guides on L-head engines, remove the tappet and guide cluster assemblies, take out the valves and use a suitable puller to take out the guides.**

On overhead valve engines, remove the cylinder head and take off the rocker shaft assembly, remove the valves and springs and pull out the guides.

NOTE—On all engines, it is good practice to remove and install one guide at a time. When installing an intake guide, measure the depth of an intake guide not yet removed in order to determine the correct depth of the guide being installed. Similarly, when installing an exhaust guide, measure the depth of an exhaust guide not yet removed. When all guides are installed, they should be reamed to provide a clearance within the limits given in the VALVE SYSTEM table. It is recommended that the guides be drawn in place rather than driven.



"HIVELO." See text for precaution relative to tappet cluster capscrews.

VALVE TAPPETS & GUIDES

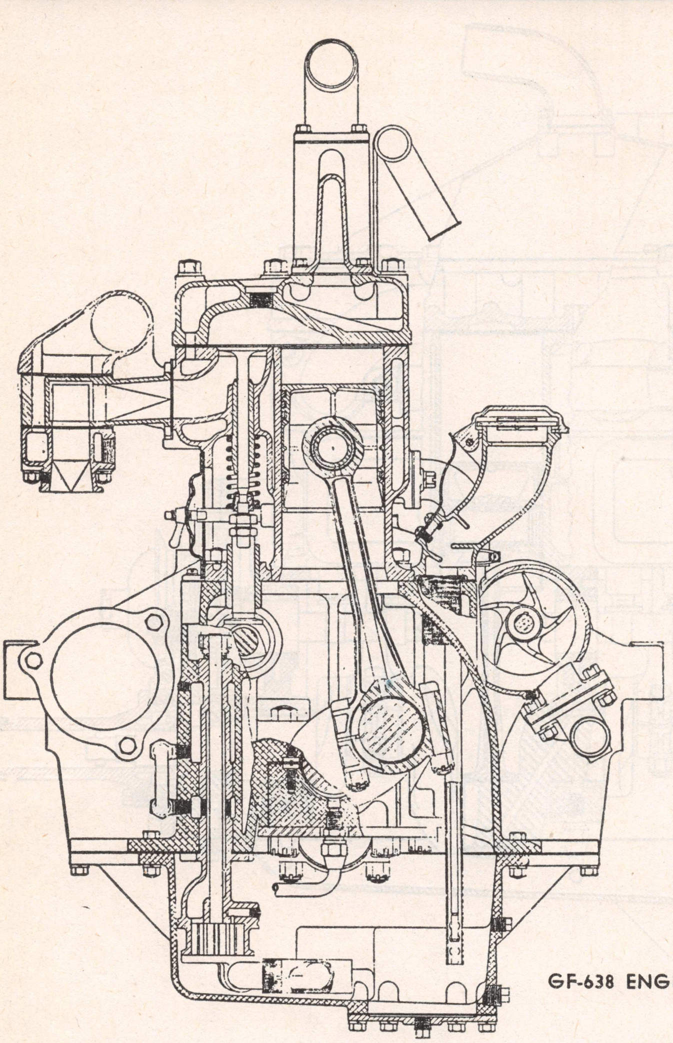
1936-46 All: Tappets must be a free fit in their guides without **excessive side play.**

NOTE—On all "Hivelo" L-head engine. sleeve dowels are used over the attaching screws to align the tappet cluster brackets in the cylinder block and it is important that they be in place when assembling.

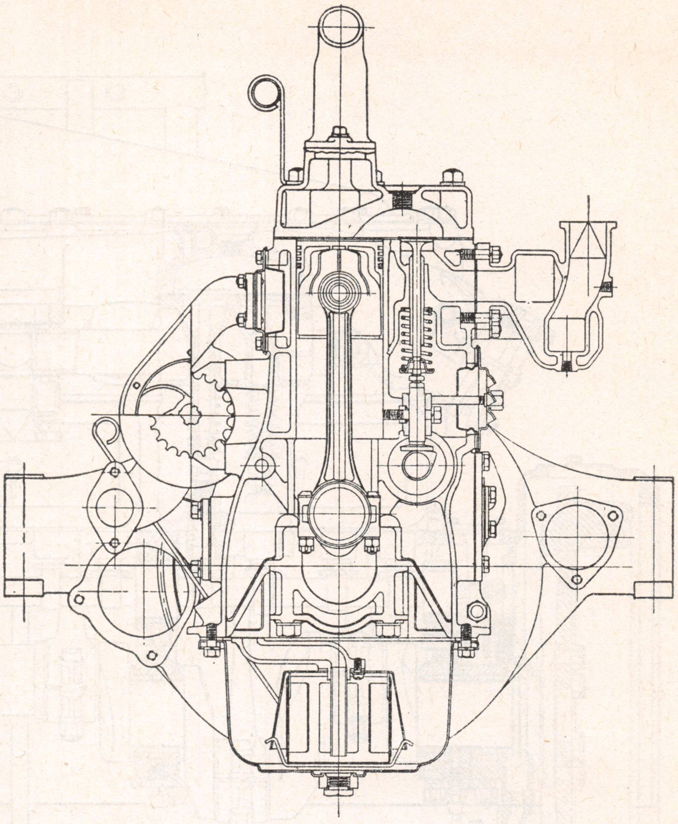
CAUTION—On the above-mentioned engines, the opening for the screws which hold the tappet clusters in place opens into the cylinder bores. If for any reason any of these capscrews are to be replaced, be sure that screws of exactly the same length are used, otherwise, if too long, may result in a broken piston.

VALVE TIMING, CHECK

1936-46 All: With the engine at normal room temperature and No. 1 intake valve tappet set to the clearance for timing as given in the VALVE SYSTEM table, crank the engine until the "IN. OP. 1 & 6" mark on the GF-638 flywheel or the "I. O." (intake opens) mark on all "Hivelo" model flywheels, is in line with the center of the opening in the flywheel housing. **In this position, No. 1 intake valve should just be starting to open.**



GF-638 ENGINE.



End cross section of typical "Hivelo" engine.

TIMING GEARS

1936-46 All: Whenever these gears are removed for any reason, it is important that they be assembled so that the marked teeth on the crankshaft, camshaft and idler gears are meshed at the same time. If the gears are not marked, the correct assembly may be made in the manner described further along in this chapter under "Camshaft Timing".

Replacement Gears: These gears are marked with a number imposed within a circle or a letter U. If marked with a number 2 within a circle, it signifies that the gear is .002" oversize. If marked with a number 3 within a U, it denotes a .003" undersize gear.

Fitting Gears: The crankshaft, camshaft and idler gears should be fitted with .002" backlash. When replacing one gear, use the size marking on the old gear, making allowance for wear on the others. The accessory drive gear may have considerably more lash than .002" and therefore, it need not be replaced as often as the others.

Idler Gear: On all "Hivelo" engines, this gear rotates on a stud which is pressed in the crankcase. On M series engines, this stud is secured by a slotted nut on the inside of the case. On all other models, the stud is secured by means of a lockscrew which is entered into the right side of the case. Since oil is fed to the base of the stud, an acorn lock nut is screwed over the protruding end of the screw and sealed against the crankcase by a gasket.

NOTE—When installing the stud, the setscrew hole in the stud must line up with the corresponding hole in the crankcase. With this arrangement, oil is fed to the base of the hollow stud which supplies a stream to the gear hub.

The idler gear bushing is of the thin wall type and broached in place after being installed and prior to the cutting of the gear teeth. Therefore, if worn excessively, the gear and bushing should be replaced as a unit.

Idler gear end play is controlled by a thrust washer on the end of the shaft and should not exceed .008" on M series engines and .006" on all others.

NOTE—The idler gear thrust washer is pinned to the shaft to prevent its turning and secured by a capscrew. This capscrew has either a right or left-hand thread, depending upon the rotation of the gear, to prevent it from working loose.

On GF-638 engine, the idler gear is held in place by a flange with three bolts. The gear is the spoke type which, when an adjustment for lash is required, a wrench may be inserted in between the spokes to obtain the desired result.

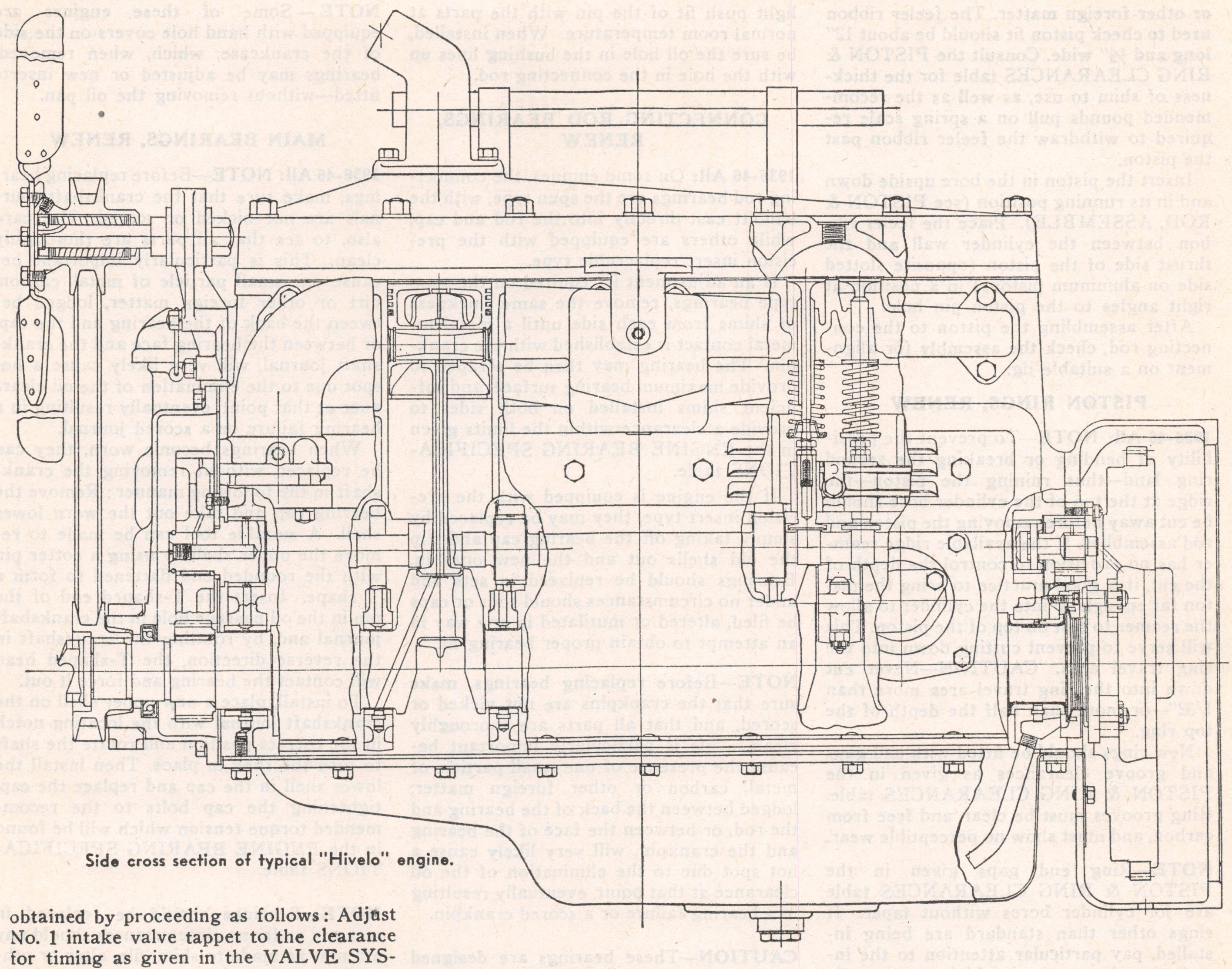
Camshaft Gear: On all "Hivelo" models, the camshaft end thrust is controlled by a thrust plate attached to the front end of the crankcase, between the front face of the front camshaft bearing and the rear of the camshaft gear hub. On GF-638 engine, end thrust is controlled by a thrust screw at the front of the shaft.

On M series engines, the gear is keyed and held in place by a retaining washer and slotted nut. On all other "Hivelo" models, the gear is pressed on the shaft and retained by a spring wire lock, which snaps in a groove in the end of the shaft. When installing a gear of the pressed-on type, allow from .004" to .008" end play.

On the GF-638 engine, the gear is fastened to the camshaft by screws and the screw holes are unevenly spaced to prevent the possibility of installing the gear incorrectly.

Crank Gear: When installing, heat the gear in boiling water to expand the metal and coat the shaft with white lead in order to make assembly easier.

Camshaft Timing: If the gears are not marked, the correct valve timing may be



Side cross section of typical "Hivelo" engine.

obtained by proceeding as follows: Adjust No. intake valve tappet to the clearance for timing as given in the VALVE SYSTEM table and crank the engine until the "IN. OP 1 & 6" mark on GF-638 flywheels, or the "I. O." (intake opens) mark on all "Hivelo" models is in line with the center of the opening in the flywheel housing. Then turn the camshaft in the direction of rotation when the engine is operating, until No. 1 intake valve tappet can just be turned with the fingers, which is the correct position for the installation of gears. Because of the angle of the gear teeth, an allowance of approximately two teeth must be made when pressing the gear in place.

NOTE—When the gears are installed, but before replacing the gear cover, check the valve timing as follows: Turn the flywheel until the exhaust valve opens and then closes. At the closing point, the "E. C." (exhaust closes) mark on the flywheel should be in the center of the opening in the flywheel housing.

CAMSHAFT & BEARINGS

1936-46 All: Camshaft end thrust is controlled by a thrust plate located between the front face of the front camshaft bearing and the rear of the camshaft gear hub. End play should be held within from .005" to .008" and can be checked by forcing the shaft back to the limit of its end play and inserting a feeler gauge between the thrust plate and the front end of the shaft.

When necessary to replace bearings, they should be installed in sets and line-reamed to provide a clearance within the limits given in the ENGINE BEARING SPECIFICATIONS table.

PISTONS & RODS, REMOVE

1936-46 All: Pistons and connecting rods are removed from the top of the block on all engines except GF-638 which are removed from the bottom. Although regular production rods are marked with the cylinder number in which they are installed, replacement rods are not; therefore, unmarked rods should be suitably identified with punch-marks, as removed.

PISTONS & RODS, ASSEMBLE

1936-46 All: If the engine is equipped with aluminum pistons of the slotted type, they should be assembled to the rods so that when installed in the cylinder bores, the slotted side of the piston should face away from the camshaft.

PISTONS, RENEW

1936-46 All: NOTE—A variation of 10 degrees between the temperature of the pistons and cylinder bores is sufficient to produce a difference of .0005". Therefore, both the pistons and cylinder bores should be at normal room temperature (about 70 degrees) when fitting pistons. This is particularly important because the clearances given in the PISTON & RING CLEARANCES table are minimum and pistons must not be fitted with less than specified.

Before any attempt is made to fit new pistons, cylinder bores should be carefully indicated and refinished. If bores do not require refinishing, be sure to remove the ridge at the top of each bore. If refinishing is required, it is good practice to do so in alternate cylinders due to the localized temperature build-up. Cylinder bores should not be out-of-round or tapered more than .0005".

Before fitting pistons, wipe the cylinder walls and pistons to remove all chips, dirt or other foreign matter. The feeler ribbon used to check piston fit should be about 12" long and ½" wide. Consult the PISTON & RING CLEARANCES table for the thickness of shim to use, as well as the recommended pounds pull on a spring scale required to withdraw the feeler ribbon past the piston.

Insert the piston in the bore upside down and in its running position (see PISTON & ROD, ASSEMBLE). Place the feeler ribbon between the cylinder wall and the thrust side of the piston (opposite slotted side on aluminum pistons) in a position at right angles to the piston pin hole.

After assembling the piston to the connecting rod, check the assembly for alignment on a suitable jig.

PISTON RINGS, RENEW

1936-46 All: NOTE—To prevent the possibility of bending or breaking the second ring land—thus ruining the piston—the ridge at the top of the cylinder bore should be cut away before removing the piston and rod assemblies. If the available ridge reamer has no provision to control the depth of the cut, it is good practice to bring the piston far enough up into the cylinder to allow the reamer to rest on top of the piston. This will serve to prevent cutting down into the ring travel area. CAUTION—Never cut down into the ring travel area more than 1/32"—or more than half the depth of the top ring.

New rings should be fitted with end gaps and groove clearances as given in the PISTON & RING CLEARANCES table. Ring grooves must be clean and free from carbon, and must show no perceptible wear.

NOTE—Ring end gaps given in the PISTON & RING CLEARANCES table are for cylinder bores without taper. If rings other than standard are being installed, pay particular attention to the installation instructions which are usually included in the ring package. This applies to clearances, position in grooves, etc.

When rings are properly fitted to the pistons, be sure to stagger the ring gaps so they are spaced equal distances around the circumference of the piston. However, see that no gaps are over the piston pins.

PISTON PINS, RENEW

1936-46 All: The correct fit of piston pins in cast iron pistons should be one which requires a light push with the palm of the hand to insert the pin. For aluminum pistons, at normal room temperature, it should require a light tap fit with a rubber mallet to install the pin. However, to facilitate fitting pins in aluminum pistons, heat the piston in boiling water for a few minutes, after which the pin should enter the piston easily.

These pins are of the full-floating type, being held in place by snap rings in the grooves of the piston bosses.

PISTON PIN BUSHINGS, RENEW

1936-46 All: New bushings should be pressed in place and reamed to provide a light push fit of the pin with the parts at normal room temperature. When installed, be sure the oil hole in the bushing lines up with the hole in the connecting rod.

CONNECTING ROD BEARINGS, RENEW

1936-46 All: On some engines, the connecting rod bearings are the spun type, with the babbitt cast directly into the rod and cap, while others are equipped with the precision insert replaceable type.

If an adjustment is required on the spun type bearings, remove the same thickness of shims from each side until a metal-to-metal contact is established with the crankpin. The bearing may then be scraped to provide maximum bearing surface, and sufficient shims installed on both sides to provide a clearance within the limits given in the ENGINE BEARING SPECIFICATIONS table.

If the engine is equipped with the precision insert type, they may be replaced by simply taking off the bearing cap and slip the old shells out and the new ones in. Bearings should be replaced in sets and under no circumstances should rods or caps be filed, altered or mutilated in any way in an attempt to obtain proper bearing fit.

NOTE—Before replacing bearings, make sure that the crankpins are not nicked or scored, and that all parts are thoroughly clean. This is particularly important because the presence of one small particle of metal, carbon or other foreign matter, lodged between the back of the bearing and the rod, or between the face of the bearing and the crankpin, will very likely cause a hot spot due to the elimination of the oil clearance at that point, eventually resulting in a bearing failure or a scored crankpin.

CAUTION—These bearings are designed for use without shims and under no circumstances should shims be used in an attempt to obtain a bearing fit, because the proper "crush" fit of the bearings in the connecting rod bores will not be obtained.

To check the fit of new bearings, use a piece of brass shim stock ¼" wide, the length of which should be ¼" less than the length of the bearing, while the thickness should be approximately the same as the minimum allowable clearance.

CAUTION—To avoid damaging the bearing material, smooth down the edges of the shim stock on an oil stone so that no sharp edges remain. Install the shim between the bearing and the crankpin, in the center of the bearing, then tighten the cap bolts to the recommended torque tension. When fitted properly, it should not be possible to move the rod endwise by hand, but a light tap with a hammer should cause the rod to move endwise. Then remove the checking shim and re-install the cap, tightening the cap bolts with a torque wrench, after which the rod should move endwise by hand. If the rod is too loose with the checking shim in place, the crankpin should be turned down and undersize bearings fitted.

NOTE—Some of these engines are equipped with hand hole covers on the side of the crankcase, which, when removed, bearings may be adjusted or new inserts fitted—without removing the oil pan.

MAIN BEARINGS, RENEW

1936-46 All: NOTE—Before replacing bearings, make sure that the crankshaft journals are not nicked or scored. Use care also, to see that all parts are thoroughly clean. This is particularly important because one small particle of metal, carbon, dirt or other foreign matter, lodged between the back of the bearing and the cap, or between the bearing face and the crankshaft journal, will very likely cause a hot spot due to the elimination of the oil clearance at that point, eventually resulting in a bearing failure or a scored journal.

When bearings become worn, they can be replaced without removing the crankshaft in the following manner: Remove the bearing cap and take out the worn lower shell. A suitable tool can be made to remove the upper shell by using a cotter pin with the rounded end flattened to form a T shape. Insert the T-shaped end of the pin in the oil passage hole in the crankshaft journal and, by rotating the crankshaft in the reverse direction, the T-shaped head will contact the bearing and force it out.

To install, place a new upper shell on the crankshaft journal with the locating notch in the correct position and rotate the shaft to turn the shell in place. Then install the lower shell in the cap and replace the cap, tightening the cap bolts to the recommended torque tension which will be found in the ENGINE BEARING SPECIFICATIONS table.

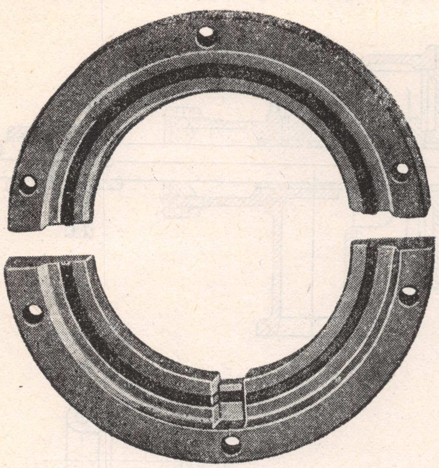
NOTE—Bearings should be replaced in sets and under no circumstances should any attempt be made to shim, file, alter or otherwise mutilate the bearing caps to obtain proper bearing fit.

To check the fit of new bearings, use a piece of brass shim stock ¼" wide, the length of which should be ¼" less than the length of the bearing, while the thickness should be about the same as the minimum allowable clearance.

CAUTION—To avoid damaging the bearing material, smooth down the edges of the shim stock to remove sharp edges or turned over corners. And before inserting it in place, coat the shim on both sides with a light film of engine oil.

Then lay the shim lengthwise in the center of the bearing and install the bearing cap to the crankshaft, tightening the cap bolts to the recommended torque tension which can be found in the ENGINE BEARING SPECIFICATIONS table. Test the fit of the bearing by rocking the flywheel through an arc of 2"—not more than 1" in either direction. The bearing may be considered fitted properly if the shaft is movable with a fairly heavy drag.

NOTE—Remove the shim and replace the cap, but do not tighten the cap bolts, as this



Crankshaft rear oil seal installation.

bearing must be loose in order to check the fit of the other bearings. It is good practice to fit bearings by starting at the center—or one of the intermediates on a four bearing job—then the rear bearing, front bearing, and finally, the intermediates.

CRANKSHAFT END THRUST

1936-46 All: Crankshaft end thrust in controlled by flanges on the rear main bearing. Through normal wear, the end play will seldom become excessive but whenever new bearings are fitted, the clearance should be carefully checked and, if required, the bearing flanges may be dressed down to obtain the desired end play.

CRANKSHAFT OIL SEALS

1936-46 All: Whenever the front or rear bearing caps are replaced, be sure that the cork fillers which fit into the milled slots in the caps are properly installed to prevent an oil leak.

If the standard cork fillers are not available, use woolen yarn in the grooves, calking it firmly in place, using a small drift and hammer, pounding the yarn gradually up into the grooves until fully packed.

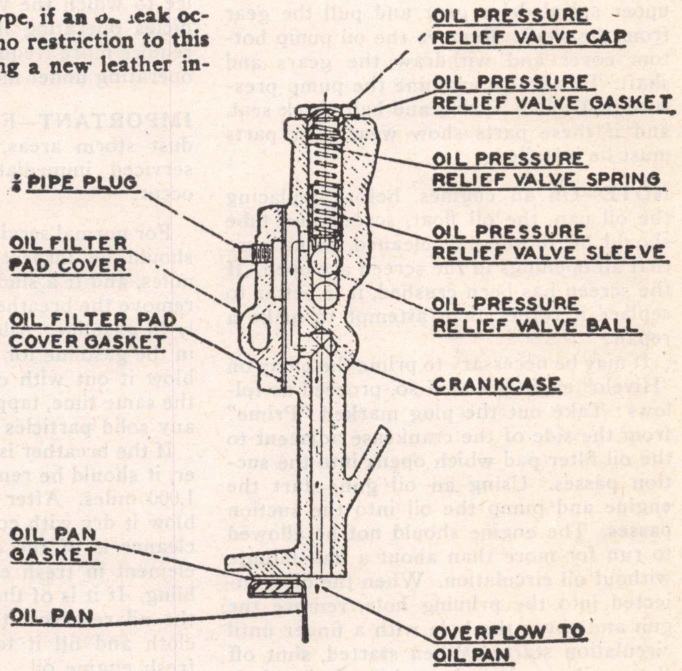
The rear main bearing oil seal consists of a split aluminum disc bolted to the rear end of the crankcase and two types are used. One type has a leather insert which contacts the oil slinger on the crankshaft. The other type has a groove which catches the oil thrown from the slinger, permitting the oil to drain back into the oil pan through the bearing cap.

With both types, the oil thrown off by the slinger drains down into the reservoir in the bearing cap and then through a tube to the oil level in the pan.

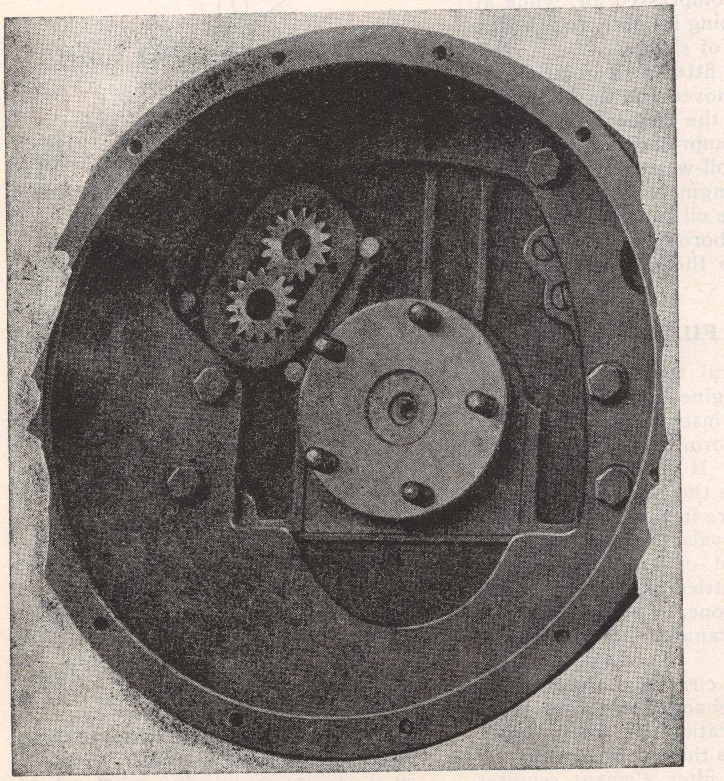
NOTE—With either type, if an oil leak occurs, be sure there is no restriction to this oil return. When fitting a new leather insert, the lower portion of the leather should be trimmed flush with the seal to prevent an air lock. In other words, the leather in the lower half of the seal should be trimmed ¾″ in either direction of the lowest point of the seal—at the drain tube position. When replacing the leather wiper, apply shellac or gasket cement to hold it securely in place.

FLYWHEEL & HOUSING

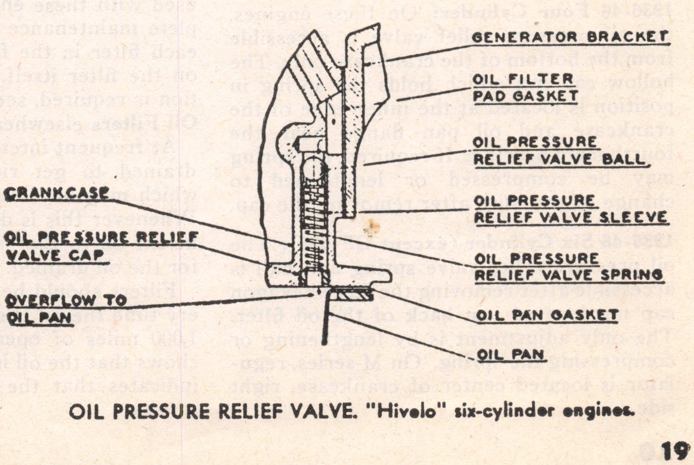
1936-46 All: Whenever replacing the flywheel, it should be checked for wobble or excessive run-out. If a dial indicator is available, mount it on the flywheel housing and allow its stem to contact the flywheel as the engine is being turned slowly. Make a note of the high and low sides of the flywheel through one complete revolution and if run-out exceeds .010″, it should be removed and the crankshaft flange recess inspected for burrs, dirt or other foreign matter.


OIL PRESSURE RELIEF VALVE CAP
OIL PRESSURE RELIEF VALVE GASKET
OIL PRESSURE RELIEF VALVE SPRING
OIL PRESSURE RELIEF VALVE SLEEVE
OIL PRESSURE RELIEF VALVE BALL
CRANKCASE
½ PIPE PLUG
OIL FILTER PAD COVER
OIL FILTER PAD COVER GASKET
OIL PAN GASKET
OIL PAN
OVERFLOW TO OIL PAN

OIL PRESSURE RELIEF VALVE. "Hivelo" four-cylinder engines.



OIL PUMP. "Hivelo" engines.


GENERATOR BRACKET
OIL FILTER PAD GASKET
OIL PRESSURE RELIEF VALVE BALL
OIL PRESSURE RELIEF VALVE SLEEVE
OIL PRESSURE RELIEF VALVE SPRING
OIL PAN GASKET
OIL PAN
CRANKCASE
OIL PRESSURE RELIEF VALVE CAP
OVERFLOW TO OIL PAN

OIL PRESSURE RELIEF VALVE. "Hivelo" six-cylinder engines.

ENGINE OILING

OIL PUMP

1936-46 All: With the engine operating at normal temperature, oil pressure should be about 30 pounds at normal engine speeds. Clearance between the pump body and the gear on any one side should not exceed .002". Backlash between gears, not more than .002". The face of the gears should be flush with the pump cover.

On all "Hivelo" engines, the pump is located in a recess in the flywheel end of the crankcase. After removing the flywheel, the pump is accessible for inspection by simply removing the cover. If, after inspection, the pump is to be removed, take out the four cap screws which fasten the assembly to the crankcase and withdraw the pump.

On GF-638 engines, the pump is easily removed for inspection or repairs after taking down the oil pan. To disassemble the pump, drive the pin out of the hub of the upper spiral drive gear and pull the gear from the shaft. Remove the oil pump bottom cover and withdraw the gears and shaft. Be sure to examine the pump pressure ball check, spring and ball check seat, and if these parts show wear, new parts must be installed.

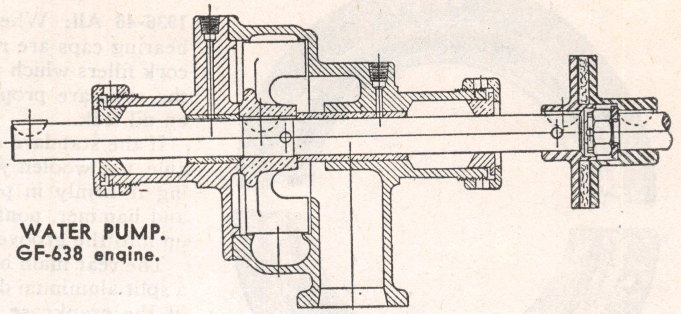
NOTE—On all engines, before replacing the oil pan, the oil float, screen and tube should be thoroughly cleaned, being sure that all openings in the screen are open. If the screen has been crushed, it is better to replace it rather than attempt to make a repair.

It may be necessary to prime the pump on "Hivelo" engines and if so, proceed as follows: Take out the plug marked "Prime" from the side of the crankcase adjacent to the oil filter pad which opens into the suction passes. Using an oil gun, start the engine and pump the oil into the suction passes. The engine should not be allowed to run for more than about a half-minute without oil circulation. When the oil is injected into the priming hole, remove the gun and cover the hole with a finger until circulation starts. When started, shut off the engine and replace the priming hole plug.

OIL PRESSURE REGULATOR

1936-46 Four Cylinder: On these engines, the oil pressure relief valve is accessible from the bottom of the crankcase only. The hollow cap nut which holds the spring in position is located at the inner edge of the crankcase and oil pan flange near the fourth main bearing. If required, the spring may be compressed or lengthened to change oil pressure after removing the cap.

1936-46 Six Cylinder (except GF-638): The oil pressure relief valve spring and ball is accessible after removing the large hexagon cap nut located just back of the oil filter. The only adjustment is by lengthening or compressing the spring. On M series, regulator is located center of crankcase, right side.



WATER PUMP.
GF-638 engine.

GF-638: The relief valve is located in the pump body. See "Oil Pump" chapter for service. Late production engines, the relief valve is located on the right side of the engine, toward the rear.

CRANKCASE VENTILATOR

1936-46 All: The interval at which the ventilator and air cleaner should be cleaned can only be determined by the type of service to which the vehicle is subjected. Vehicles operating in dusty or sandy areas require more frequent service than vehicles operating under more favorable conditions.

IMPORTANT—For vehicles operating in dust storm areas, the cleaner should be serviced immediately after such storms occur.

For normal service however, the breather should be inspected at least every 2,000 miles, and if a sludge formation is evident, remove the breather and clean it thoroughly in gasoline. Allow the breather to soak in the gasoline for at least 30 minutes, then blow it out with compressed air, while at the same time, tapping it lightly to dislodge any solid particles of sludge.

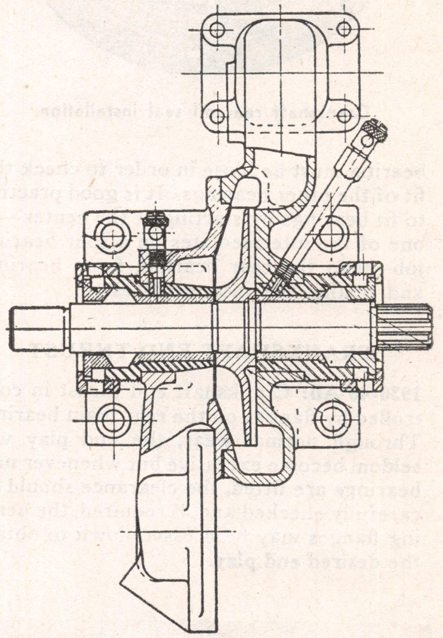
If the breather is fitted with an air cleaner, it should be removed and washed every 1,000 miles. After the element is washed, blow it dry with compressed air and, if the cleaner is of the oil-wetted type, dip the element in fresh engine oil before assembling. If it is of the oil bath type, wipe out the oil reservoir thoroughly with a clean cloth and fill it to the proper level with fresh engine oil.

OIL FILTER

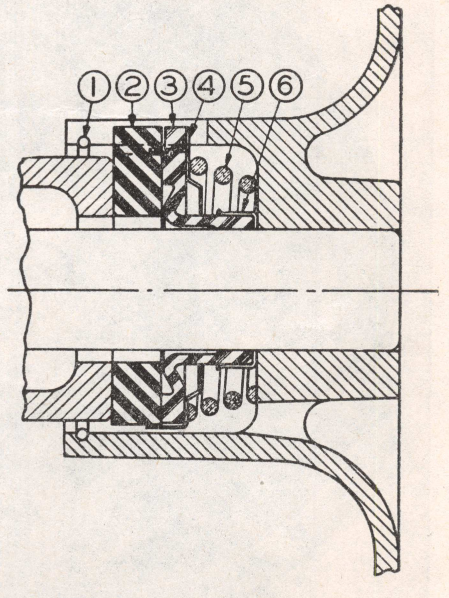
1936-46 All: Several types of filters are used with these engines and usually, complete maintenance instructions accompany each filter in the form of a sticker pasted on the filter itself. If additional information is required, see the chapter devoted to **Oil Filters** elsewhere in this book.

At frequent intervals, the filter should be drained to get rid of any solid matter which may have settled in the filter sump. Whenever this is done, be sure to add sufficient oil to the crankcase to compensate for the oil drained.

Filters should be cleaned thoroughly every time the oil is changed and after every 1,000 miles of operation. If the dip stick shows that the oil is thick and very dirty, it indicates that the filter element requires service.



PACKING TYPE WATER PUMP.
"Hivelo" engines.



SPRING GLAND PACKING PUMP.
"Hivelo" engines.

1—Lock wire. 2—Carbon disc. 3—Flexible seal. 4—Brass shield. 5—Seal spring. 6—Brass shield.

COOLING SYSTEM

WATER PUMP, OVERHAUL

1936-46 All (except HP): The pump used on these engines is of the conventional packing gland type. The pump shaft is supported in the body by two bronze bushings and packed with ring packing.

This type pump is easily disassembled by separating the pump housing, and when this is done, the internal parts are accessible and readily removed. If new bushings are to be installed, they should be reamed to provide a shaft clearance of from .002" to .003". When tightening the gland nuts, tighten only sufficiently to stop leakage and back off slightly to relieve the pressure.

HP Series: This pump is of the spring gland or packingless type. Water sealing is accomplished by a non-adjustable packless seal, consisting of a carbon disc, flexible seal, seal spring and brass shields.

NOTE—The water pump impeller is keyed and secured on the shaft by a spring wire retainer in a groove in the end of the shaft. Before disassembling the pump, be sure to remove the burrs from the ends of the shaft to prevent damage to the pump bushings.

To disassemble the pump, disconnect the pump body from the drive housing. Use a suitable puller to remove the impeller from the shaft. Insert a screw driver through one of the slots in the impeller hub and press the snap ring out of the groove, after which, take out the seal parts.

When assembling, be sure the oil retainer is in the proper position in the pump housing. When installing the shaft, do not push it in any farther than necessary to assemble the impeller to avoid damaging the seal parts.

ENGINE WATER THERMOSTAT

Thermostats are not furnished as standard equipment but if the engine being serviced is equipped with one, and it fails to function properly, remove the assembly from the water outlet and see if the bellows and valve are in good condition. If they are, test its operation by completely submerging in water, heating the water gradually until it reaches the opening temperature of the thermostat, and then in water at the fully open temperature.

When taking temperature readings, agitate the water thoroughly, and if the thermostat fails to function properly, it should be replaced rather than attempt to make a repair. However, before installing a new unit, it is good practice to make a test as directed above.

Normally, the thermostat should start to open at from 145 to 150 degrees and be fully open at from 170 to 175 degrees F. However, thermostats are available which have lower, as well as high opening temperatures, depending upon the climatic conditions under which the vehicle is operating.

FUEL SYSTEM

NOTE—For service information on Carburetors, Automatic Chokes, Governors, Fuel Pumps, Air Cleaners and Gasoline Gauges, see the Table of Contents on page 1.

MANIFOLD HEAT CONTROL

1936-46: On all "Hivelo" engines, the manifold heat is controlled automatically by casting the intake and exhaust manifolds in one piece, thereby eliminating the necessity of a manual control.

On GF-638 engine, manifold heat is controlled by an intake riser having fixed openings and no provision for seasonal settings.

ELECTRIC SYSTEM

NOTE—For service information on Distributors, Magnetos, Generators, Generator Controls, Starting Motors and Starter Controls, see the Table of Contents on page 1.

IGNITION TIMING

1936-46: Instructions for ignition timing will differ slightly with different makes of electrical equipment, and the following instructions are to be considered general. Firing order on all six-cylinder engines is 1-5-3-6-2-4, and 1-3-4-2 on four-cylinder engines.

With battery ignition, crank the engine to bring No. 1 piston up on its compression stroke and stop when the "TDC" mark is ½" past the center of the inspection hole in the flywheel housing. In this position, the points should be just starting to open, with the spark retarded and the distributor rotor in the No. 1 firing position.

With magneto ignition, bring No. 1 piston up to its firing position—as with battery ignition. Loosen the coupling connection between the magneto shaft and the engine shaft. Take off the breaker and distributor covers. Move the advance arm to the retarded position. Then turn the magneto in the direction of its rotation until the points just begin to open, being sure the rotor is in line with the proper segment to distribute spark to No. 1 cylinder. With the magneto in this position, connect the coupling flanges and replace the breaker and distributor covers.

NOTE—If the magneto is equipped with an impulse coupling, turn the magneto until the coupling trips, then turn it back until the points close, then forward again until the points just open.

The spark may be retarded or advanced to compensate for the grade of fuel being used. Likewise, certain operating conditions may require either more or less spark advance. However, for best performance and fuel economy, the spark setting should be one which will provide smooth engine performance with a slight "ping" on wide-open throttle at comparatively low vehicle speed.

CHEVROLET

Year	Engine Model	Number Cylinders and Valve Arrangement	Bore and Stroke	Displacement Cubic Inches	Compression Ratio	Taxable H. P.	Brake H. P. at R. P. M.	Maximum Torque at R. P. M. Pounds Feet	Oil Capacity Quarts
1936	All	6-I	3 5/16x4	206.80	6.00	26.30	68.5@3200	156@900	5
1937–39	All	6-I	3 1/2x3 3/4	216.50	6.25	29.40	78@3200	170@850	5
1940	Conv.	6-I	3 1/2x3 3/4	216.50	6.25	29.40	78@3200	168@1100	5
	C.O.E.	6-I	3 1/2x3 3/4	216.50	6.25	29.40	80@3100	168@1100	5
1941	Conv.	6-I	3 1/2x3 3/4	216.50	6.50	29.40	90@3300	174@1200	5
	C.O.E.	6-I	3 1/2x3 3/4	216.50	6.50	29.40	90@3100	174@1200	5
	H.D.E.	6-I	3 9/16x3 15/16	235.50	6.62	30.40	93@3100	192@1000	5
1942–46	Conv.	6-I	3 1/2x3 3/4	216.50	6.50	29.40	90@3300	174@1200	5
	C.O.E.	6-I	3 1/2x3 3/4	216.50	6.50	29.40	87@3300	172@1200	5
	Conv. H.D.E.	6-I	3 9/16x3 15/16	235.50	6.62	30.40	93@3100	192@1000	5
	COE HDE	6-I	3 9/16x3 15/16	235.50	6.62	30.40	90@3100	189@1000	5

Serial Number Location—Plate on dash.
Engine Number Location—Right side of cylinder block behind fuel pump.

Conv.—Conventional truck.
C.O.E.—Cab-over-engine.
H.D.E.—Heavy duty engine.

TUNE UP CHART

Year	Engine Model	Firing Order	Spark Plug Gap	Breaker Gap	Cam Angle, Degrees	Timing Mark Location	Spark Timing, Degrees	Tappet Clearance For Running, Hot Int.	Tappet Clearance For Running, Hot Exh.	Tappet Clearance For Timing, Intake	Battery Terminal Grounded
1936	All	153624	.032	.018	35	Flywheel	5BTDC	.007	.014	.006	Negative
1937–46	All	153624	.040	.018	35	Flywheel	5BTDC	.007	.014	.006	Negative

VALVE SYSTEM

Year	Engine Model	Stem Clearance Intake	Stem Clearance Exhaust	Tappet Guide Clearance	Tappet Clearance Running Hot Intake	Tappet Clearance Running Hot Exhaust	Tappet Clearance Timing Intake	Tappet Clearance Timing Exhaust	Valve Spring Pressure Test Free Length, Inches	Valve Spring Pressure Test Pounds at Inches, Length	Valve Seat Angle, Degrees
1936–37	All	.001–.003	.002–.004	.0005–.0025	.006–.008	.013–.015	.006	.013	2 1/4	94–102@1 9/16	30
1938–46	All	.001–.003	.002–.004	.0005–.0025	.006–.008	.013–.015	.006	.013	2 1/8	125–133@1 1/2	30

PISTON AND RING CLEARANCES

Year	Engine Model	Piston Skirt, Inches Top	Piston Skirt, Inches Bottom	Fitting Pistons with Shim and Spring Scale Shim Thickness	Fitting Pistons with Shim and Spring Scale Pounds Pull on Scale	Ring End Gap, Inch ① Compression	Ring End Gap, Inch ① Oil	Ring and Groove, Inch Compression	Ring and Groove, Inch Oil
1936	All	②	②	②	②	.004–.014	.004–.014	.0015–.003	.0015–.0025
1937–46	All	②	②	②	②	.005–.015	.005–.015	.0015–.003	.002–.0035

① Clearances are for cylinder bores without taper. Fit rings in tapered bores with not less than the maximum dimension given in the table.

② Piston should pass on a .002″ feeler and lock on a .003″ feeler.

ENGINE BEARING SPECIFICATIONS

Year	Engine Model	Camshaft		Connecting Rod			Mains				
		Journal Diameter	Clearance	Journal Diameter	Clearance	Bearing Bolt Tension Lb. Ft.	Journal Diameter	Clearance	Bearing Bolt Tension Lb. Ft.	Thrust on No.	End-play
1936	All	①	.002–.004	2.123–2.124	.001–.003	60–65	③	.001–.003	100–110	2	.004–.007
1937–46	All	②	.002–.004	2.311–2.312	.0015–.0035	60–65	④	.0015–.0035	100–110	3	.004–.007

① Front, 1.808″–1.809″. Center, 1.776″–1.777″. Rear, 1.620″–1.621″.

② Front, 2.0282″–2.0292″. No. 2, 1.9657″–1.9667″. No. 3, 1.9032″–1.9042″. No. 4, 1.8407″–1.8417″.

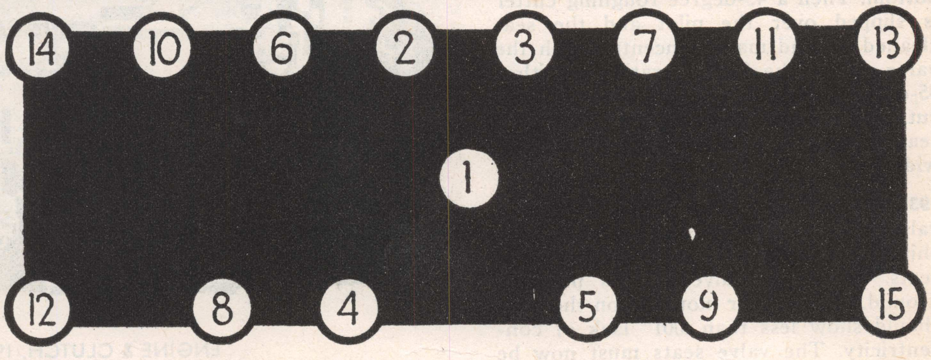
③ Front, 2.058″–2.059″. Center, 2.1205″–2.1215″. Rear, 2.183″–2.184″.

④ Front, 2.6835″–2.6845″. No. 2, 2.7145″–2.7155″. No. 3, 2.7455″–2.7465″. No. 4, 2.7765″–2.7775″.

ENGINE

CYLINDER HEAD

NOTE—The cylinder head gasket must be installed with the side marked "THIS SIDE UP" on top, so that water passage holes and cylinder head bolt holes will line up properly. To align correctly the cylinder head on the cylinder block and keep the cylinder head gasket in place and free from damage, cylinder head guide pins should be used. Cylinder head bolts without heads will do. They should be screwed in holes 13 and 14 as indicated on the cylinder head bolt tightening diagram.



Cylinder Head Tightening Sequence, 1936-46.

1936-46 ALL: Tighten cylinder head bolts in the order shown in the diagram. Draw down evenly and repeat the operation until all are normally tight. After the engine has been run long enough to reach normal operating temperature, the bolts should be given a final tightening.

When using a torque indicating wrench be sure the bolts are free from rust or dirt, otherwise the reading on the wrench will be false, due to the increased friction. In the final tightening, a uniform tension of from 75 to 80 pounds feet is recommended. Always check valve tappet clearance after the final tightening of the cylinder head bolts.

VALVE ROCKER ARMS

1936-40: All engines in this series have three types of rocker arms. The right inclined arms are for intake valves of cylinders 1, 3 and 5. The left inclined arms are for 2, 4 and 6. Exhaust arms are all alike.

The rocker arms come with bushings installed and diamond bored ready for assembly. Worn rocker arm bushings necessitate the replacement of the rocker arms. Worn rocker arm shafts should also be replaced at the same time.

1941-46: These engines have four types of rocker arms that are not interchangeable, one with the other, or with those of previous engines. These rocker arms are unbushed, are diamond bored and the bores are coated with a material which prevents scoring or scuffing during the break-in period. There are two intake and two exhaust rocker arms.

NOTE—Each rocker arm carries an identification number and is installed in the following manner: Rocker arm marked number 1 is for 1-3-5 exhaust; arm number 2, 2-4-6 exhaust; arm number 5, 2-4-6 intake, and arm number 6 is for 1-3-5 intake.

VALVE ROCKER ARM SHAFTS

1936-39: There are two hollow rocker arm shafts, each supported by three pedestals through which the hold down cap screws pass. These screws prevent the rocker arm shaft from turning. A washer is placed under the cap screw head to prevent oil leakage. One end of each rocker arm shaft is closed. The open ends must face each other at the center.

After the rocker arm and shaft assemblies are installed to the cylinder head, assemble the spring on the brass coupling and then place the elbow pipe onto this assembly. Compress the elbow pipe back onto the spring and assemble the brass coupling to the end of the rear shaft, then allow the elbow pipe to come into place on the front shaft. Complete the operation by fastening the coupling nut onto the end of the oil feed pipe.

1940-46: The method of holding these rocker arm shafts is the same as 1939 but a different style oil connector is used. The two rocker arm shafts are joined at the center by a brass oil connector which slips over the end of each shaft. With this type connector, when the rocker assemblies are removed or replaced, they must be handled as one unit. A stamped steel baffle is pressed into the open end of the rear rocker arm shaft. This baffle must be installed in the vertical plane.

VALVE STEM GUIDES

1936-46: Since the diameter of the intake and exhaust valve stems are different, check the clearance in the intake guides with a new intake valve and the exhaust guides with a new exhaust valve.

When installing new guides on 1937-46 engines, drive in the intake guides until they extend above the cylinder head 1$\frac{1}{16}$″. The exhaust guides should be installed so they extend 61/64″ above the head.

When replacing valve guides on 1936 engines, assemble the valve guide collar to the valve guide with the open face toward the cylinder head on the exhaust valves, and with the intake valve spring seat assembled to the guide with its open end up on the intake valve guides.

On all engines, when new guides are installed, they should be reamed to provide a clearance within the limits given in the VALVE SYSTEM table. This can be accomplished by rough-reaming with a .341″ reamer and finishing off with a .343″ reamer.

VALVE SPRING RETAINERS

1941-46: The valve spring is held on the valve stem by a cap and key. Due to the difference in the recess depth of the cap, the **round** valve spring caps must be installed on the intake valves and the **hexagonal** caps on the exhaust valves. Also the valve spring cap **covers** must be installed on the inlet valves only. These covers prevent oil—which might cause smoking when the engine is idling—from flooding the intake valve stems.

VALVE SEAT REFINISHING

1936: Place an expanding pilot in the valve guide and tighten up the nut on the bottom. Then a 45-degree roughing cutter is slipped over the pilot and the seat cleaned up and made concentric with the valve guide. The final operation is with a 45-degree finishing cutter which should cut just enough metal so that the valve seat is smooth, and from 1/16″ to 3/32″ wide.

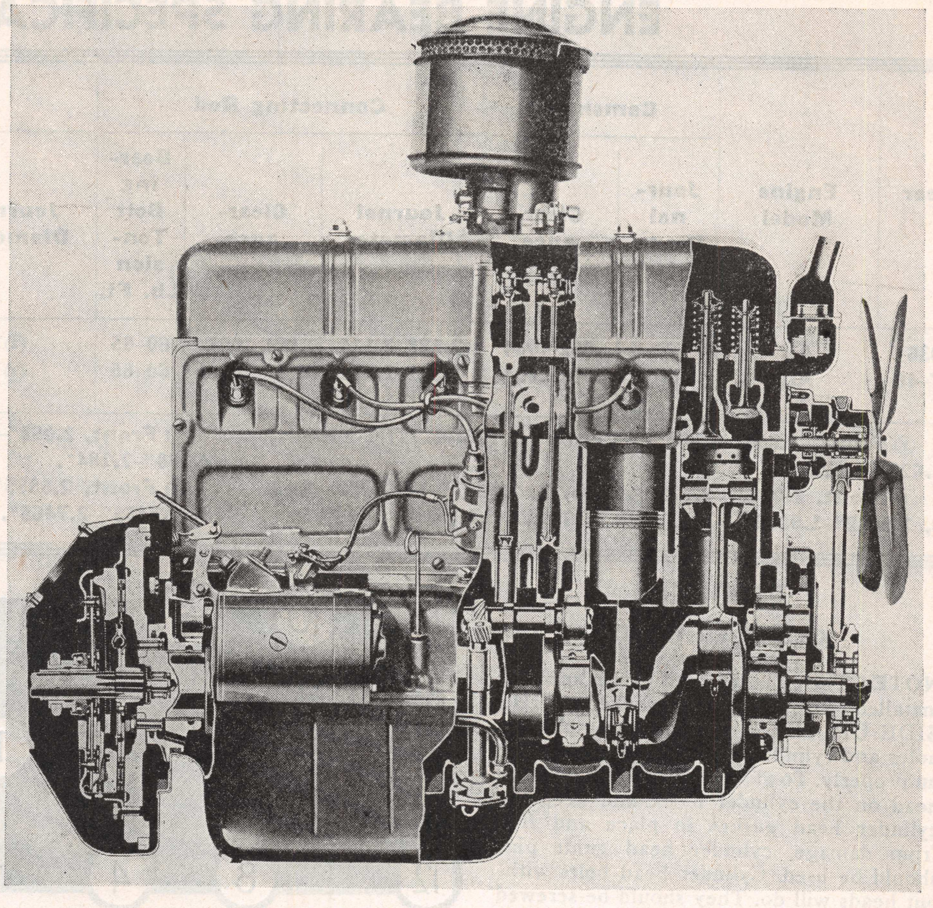
1937-46: All these engines have 30-degree valve seats. A special seat grinding machine is recommended for finishing these seats. After the valve seat is properly ground, an indicator mounted on the pilot should show less than .001″ lack of concentricity. The valve seats must now be narrowed down. The operation is performed by machining both the valve port and the top of the valve seat. A 70-degree grinding wheel is used to open up the port and a form cutter to thin down the seat top. The proper limits for the intake seat width are 3/64″ to 1/16″; for the exhaust 1/16″ to 3/32″.

VALVES, GRIND

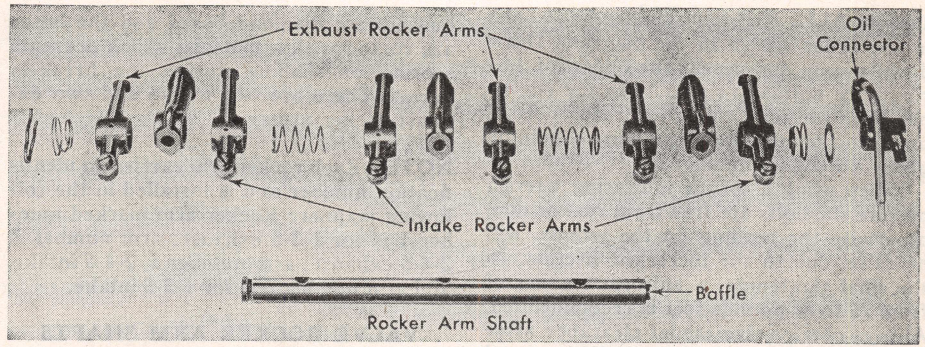
1936-46: When the valves are removed, the valve stems and heads should be cleaned on a buffing wheel to remove all carbon and other foreign matter. Then the condition of the valve head, stem sides and ends can be checked. For quiet operation it is important that the end of the valve stem be free from pits. Put the valve stem on a valve facing machine and grind the end until it is smooth.

VALVE CLEARANCE, ADJUST

1936-46 ALL: After the engine temperature has been normalized, run the engine at idling speed and adjust the valve to rocker arm clearances within the limits given in the VALVE SYSTEM table. The high limit is specifically recommended for truck operation. During the warming up period, it is recommended that the valve stems be well lubricated with light engine oil to prevent valves sticking or to free them if such a tendency is apparent. All cylinder head and manifold bolts should be checked for tightness before adjusting valve clearances.



ENGINE & CLUTCH, 1941-46. 1937-40 are Similar.



Rear Rocker Arm & Shaft Layout. 1940-46.

VALVE LIFTERS & PUSH RODS

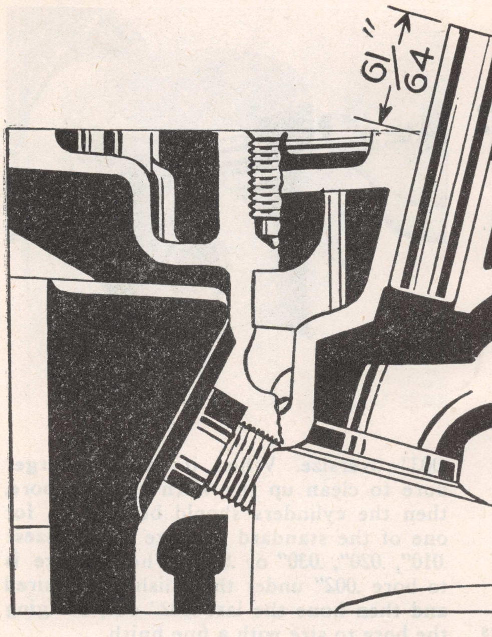
1936-46: Valve lifters should be a free fit in their guides and the end that contacts the camshaft should be smooth. If wear is apparent, replace with new parts.

On 1936-37 engines, push rods are assembled to the engine in groups of six in the following manner: Slip the push rods through the spring retainer, and the push rod springs over the lower end of the rods, holding them in place with the spring retainer keys. Place these assemblies in the engine, being sure the push rods are seated in the bottom of the lifters, and that the spring retainer is fastened securely to the engine.

On 1938-46 engines, the push rod springs and retainers have been discontinued, thereby simplifying service. Just be sure that the push rods are seated in the bottom of the lifters on 1938-39 engines. On 1940-46 engines, the upper part of the lifter has a hardened steel seat brazed into the lifter body.

VALVE TIMING

1936-41: With No. 1 intake valve set to the clearance for timing as given in the VALVE SYSTEM table, crank the engine until No. 1 piston is coming up on its exhaust stroke, and the steel ball in the flywheel is in the position indicated in the following: For 1936-39, intake opens 9 degrees before TDC, or about 2 teeth before the ball. For 1940-41, intake opens 3 degrees before TDC, or about 1 tooth after the ball.



Install Valve Guides as Shown. 1937-46.

At this point No. 1 valve rocker should be tight against the valve stem and the valve about to open.

1942-46: To check the timing, tighten No. 1 exhaust valve adjusting screw to eliminate all clearance. Then crank the engine until No. 1 exhaust valve starts to close. Continue cranking until the **triangular** mark on the flywheel lines up with the pointer on the flywheel housing.

Mount a dial indicator on the rocker shaft support with the indicator spindle bearing on top of the No. 1 exhaust valve adjusting screw. Now set the indicator to read .036", and continue to crank the engine by hand until the indicator hand stops moving. At this point, the indicator should read plus or minus .003". If it does, the camshaft is properly timed in relation to the crankshaft

TIMING GEARS, R&R

1936-46: When necessary to install a new camshaft gear, the camshaft will have to be removed as the gear is a pressed fit on the shaft. The camshaft is held in position by a thrust plate which is fastened to the crankcase by two capscrews which are accessible through two holes in the gear web.

Use an arbor press to remove the gear and when doing so, a suitable sleeve should be employed to support the gear properly on its steel hub.

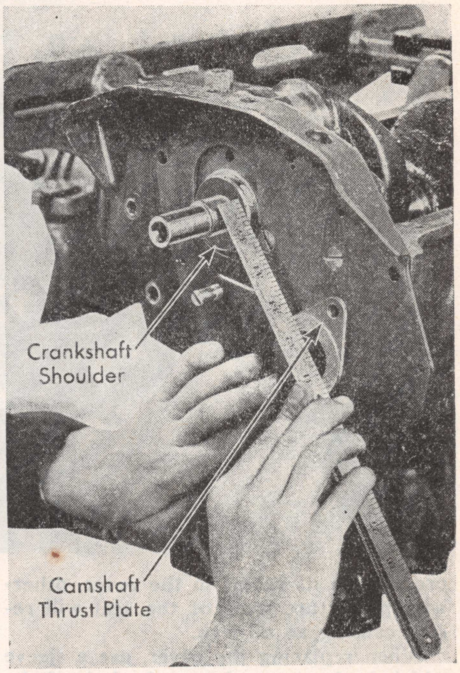
Before installing a new gear, assemble a new thrust plate on the shaft and press the gear on just far enough so that the thrust plate has practically no clearance, yet is free to turn. The correct clearance is from a free fit to a maximum of .003".

The crankshaft gear can be removed by utilizing the two tapped holes in conjunction with a gear puller.

When the timing gears are installed, be sure the punch-marks on both gears are in mesh. Backlash between the gears should be from .002", to .005". Check the run-out of the gears, and if the camshaft gear run-out exceeds .004" or the crank gear run-out is in excess of .003", remove the gear (or gears) and examine for burrs, dirt or some other cause which may cause the run-out. If these conditions are not the cause, replace the gear (or gears).

CRANKCASE FRONT END PLATE

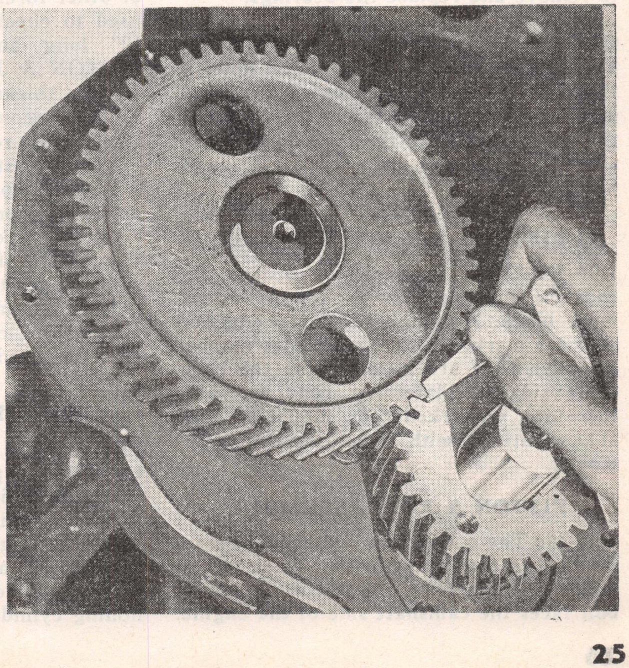
1936-46: This plate is assembled to the cylinder block with from one to three gaskets which are used for the purpose of aligning the timing gears. To check the alignment of the gears, install the front end plate to the block and use two gaskets, holding them in position with three screws. Then use a new, spare, camshaft thrust plate over the camshaft hole in the end plate and place a steel straight edge against the camshaft thrust plate and over the shoulder of the crankshaft to see whether these two surfaces are flush. If the scale strikes the shoulder on the crankshaft, add another gasket. On the other hand, if there is space between the scale and the crankshaft shoulder, remove a gasket. When the desired result is obtained, assemble the screws and bolts, using a center punch to lock the screws.



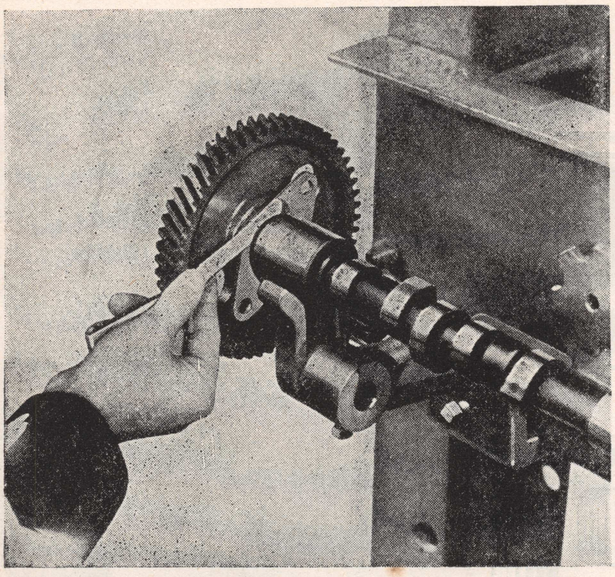
Checking Timing Gear Alignment. 1936-46.

TIMING GEAR COVER

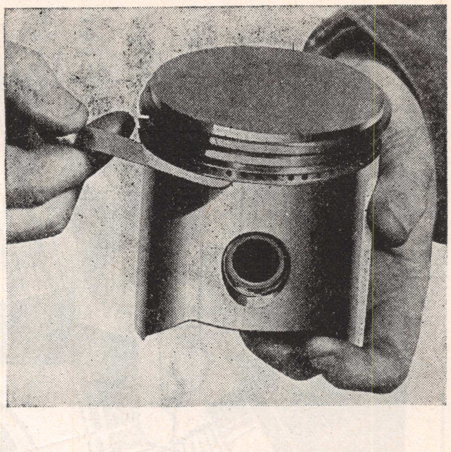
1936-46: Before installing the timing gear cover, be sure that the oil seal is seated



Checking Timing Gear Backlash 1936-46.



Checking Camshaft End Play. 1936-46.



Checking Ring to Groove Clearance. 1936-46.

properly in its recess in the cover, otherwise premature wear of the seal will result, causing an oil leak.

When replacing the cover, use a sleeve which is the same size as the hub of the vibration damper, slipping it over the front end of the crankshaft to act as a guide when replacing the cover.

Apply a light film of grease on the inner circumference of the seal to prevent it from being damaged when the vibration damper is being installed.

CAMSHAFT & BEARINGS

1936-46: Camshaft end play should be from a free fit to a maximum of .003" and is controlled by a thrust plate at the front end of the shaft. This clearance can be checked by inserting a feeler ribbon between the front end of the shaft and the thrust plate.

If necessary to replace bearings, drive out the expansion plug at the rear of the rear bearing and use suitable equipment to remove and replace the bearings.

CAUTION—Be sure the oil holes in the bearings are lined up with the oil holes in the crankcase. Before reaming the bearings, insert a round-nosed punch through the oil passage from the main to the camshaft bearings and stake each bearing in place.

PISTONS & RODS, REMOVE

1936-46: On all engines, the pistons and rods are removed from the top of the cylinder block. Although regular production rods are marked with the cylinder number in which they are installed (on the camshaft side), replacement rods are not; therefore, unmarked rods should be suitably identified with punch-marks, as removed.

PISTON & ROD, ASSEMBLE

1936-46: The connecting rod should be assembled to the piston so that when placed in the cylinder bore, the piston pin clamp bolt faces the camshaft side of the engine.

PISTONS, RENEW

1936-46: NOTE—A variation of 10 degrees between the temperature of the pistons and cylinder bores is sufficient to produce a difference of .0005". Therefore, both the pistons and cylinder bores should be at normal room temperature (about 70 degrees) when fitting pistons. This is particularly important because the clearances given in the PISTON & RING CLEARANCES table are minimum and pistons must not be fitted with less than specified.

Before any attempt is made to fit new pistons, cylinder bores should be carefully indicated and refinished. If bores do not require refinishing, be sure to remove the ridge at the top of each bore. If refinishing is required, it is good practice to do so in alternate cylinders due to the localized temperature build-up. Cylinder bores should not be out-of-round or tapered more than .0005".

Before fitting pistons, wipe the cylinder walls and pistons to remove all chips, dirt or other foreign matter. The feeler ribbon used to check piston fit should be about 12" long and ½" wide. Consult the PISTON & RING CLEARANCES table for the thickness of shim to use, as well as the recommended pounds pull on a spring scale required to withdraw the feeler ribbon past the piston.

Insert the piston in the bore upside down and in its running position. Place the feeler ribbon between the cylinder wall and the thrust side of the piston in a position at right angles to the piston pin hole.

After assembling the piston to the connecting rod, check the assembly for alignment on a suitable jig.

CYLINDER BORES, REFINISH

1936-46 ALL: Before any attempt is made to fit new pistons, the cylinder bores should be refinished. Remove any ridge at the top of ring travel if it exists. In refinishing, it is good practice to do alternate cylinders so as to reduce a localized temperature build-up. Chevrolet recommends honing cylinders that can be refinished to .003" oversize. When it takes a larger bore to clean up the worn cylinder bore, then the cylinders should be rebored for one of the standard oversize piston sizes: .010", .020", .030" or .040". The practice is to bore .002" under the finish size desired and then hone the last .002" out, bringing the bore to size with a fine finish.

If a micrometer is used, bore the cylinder to the diameter of the piston, measured just below the lower ring groove and at right angles to the piston pin. As the .002" clearance is allowed on the piston, this will mean boring out .018" for a .020" oversize piston. Then finish or polish with a hone.

PISTON RINGS, RENEW

1936-46: NOTE—To prevent the possibility of bending or breaking the second ring land—thus ruining the piston—the ridge at the top of the cylinder bore should be cut away before removing the piston and rod assemblies. If the available ridge reamer has no provision to control the depth of the cut, it is good practice to bring the piston far enough up into the cylinder to allow the reamer to rest on top of the piston. This will serve to prevent cutting down into the ring travel area.

CAUTION—Never cut down into the ring travel area more than 1/32"—or more than half the depth of the top ring.

New rings should be fitted with end gaps and groove clearances as given in the PISTON & RING CLEARANCES table. Ring grooves must be clean and free from carbon, and must show no perceptible wear. Install rings according to the instructions which is usually included in each ring package.

When rings are properly fitted to the pistons, be sure to stagger the ring gaps so they are spaced equal distances around the circumference of the piston. However, see that no gaps are over the piston pins.

PISTON PINS, RENEW

1936-46 ALL: Chevrolet pistons are sold with the piston pin bushings and pins fitted. Should it be necessary to replace a piston pin, three oversizes, .003", .005" and .010" sizes are available. The piston pin bushings in the piston will have to be reamed out. This should only be attempted in a fixture designed to keep the reamed hole at right angles to the piston skirt.

Carefully expand the reamer in reaming the first piston. Once the right size is obtained, reduce the reamer about half a thousandth and rough ream the rest of the pistons. Always "mike" all the pins before starting the job to be sure they are all the same size.

CONNECTING ROD BEARINGS, ADJUST

1936-46: These bearings are the spun type and are not replaceable. If bearings require adjustment, remove the same thickness of shims from each side until a metal-to-metal contact is established with the crankpin. The bearing may then be scraped to provide maximum bearing surface and sufficient shims installed on both sides to provide a clearance within the limits given in the ENGINE BEARING SPECIFICATIONS table.

NOTE—Before replacing or refitting connecting rods, the crank pins should be carefully checked for nicks or scoring and "miked" to be sure they are not out-of-round. Clean all parts thoroughly and oil well when assembling. One small particle of metal, carbon or other foreign matter lodged between the bearing and crankpin may cause bearing failure and a scored crankpin.

Standard connecting rods carry three .002" shims on each side. Be sure the cap is installed with the numbered side toward the camshaft. Then install the connecting rod oil dipper with its open side towards the camshaft. Assemble and tighten the nuts.

On 1940-46, the rod bolt nuts are first tightened up properly, then locked with "pal" nuts. These must be installed with the open side of the nut toward the end of the bolt. Turn the "pal" nut up finger tight and then ½ turn more with a wrench.

The last check is to make sure the piston and rod assembly travel true with the cylinder bore. To do this, check the clearance between the upper end of the connecting rod boss and the piston pin bosses. Using a feeler gauge, there should not be less than .025" at any point in the stroke when measured on each side of the connecting rod upper end.

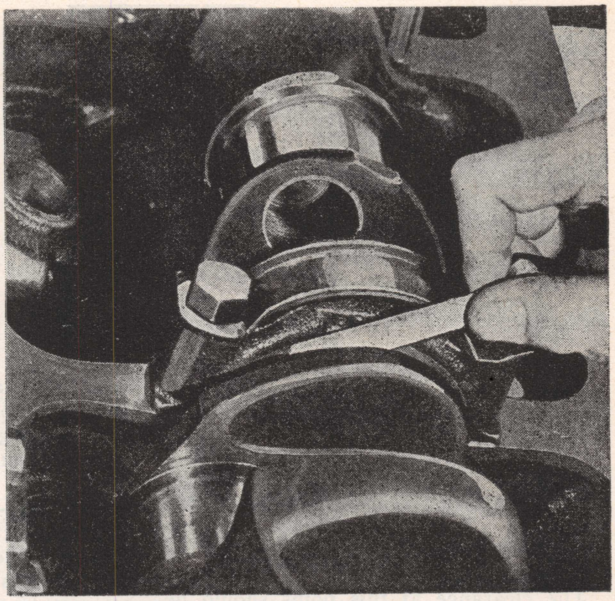
MAIN BEARINGS, ADJUST

1936-46 ALL: Starting with the rear main bearing, remove shims evenly until there is a slight drag on the crankshaft (when turned by hand) with the bolts pulled down tight. Then replace a .002" shim on one side. Again tighten the bolts. The shaft should now turn freely. Loosen the bolts of this bearing and follow the same procedure with each of the other bearings.

NOTE—Shims should be removed evenly if possible. When they are not even, have the greatest number of shims on the same side of all bearings.

MAIN BEARINGS, RENEW

1936-46 ALL: Main bearings are all babbitt lined steel half shells which are inserted in crankcase and main bearing caps. When main bearings have to be renewed, the engine must be removed from the chassis so that the new bearings may be bored out to exact size.



Checking Crankshaft End Play. 1936-46.

NOTE—When it is necessary to replace main bearings, the clutch housing should not be removed from the cylinder block. This is very important as the transmission pilot hole in the clutch housing is used in aligning the boring bar. Should it be necessary to replace the clutch housing, the new housing must be assembled to the block and checked for alignment before the main bearings are installed.

The procedure followed in boring out the main bearings is the same on all engines and detailed instructions are given with the boring machine. The following important points must be observed no matter how the bearings are bored. To assure proper alignment of clutch and transmission with the crankshaft after the main bearings have been fitted and bored, it is necessary to center the boring bar, at the rear, from the transmission pilot hole in the clutch housing. The runout must not exceed .015". If it does, it will be necessary to replace the clutch housing before proceeding with the bearing installation.

1936: The main bearings on these engines must be centralized before they are bored, otherwise an unequal amount of babbitt will be removed from the circumference of the bearing. A round bar, with three steps or diameters to fit each main bearing, is used when each main bearing cap is bolted down. Four .002" shims must be placed under each side of the cap, otherwise the centralizing bar cannot be removed to allow the bearing to be bored.

1937-46: When installing bearing shells in the cylinder block and cap, be sure to place four .002" shims on each side of each bearing. The intermediate bearing caps are marked "front" and "rear" for identification purposes. The front intermediate bearing cap is installed with the "FRONT" mark to the front of the engine and the rear intermediate bearing cap is installed with the "REAR" mark to the rear of the engine.

NOTE—The front and front intermediate bearing shells are very similar in appearance and it is possible to get them mixed. The front intermediate shells are identified by the letter "I" in the bottom of the oil groove. Should the intermediate bearing shell be installed in the front bearing bore, the sides of the bearing would be too high and would not permit the cap to seat firmly on the shims.

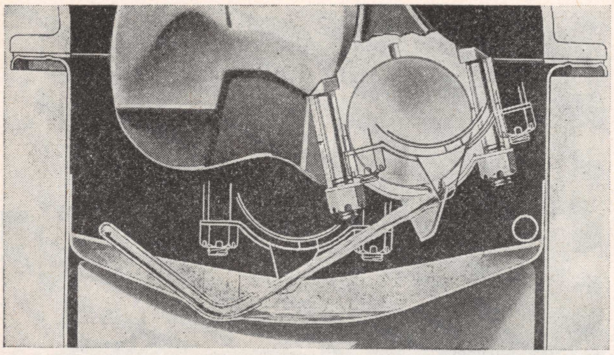
NOTE—Before installing the crankshaft, make sure all cuttings have been removed. Clean the bearing surfaces thoroughly and blow out all oil holes with compressed air. When blowing out the oil holes, block off all holes except the one being blown out, repeating the process with each bearing. After installing the crankshaft, replace the bearing caps, using four .002" shims on each side of the cap. Draw the cap bolts down tight and turn the crankshaft to be sure it is free.

CRANKSHAFT END THRUST

1936-46: Crankshaft end thrust is controlled by flanges on a bearing. (See the ENGINE BEARING SPECIFICATIONS table for the bearing which takes the thrust and for the correct end play limits.)

Through normal wear, this clearance will seldom become excessive, but whenever new bearings are fitted, check the end play carefully and if necessary, the bearing flanges may be dressed down to provide the desired clearance.

When dressing down the bearing flange, first face off the front side of the bearing just enough to give a fresh bearing surface. Then face off the rear side and install the bearing on the crankshaft. Check the clearance with a feeler gauge, and if not



Showing Oil Stream to Connecting Rod Dipper. 1936-46.

enough material has been removed to provide the desired end play, carefully face off a little more.

NOTE—On 1936-39 engines, if the front side of the thrust bearing is faced off too much, the oil slinger at the rear of the crankshaft may strike the back wall of the slinger groove.

The clearance at this point should be from .002" to .032" as measured with a feeler between the back face of the slinger and the groove in the crankcase (bearing cap removed).

REAR MAIN BEARING OIL SEAL

1936-39: Oil sealing at the rear main bearing is controlled by an oil slinger, integral with the crankshaft, running in a groove leading into the oil sump.

1940-46: The rear bearing cap and crankcase have a groove into which a wick-type seal is rolled. As it would be necessary to remove the engine and crankshaft to install the wick seal in the crankcase, this seal should always be renewed when new bearings are installed.

To install a new seal in the rear main bearing cap, insert the seal in the groove with the fingers. Then, using a rounded tool, roll the seal down into the groove. Start at one end and roll to the center. Start again at the other end and roll to the center. The small portion of the seal which protrudes from the groove at each end should be cut off flush with a sharp knife. To prevent pulling the seal out of the groove, use a round block of wood the same diameter as the crankshaft to hold the seal firmly while cutting it off.

ENGINE OILING

OIL PUMP, OVERHAUL

NOTE—On all engines, if the oil pressure drops below normal, do not remove the oil pump or oil pan until the oil gauge is checked with another gauge known to work and to be accurate. Another method is to disconnect the oil gauge tube at the oil distributor on the left side of the crankcase. With the tube disconnected, place a finger over the opening and have someone start the engine. If the pump is functioning, you will feel the pressure and oil will squirt out if the finger is removed. If there is little or no oil pressure, check the oil level and examine the condition of the oil. If satisfactory, remove and clean the oil pan thoroughly, and disassemble the oil pump and oil distributor.

CAUTION—Before replacing the oil pump, be sure that all openings in the screen are free and clean. If the screen has been crushed, it is safer to replace it rather than attempt to make a repair. When assembling the pump, dip the parts in fresh engine oil as a means of priming the pump. Before replacing the oil pan, check the height and aim of the oil nozzles, as well as the height of the oil trough and connecting rod dippers. Instructions for checking these points are explained under their respective headings.

1936: Before assembling the pump, check for excessive looseness or too much play between the rotor and its bearing surface in the oil pump body. Excessive clearance at this point will seriously reduce pump pressure. The clearance between the oil pump shaft and its bearing should not exceed .009".

When the oil pump is assembled into the body with the two blades and springs, see that the tapered end of the blades are in the direction of pump rotation. Be sure also, that the oil inlet hole in both the pump cover **and gasket** are in line with the oil inlet hole in the pump body. Assemble the oil pump screen cover and connect the oil inlet pipe to the cover to hold it in place.

CAUTION—Be sure the tapered set screw which holds the oil pump in the crankcase is fully seated in the tapered hole in the pump body, otherwise, the crankshaft cheeks may strike the pump body. Be sure to tighten the tapered screw lock nut.

1937-46: The pumps used in these engines are of the positive gear type. After disassembling the pump, examine the shaft and gears for excessive wear and replace where necessary, or better still, install a new pump. When assembling the pump, be sure the ground side of the idler gear is toward the cover.

NOTE—The gasket which is used between the pump cover and the body is special in that it controls the clearance in the pump. If the relief valve parts show wear, install new parts. Be sure that the tapered set screw which holds the pump in place is fully seated and locked with its lock nut.

TIMING GEAR LUBRICATION

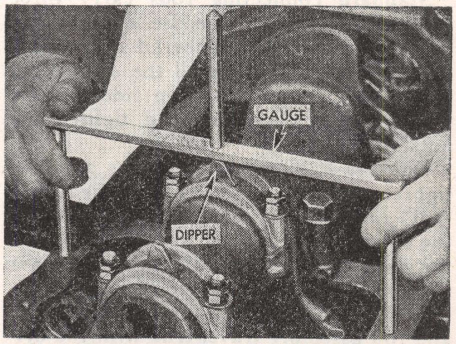
1936-46: The nozzle in the front end of the crankcase, through which a stream of oil flows to the timing gears, should point somewhere between straight down and 30 degrees to the left.

For 1941-46 engines, the oil nozzle is fitted into the crankcase front end plate by being pressed and flared in place. If the nozzle becomes damaged, it will be necessary to replace the front end plate rather than attempt to replace the nozzle without the use of special equipment.

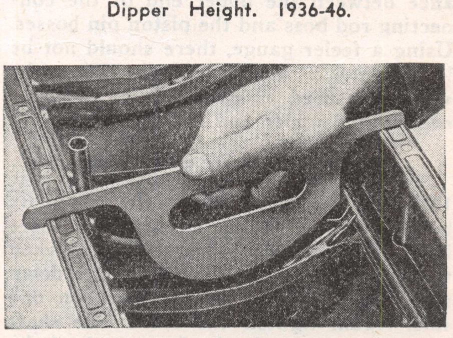
ROD BEARING LUBRICATION

1936-46: Every time the oil pan is removed or a new one installed, it is important that the height of the oil troughs and the aim of the oil nozzle be checked. Proper adjustment of the rod dippers is equally important.

At low engine speeds, the connecting rod dippers pick up oil directly from the oil troughs. At higher engine speeds, as the oil pressure increases, the nozzle oil streams rise, being caught by the dippers, forcing oil into the connecting rod bearings under high pressure.



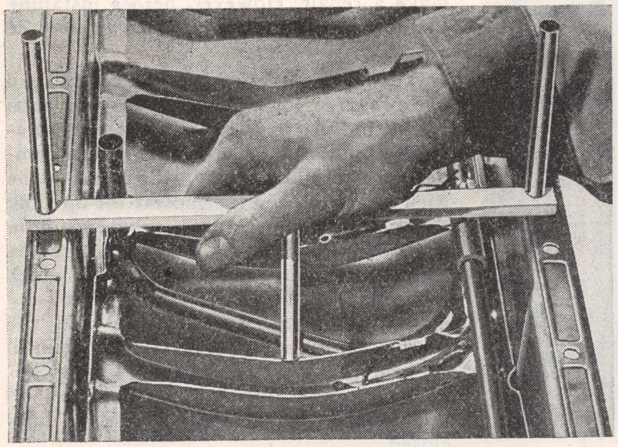
Checking Connecting Rod Dipper Height. 1936-46.



Checking Oil Nozzle Height. 1936-46.

ROD DIPPERS & OIL TROUGHS, ADJUST

1936-46: A special gauge is available for checking the height of rod dippers and oil troughs. It consists of a bar having three pins (see illustration), the center pin being used to check the oil level in the troughs. When the tool is inverted, with the two outer pins resting on the crankcase flange,



Checking Oil Trough Depth. 1936-46.

the rod dipper should contact the center of the bar when the dipper being checked is at bottom dead center.

If the dipper does not contact the cross bar, replace the dipper. If the dipper hits the bar before the rod is at bottom dead center, it may be bent to the correct position.

When checking the height of oil troughs, rest the bar on the oil pan flange (without gasket) with the center pin facing down. The height of the trough is correct if the gauge pin just touches the top edge of the trough. Raise or lower the trough until the desired result is obtained.

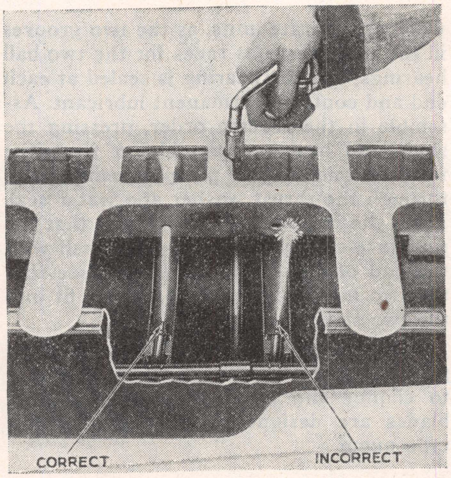
OIL NOZZLES, ADJUST

1936-46: To check the oil nozzle height, a nozzle depth gauge is available. With the oil pan gasket removed, hook the edge of the gauge over the oil pan flange, with the side of the gauge marked "Front" toward the front of the oil pan. With the gauge resting flat on the pan, move it from one oil trough to another, being sure that the open end of each nozzle is below the gauge.

To check the aim of the nozzles, a special target gauge should be used. Locate the target gauge on the oil pan with the dowels in the oil pan screw holes, which will bring the target holes in line with the nozzles. Insert a water nozzle in the main oil line and tip the oil pan sideways about 45 degrees so that the tips of the nozzles will not be covered by water in the troughs. When the water is turned on, the streams from the nozzles should pass through the target holes. If not, a special nozzle adjusting tool is available. After obtaining the desired result, again check the nozzles for correct height.

OIL DISTRIBUTOR VALVE

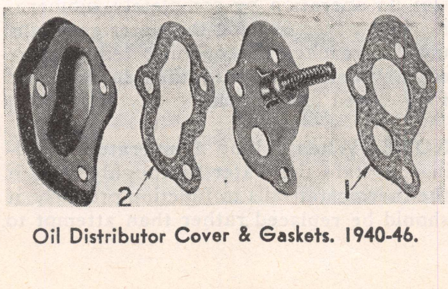
1936-39: Before replacing the oil distributor body to the cylinder block, be sure that the parts are positioned properly. The oil distributor valve gasket should be in good condition and assembled to the body so that it rests firmly against the valve seat. The valve is then assembled with the spring, copper gasket and the retaining nut.



Checking Oil Nozzle Aim Using Target Gauge & Water. 1936-46.

1940-46: When assembling the oil distributor valve assembly, install a cork gasket between the valve assembly and the cylinder block, and another cork gasket between the valve assembly and the oil distributor cover.

NOTE—Care must be exercised when assembling the gaskets that they are installed properly. By matching the holes of the gasket which fits against the cover, and the holes in the gasket which is assembled over the valve, assembly will be made correctly.



Oil Distributor Cover & Gaskets. 1940-46.

OIL DISTRIBUTOR PIPE, RENEW

1936-46: To replace the oil pipe from the distributor to the rocker arm: Drain the cooling system, then remove the rocker arm and push rod covers, disconnect the pipe from the rocker arm shaft coupling and oil distributor. Remove the packing nut, compression coupling and fitting from the cylinder block and remove pipe.

Thread the new pipe through the block, install the fittings, compression coupling and pack nut, making sure all joints are tight. Connect the pipe to the oil distributor and rocker-arm shaft coupling. Refill the cooling system and check for leaks. Install push rod and rocker arm covers.

CRANKCASE VENTILATOR BAFFLE

1936-46: This baffle is used to separate the oil mist from the fumes, thereby preventing oil from being carried out of the crankcase with the fumes.

When assembling the baffle, be sure to lock the nuts securely and check to see that the connecting rods have sufficient clearance.

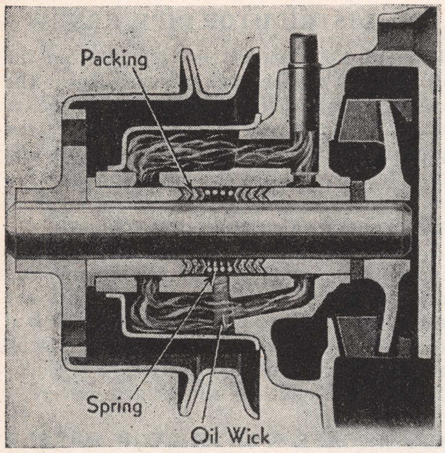
COOLING SYSTEM

WATER PUMP, OVERHAUL

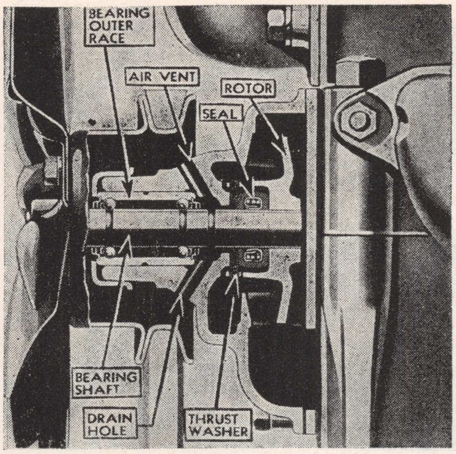
1936: Use a puller to remove the pulley from the shaft. Pull the impeller and shaft out of the pump from the rear. Remove the packing nut and clean out all the old packing. Use a new impeller shaft to check the bushings for wear. If they are worn enough to cause a loose fit of the new shaft in the bushings, they should be replaced. Use a water pump bushing pilot driver and an arbor press to remove the old bushings and to press the new bushings into place in the housing. Slip a thrust washer over the impeller shaft, down against the impeller hub and enter the shaft through the rear bushing, the rear packing rings, the packing spacer, the front packing rings and the packing nut. Then push it through the front bushing until the impeller is up against the thrust washer. Press the pulley on the front end of the shaft, far enough to remove practically all end play, but not so far as to cause binding. Tighten the packing nut firmly against the packing, back it off and turn it up with a light pull on a short wrench. Do not tighten the packing nut too much as this will cause the shaft to bind and the fan belt to slip. It may also cause scoring of the shaft. Make sure that the water pump grease cup is filled with water pump lubricant and that the lubricant is getting through the perforated spacer washer to the shaft.

1937-38: To replace the packing, which is spring loaded, the pump must be dismantled. Proceed as follows: Remove fan blades and the head plate to housing screws. Remove the plate and gasket. Press the shaft out of the pulley. Remove impeller and shaft.

Screw a threaded bushing puller into the inner bushing and press bushing out of pump housing. The packing, spring seats and spring may then be removed before



Water Pump, 1937-38. Plain Bearing Type.



Water Pump. 1938-46.

pressing the front bushing out of the housing, on the 1937. On the 1938, remove front bushing in same manner as the inner bushing, before removing packing, spring and seats.

Two types of lubrication wicks have been used in 1937, one a felt wick, the other of copper-graphite. Always replace with the same type as originally used. The copper graphite wick is backed up with a spring. No spring is used with the felt wick. New copper-graphite wicks should be installed by pressing in, to within 1/16" of inner bushing bore.

New felt wicks are installed by pushing through the hole and flaring over on inside of bushing bore in housing.

To replace and resize the bushings properly, and install the packing, the following special tools should be used: Bushing Driver, Pilot Sleeve, Packing Guide Sleeve and Packing Driver.

Assemble in the following order: Front bushing, two packing rings with grooved side toward front bushing, one spring seat with open V against the packing, the packing spring, the second spring seat with open V to the rear, four packing rings on the 1937 models, three on 1938, with grooved side to the rear. Use packing installing sleeves to install packing rings. Press them in place with packing driver. Install the inner bushing. Press oil reservoir in place with special driver, on the 1938.

Soak the bushings in light engine oil before installing in the 1938 pump.

Assemble impeller and shaft with new thrust washer and press the pulley on the shaft just far enough to obtain .003" to .005" endplay.

1938-40, BALL BEARING TYPE. Take the screws out of the hub and remove the fan blades and pulley. Remove the hub from the shaft with a puller. Use a puller to remove the metal cap from the front of the pump housing. (Or drive it off by tapping it around its edge with a drift, driving it off forward.) Remove the plate from the rear of the pump housing. Press the shaft and bearing assembly out forward, pressing the shaft out of the impeller at the rear. The shaft and bearing are not serviced as separate units, as the two grooves in the shaft serve as races for the two ball bearings, and the bearing is sealed at each end and contains permanent lubricant. Assemble in the reverse order, pressing the shaft and bearing assembly in from the forward end of the pump housing, then through the thrust washer and water seal. Press the impeller on the shaft so that the rear face of the impeller hub is flush with the end of the shaft. Be sure to see that the two lugs on the thrust washer fit into the two slots in the impeller.

When installing the ball bearing type pump on previous models, it is necessary to change the fan blades also as these blades are designed specifically for this type pump.

1941-46: Overhaul procedure for this pump is basically the same as described for the 1940 pumps. However, the pump is changed to improve water circulation within the pump body and to obtain two discharge outlets instead of one.

ENGINE WATER THERMOSTAT

1936-46: If the thermostat is not functioning properly, remove the assembly from the water outlet and see if the bellows and valve are in good condition. If they are, test its operation by completely submerging it in water, heating the water gradually until it reaches the opening temperature of the thermostat, and then in water at fully closed temperature.

NOTE—When taking temperature readings, agitate the water thoroughly. And if the thermostat fails to function properly, it should be replaced rather than attempt to make a repair. However, before installing the new unit, it should be tested as directed above.

Whenever an engine is being cleaned and prepared for winter service with anti-freeze, be sure to check the water thermostat to see that it opens at the proper temperature for the type of anti-freeze to be used. To check the thermostat for opening and closing temperatures, submerge it in hot water which is 25 degrees above the temperature stamped on the valve, at which time, it should be fully open. To check the closing temperature operation, keep the thermostat submerged in the water until the water has cooled down 10 degrees below the temperature which is marked on the valve, when the valve should be fully closed.

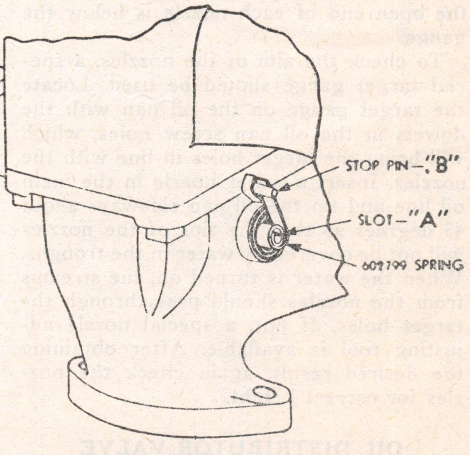
Thermostats of three temperature ranges are available: For normal service, 140 degrees; for use with alcohol or non-permanent anti-freeze, not more than 148 degrees, and for permanent anti-freeze, 166 degrees.

EXHAUST VALVE COOLING NOZZLES

1936-46: Copper nozzles are installed in the cylinder head in such a manner that the opening near the upper end directs the flow of water toward the valve seat. If removed, use care to see that the openings are pointed in the right direction. If necessary to replace, be sure that the new nozzles are of the correct length.

FUEL SYSTEM

NOTE—For service information on Carburetors, Automatic Chokes, Governors, Fuel Pumps, Air Cleaners and Gasoline Gauges, see the index.



Installing Manifold Heat Control Anti-Rattle Spring. 1938-46.

MANIFOLD HEAT CONTROL

1936: The manifold heat control valve thermostat spring is located on the outside of the exhaust manifold and held in place by a cover. When the thermostat cover is installed, be sure that the spring is free and not that the slot in the cover matches up with the prong on the end of the spring. Then turn the cover to the right until the bolt hole lines up with the bolt hole in the manifold.

1937-46: Unhook the thermostatic spring from its anchor on the manifold and check the adjustment. The proper adjustment and hook-up requires only ½ turn of the spring from its unhooked position to slip it over the anchor pin. Should this spring be distorted in any way, it should be replaced.

NOTE—On 1938-46 engines, an anti-rattle spring is used on the manifold heat control. To install this spring, rotate the heat control valve weight to the "heat off" position and insert the center end of the spring in the valve shaft slot. If an adjustment is required, turn the balance weight on the shaft to a point 3/16" above the "heat on" position, and bend the spring until it touches the stop pin above the shaft.

ELECTRIC SYSTEM

NOTE—For service information on Distributors, Magnetos, Generators, Generator Controls, Starting Motors and Starting Switches, see Table of Contents, on page 1.

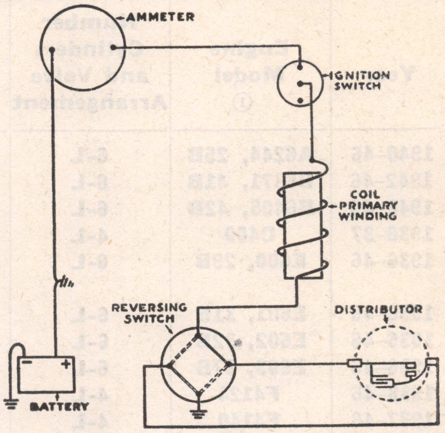
IGNITION TIMING

1936-46: There is no manual spark control but a vacuum spark control unit and an octane selector are fitted. Instead of the usual timing mark on the flywheel, a bright steel ball is pressed into a hole in the flywheel 5 degrees before TDC. This ball should register with the pointer at the opening in the right side of the flywheel housing when the breaker points open to fire No. 1 cylinder. Set the octane selector at zero. Check to see that the vacuum control operates freely, and is in full retard position. Crank the engine until No. 1 piston is coming up on its compression stroke and the steel ball in the flywheel registers with the line on the inspection hole in the flywheel housing. Loosen the distributor clamp screw and turn the housing until the points just break. Then set the octane selector so that a slight ping is heard on open throttle at 10 to 15 MPH.

When a Neon timing light is used, the engine should be run at idling speed for if it is turning faster the spark may be advanced by the centrifugal weights on the distributor and the timing will not be correct. The stroboscopic effect of the Neon light makes the ball appear to stand still in relation to the pointer at the flywheel opening. The distributor can then be rotated until the ball appears to remain exactly in line with the pointer, when the timing is correct. The factory recommends using the Neon light in timing the ignition.

CURRENT REVERSING SWITCH

1941-42: The switch is mounted on top of the starting motor and is actuated by a link connected to the starting motor gear shift lever. The switch is used to reverse the direction of the current flowing through the breaker points in the distributor, each time the engine is started, without changing the polarity of the secondary circuit.



Current Reversing Switch Wiring Diagram. 1941-42.

The purpose of the switch is to produce uniform wear on both contact points in the distributor by periodically reversing the direction of the current flow across the points.

When current passes through the points, there is a transfer of tungsten from one point to the other, depending upon the direction of current flow. After the engine is stopped, and then started again, the direction of current flow is reversed with a consequent transfer of tungsten. This results in increased contact point life.

ENGINES GASOLINE CONTINENTAL

Year	Engine Model ①	Number Cylinders and Valve Arrangement	Bore and Stroke	Displacement Cubic Inches	Compression Ratio	Taxable H. P.	Brake H. P. at R. P. M.	Maximum Torque at R. P. M. Pounds Feet	Oil Capacity Quarts
1940–46	A6244, 25B	6-L	3 7/16x4 3/8	243.6	6.02	28.36	85@3000	182@1200	5
1942–46	B6371, 41B	6-L	4 1/8x4 5/8	370.9	5.74	40.84	100@2600	280@1000	7
1940–46	B6405, 42B	6-L	4 5/16x4 5/8	405.3	5.74	44.63	112@2600	314@1000	7
1936–37	C400	4-L	3 3/8x4	143.1	5.13	18.23	38@2600	99@1200	4
1936–46	E600, 29B	6-L	3 11/16x4 1/2	288.3	5.43	32.63	87@2650	193@900	8
1936–46	E601, 31B	6-L	3 7/8x4 1/2	318.4	5.48	36.04	95@2600	214@1000	8
1936–46	E602, 32B	6-L	4 1/8x4 1/2	360.8	5.40	40.84	102@2500	253@ 850	8
1936–46	E603, 37B	6-L	4 1/4x4 1/2	383	5.29	43.35	105@2400	265@1000	8
1938–46	F4124	4-L	3x4 3/8	124	6.00	14.40	48@3300	94@1800	4
1937–46	F4140	4-L	3 3/16x4 3/8	140	6.00	16.26	52@3250	106@1600	4
1937–46	F4162	4-L	3 7/16x4 3/8	162	5.75	18.91	59@3300	124@1600	4
1936–46	F6170	6-L	3x4	170	6.60	21.60	65@3500	124@1200	5
1936–46	F6199	6-L	3 1/4x4	199	6.00	25.35	69@3400	150@1200	5
1936–46	F6209, 24B	6-L	3 3/16x4 3/8	209.5	5.75	24.38	71@3100	155@1200	5
1936–46	F6218	6-L	3 1/4x4 3/8	218	5.95	25.35	74@3100	162@1200	5
1940	F6226	6-L	3 5/16x4 3/8	226	6.00	26.33	73@3000	170@1200	5
1940	M6253	6-L	3 1/2x4 3/8	253	5.80	29.40	87@3000	175@1200	7
1938–46	M6271	6-L	3 5/8x4 3/8	270.93	5.75	31.54	89@2900	207@1200	7
1938–46	M6290, 38B	6-L	3 3/4x4 3/8	289.93	5.70	33.75	92@2800	225@1200	7
1938–46	M6330, 40B	6-L	4x4 3/8	329.86	5.50	38.40	104@2800	258@1000	7
1937–46	Y4069	4-L	2 1/2x3 1/2	68.72	6.15	10.00	27@3400	52@2000	3 1/2
1936–46	Y4091	4-L	2 7/8x3 1/2	90.89	6.00	13.22	36@3300	70@1800	3 1/2
1940–46	Y4112	4-L	3 3/16x3 1/2	111.7	6.00	14.40	41@3300	87@1800	3 1/2
1936–46	20R, 33B	6-I	4 1/8x4 1/2	381	4.76	40.84	106@2600	276@1200	10
1936–46	21R, 34B	6-I	4 3/8x4 3/4	428.4	4.63	45.94	118@2550	323@1000	10
1936–46	22R, 35B	6-I	4 1/2x5 1/4	501	4.50	48.60	138@2400	375@1000	10

① Engine models having the letter "B" following the number are Brockway models.

NOTE—For Tune Up Chart on these engines, see page 913.

VALVE SYSTEM

Year	Engine Model ①	Stem Clearance		Tappet Guide Clearance	Tappet Clearance				Valve Spring Pressure Test		Valve Seat Angle Degrees
					Running, Hot		Timing				
		Intake ③	Exhaust ③		In-take	⑦Ex-haust	In-take	⑦Ex-haust	Free Length, Inches	⑫ Pounds at Inches, Length	
1940–46	A6244, 25B	.002	.0035	.0015	⑧	⑧	⑧	⑧	④	④	②
1942–46	B6371, 41B	.002	.004	.0015	.017	.025	.022	.022	⑤	⑤	②
1940–46	B6405, 42B	.002	.004	.0015	.017	.025	.022	.022	⑤	⑤	②
1936–37	C400	.002	.004	.0015	.013	.013	.014	.014	---	--------	②
1936–46	E600, 29B	.002	.004	.0015	.018	.018	.018	.018	---	⑪	30
1936–46	E601, 31B	.002	.004	.0015	.018	.018	.018	.018	---	⑪	30
1936–46	E602, 32B	.002	.004	.0015	.018	.018	.018	.018	---	⑪	30
1936–46	E603, 37B	.002	.004	.0015	.018	.018	.018	.018	---	⑪	30
1938–46	F4124	.002	.004	.0015	⑨	⑨	⑨	⑨	2	50@1 45/64	②
1937–46	F4140	.002	.004	.0015	⑨	⑨	⑨	⑨	2	50@1 45/64	②
1937–46	F4162	.002	.004	.0015	⑨	⑨	⑨	⑨	2	50@1 45/64	②
1936–46	F6170	.002	.004	.0015	.014	.014	.017	.017	1 15/16	45@1 21/32	②
1936–46	F6199	.002	.004	.0015	.014	.014	.017	.017	1 15/16	45@1 21/32	②

Continued on next page

NOTE—For Continental engines developed since 1942, see page 915.

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VALVE SYSTEM

Year	Engine Model ①	Stem Clearance		Tappet Guide Clearance	Tappet Clearance Running, Hot		Tappet Clearance Timing		Valve Spring Pressure Test		Valve Seat Angle Degrees
		Intake ③	Exhaust ③		In-take	⑦Ex-haust	In-take	⑦Ex-haust	Free Length, Inches	⑫ Pounds at Inches, Length	
1936–46	F6209, 24B	.002	.004	.0015	.014	.014	.017	.017	$1\frac{15}{16}$	45@$1\frac{21}{32}$	②
1936–46	F6218	.002	.004	.0015	.014	.014	.017	.017	$1\frac{15}{16}$	45@$1\frac{21}{32}$	②
1940	F6226	.002	.004	.0015	.014	.014	.017	.017	$1\frac{15}{16}$	45@$1\frac{21}{32}$	②
1940	M6253	.002	.004	.0015	.022⑩	.022⑩	.022⑩	.022⑩	$2\frac{1}{2}$	60@$1\frac{7}{8}$	②
1938–46	M6271	.002	.004	.0015	.022⑩	.022⑩	.022⑩	.022⑩	$2\frac{1}{2}$	60@$1\frac{7}{8}$	②
1938–46	M6290, 38B	.002	.004	.0015	.022⑩	.022⑩	.022⑩	.022⑩	$2\frac{1}{2}$	60@$1\frac{7}{8}$	②
1938–46	M6330, 40B	.002	.004	.0015	.022⑩	.022⑩	.022⑩	.022⑩	$2\frac{1}{2}$	60@$1\frac{7}{8}$	②
1937–46	Y4069	.002	.0035	.0015	.012	.012	.014	.014	2	50@$1\frac{45}{64}$	②
1936–46	Y4091	.002	.0035	.0015	.012	.012	.014	.014	2	50@$1\frac{45}{64}$	②
1940–46	Y4112	.002	.0035	.0015	.012	.012	.014	.014	2	50@$1\frac{45}{64}$	②
1936–46	20R, 33B	.002	.003	.0015	.014	.020	.013	.013	⑥	⑥	30
1936–46	21R, 34B	.002	.003	.0015	.014	.020	.013	.013	⑥	⑥	30
1936–46	22R, 35B	.002	.003	.0015	.014	.020	.013	.013	⑥	⑥	30

① Engine models having the letter "B" following the number are Brockway models.

② Intake 30 degrees, exhaust 45 degrees.

③ Plus or minus .0005".

④ Spring No. 20C1–204: Free length $2\frac{15}{32}$"; 45 pounds at $2\frac{3}{16}$". Spring No. A6001–338: Free length $2\frac{3}{8}$"; 56 pounds at $1\frac{7}{8}$".

⑤ Outer spring: Free length $2\frac{3}{8}$"; 56 pounds at $1\frac{7}{8}$". Inner spring: Free length $1\frac{51}{64}$"; 13 pounds at $1\frac{17}{32}$".

⑥ Outer spring: Free length $2\frac{47}{64}$"; 57 pounds at $2\frac{1}{4}$". Inner spring: Free length $2\frac{19}{32}$"; 23 pounds at $2\frac{7}{32}$".

⑦ If engine is equipped with Stellite exhaust valves, clearance should be increased .003".

⑧ With camshaft Nos. A6001–433 and A6001–425, running clearance, intake .017", exhaust .022"; for timing, intake and exhaust .017". With Camshaft No. A6001–217, running and timing clearance .014".

⑨ With Camshaft No. F1401–300, clearance for running and timing .014". With Camshaft No. F4001–403, clearance for running and timing .017".

⑩ If equipped with Roto Valves, set clearance at .018".

⑪ Outer spring, 95 pounds at $1\frac{27}{32}$"; inner spring, 33 pounds at $1\frac{3}{4}$".

⑫ Average pressures.

PISTON AND RING CLEARANCES

Year	Engine Model ①	Piston Skirt, Inches		Fitting Pistons with Shim and Spring Scale		Ring End Gap, Inch ②		Ring and Groove, Inch	
		Top	Bottom	Shim Thickness	Pounds Pull on Scale	Com-pression	Oil	Com-pression	Oil
1940–46	A6244, 25B	.003	.003	.003	4 to 8	.005–.015④	.009–.014	.0015–.0025	.0015–.0025
1942–46	B6371, 41B	.004	.004	.004	4 to 8	.007–.017③	.007–.017	.0015–.0025	.0015–.0025
1940–46	B6405, 42B	.004	.004	.004	4 to 8	.007–.017③	.007–.017	.0015–.0025	.0015–.0025
1936–37	C400	.003	.003	.003	6 to 8	.005–.015	.005–.015	.0015–.0025	.0015–.0025
1936–46	E600, 29B	.0035	.0035	.0035	6 to 11	.008–.018	.008–.018	.0015–.0025	.0015–.0025
1936–46	E601, 31B	.004	.004	.004	6 to 11	.008–.018	.008–.018	.0015–.0025	.0015–.0025
1936–46	E602, 32B	.004	.004	.004	6 to 11	.010–.020	.010–.020	.0015–.0025	.0015–.0025
1936–46	E603, 37B	.0045	.0045	.0045	6 to 11	.010–.020	.010–.020	.0015–.0025	.0015–.0025
1938–46	F4124	.002	.002	.002	8 to 12	.008–.013	.008–.013	.0015–.0025	.0015–.0025
1937–46	F4140	.002	.002	.002	8 to 12	.008–.013	.008–.013	.0015–.0025	.0015–.0025
1937–46	F4162	.002	.002	.002	8 to 12	.008–.013	.008–.013	.0015–.0025	.0015–.0025
1936–46	F6170	.002	.002	.002	10 to 15	.008–.013	.008–.013	.0015–.0025	.0015–.0025

Continued on next page

NOTE—For Continental engines developed since 1942, see page 915.

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PISTON AND RING CLEARANCES

Year	Engine Model ①	Piston Skirt, Inches		Fitting Pistons with Shim and Spring Scale		Ring End Gap, Inch ②		Ring and Groove, Inch	
		Top	Bottom	Shim Thickness	Pounds Pull on Scale	Compression	Oil	Compression	Oil
1936–46	F6199	.002	.002	.002	10 to 15	.008–.013	.008–.013	.0015–.0025	.0015–.0025
1936–46	F6209, 24B	.002	.002	.002	10 to 15	.008–.013	.008–.013	.0015–.0025	.0015–.0025
1936–46	F6218	.002	.002	.002	10 to 15	.009–.014	.005–.015	.0015–.0025	.0015–.0025
1940	F6226	.003	.003	.003	10 to 15	.005–.015	.010–.020	.0015–.0025	.0015–.0025
1940	M6253	.0025	.0025	.0025	10 to 15	.008–.015	.009–.014	.0015–.0025	.0015–.0025
1938–46	M6271	.0025	.0025	.0025	10 to 15	.008–.015	.009–.014	.0015–.0025	.0015–.0025
1938–46	M6290, 38B	.0025	.0025	.0025	10 to 15	.008–.018	.010–.020	.0015–.0025	.0015–.0025
1938–46	M6330, 40B	.0025	.0025	.0025	6 to 11	.011–.016	.009–.014	.0015–.0025	.0015–.0025
1937–46	Y4069	.002	.002	.002	10 to 15	.008–.013	.008–.013	.0015–.0025	.0015–.0025
1936–46	Y4091	.002	.002	.002	10 to 15	.008–.013	.008–.013	.0015–.0025	.0015–.0025
1940–46	Y4112	.002	.002	.002	10 to 15	.008–.013	.008–.013	.0015–.0025	.0015–.0025
1936–46	20R, 33B	.004	.004	.004	6 to 11	.010–.020	.007–.015	.0015–.0025	.0015–.0025
1936–46	21R, 34B	.004	.004	.004	6 to 11	.007–.017	.007–.015	.0015–.0025	.0015–.0025
1936–46	22R, 35B	.005	.005	.005	6 to 11	.010–.020	.007–.017	.0015–.0025	.0015–.0025

① Engine models having the letter "B" following the number are Brockway models.

② End gaps are for cylinder bores without taper. Fit rings in tapered bores with not less than the maximum clearance given.

③ For the tapered compression ring used in the second groove, .013" to .018".

④ For the tapered compression ring used in the second groove, .009" to .014".

ENGINE BEARING SPECIFICATIONS

Year	Engine Model ①	Camshaft		Connecting Rod			Mains				
		Journal Diameter	Clearance	Journal Diameter	Clearance	Bearing Bolt Tension Lb. Ft.	Journal Diameter	Clearance	Bearing Bolt Tension Lb. Ft.	Thrust on No.	End-play
1940–46	A6244, 25B	②	.0015–.003	2.123–2.124	.0015–.002	⑧	2.374–2.375	.0015–.002	⑧	1	.004–.006
1942–46	B6371, 41B	③	.0015–.003	2.498–2.499	.0025–.003	⑧	2.873–2.874	.002–.003	⑧	1	.003–.006
1940–46	B6405, 42B	③	.0015–.003	2.498–2.499	.0025–.003	⑧	2.873–2.874	.002–.003	⑧	1	.003–.006
1936–37	C400	--	.002–.003	1.7478–1.7485	.001–.003	⑧	1.7478–1.7485	.001–.003	⑧	1	.004–.006
1936–46	E600, 29B	--	.002–.003	2.373–2.3735	.002–.0035	⑧	2.622–2.623	.002–.004	⑧	1	.004–.006
1936–46	E601, 31B	--	.002–.003	2.373–2.3735	.002–.0035	⑧	2.622–2.623	.002–.004	⑧	1	.004–.006
1936–46	E602, 32B	--	.002–.003	2.373–2.3735	.002–.0035	⑧	2.622–2.623	.002–.004	⑧	1	.004–.006
1936–46	E603, 37B	--	.002–.003	2.373–2.3735	.002–.0035	⑧	2.622–2.623	.002–.004	⑧	1	.004–.006
1938–46	F4124	④	.002–.004	1.9365–1.9375	.0015–.002	⑧	2.249–2.250	.0015–.002	⑧	1	.004–.006
1937–46	F4140	④	.002–.004	1.9365–1.9375	.0015–.002	⑧	2.249–2.250	.0015–.002	⑧	1	.004–.006
1937–46	F4162	④	.002–.004	1.9365–1.9375	.0015–.002	⑧	2.249–2.250	.0015–.002	⑧	1	.004–.006
1936–46	F6170	⑤	.002–.004	1.9365–1.9375	.0015–.002	⑧	2.249–2.250	.0015–.002	⑧	1	.004–.006
1936–46	F6199	⑤	.002–.004	1.9365–1.9375	.0015–.002	⑧	2.249–2.250	.0015–.002	⑧	1	.004–.006
1936–46	F6209, 24B	⑤	.002–.004	1.9365–1.9375	.0015–.002	⑧	2.249–2.250	.0015–.002	⑧	1	.004–.006
1936–46	F6218	⑤	.002–.004	1.9365–1.9375	.0015–.002	⑧	2.249–2.250	.0015–.002	⑧	1	.004–.006

Continued on next page

NOTE—For Continental engines developed since 1942, see page 915.

Continued from previous page

ENGINE BEARING SPECIFICATIONS

Year	Engine Model ①	Camshaft		Connecting Rod			Mains				
		Journal Diameter	Clearance	Journal Diameter	Clearance	Bearing Bolt Tension Lb. Ft.	Journal Diameter	Clearance	Bearing Bolt Tension Lb. Ft.	Thrust on No.	End-play
1940	F6226	⑤	.002–.004	2.0615–2.0625	.0015–.002	⑧	2.374–2.375	.0015–.002	⑧	1	.004–.006
1940	M6253	⑥	.0015–.0025	2.248–2.249	.002–.0025	⑧	2.623–2.624	.002–.003	⑧	1	.003–.006
1938–46	M6271	⑥	.0015–.0025	2.248–2.249	.002–.0025	⑧	2.623–2.624	.002–.003	⑧	1	.003–.006
1938–46	M6290, 38B	⑥	.0015–.0025	2.248–2.249	.002–.0025	⑧	2.623–2.624	.002–.003	⑧	1	.003–.006
1938–46	M6330, 40B	⑥	.0015–.0025	2.248–2.249	.002–.0025	⑧	2.623–2.624	.002–.003	⑧	1	.003–.006
1937–46	Y4069	④	.002–.004	1.499–1.500	.0015–.002	⑧	1.7478–1.7485	.0015–.002	⑧	1	.003–.005
1936–46	Y4091	④	.002–.004	1.499–1.500	.0015–.002	⑧	1.7478–1.7485	.0015–.002	⑧	1	.003–.005
1940–46	Y4112	④	.002–.004	1.499–1.500	.0015–.002	⑧	1.7478–1.7485	.0015–.002	⑧	1	.003–.005
1936–46	20R, 33B	⑦	.002–.0035	2.498–2.4985	.0025–.003	⑧	2.747–2.748	.0025–.0035	⑧	1	.004–.006
1936–46	21R, 34B	⑦	.002–.0035	2.498–2.4985	.0025–.003	⑧	2.747–2.748	.0025–.0035	⑧	1	.004–.006
1936–46	22R, 35B	⑦	.002–.0035	2.747–2.748	.003–.0035	⑧	2.747–2.748	.0025–.0035	⑧	1	.004–.006

① Engine models having the letter "B" following the number are Brockway models.

② No. 1: 2.060–2.061. No. 2: 1.9975–1.9985. No. 3: 1.935–1.936. No. 4: 1.8725–1.8735.

③ Center: 1.7490–1.7495. All others: 2.242–2.243.

④ No. 1: 1.8715–1.8725. No. 2: 1.7457–1.7465. No. 3: 1.2465–1.2475.

⑤ No. 1: 1.8715–1.8725. No. 2: 1.8085–1.8095. No. 3: 1.7457–1.7465. No. 4: 1.2465–1.2475.

⑥ No. 1: 2.1845–2.185. No. 2: 2.122–2.1225. No. 3: 2.0595–2.060. No. 4: 1.747–1.7475.

⑦ No. 1: 2.1845–2.1855. No. 2: 2.122–2.123. No. 3: 2.0625–2.0635. No. 4: 1.997–1.998. No. 5: 1.872–1.873.

⑧ See the Torque Wrench Data table.

ENGINE

NOTE—Service requirements on all engines listed in the charts will be referred to by the series letter before or after the number. Series letter A, C, E, F, M and Y precede the engine model, while on series R, the letter follows the number. Engine models B6371 and B6405 will be designated as series B. If servicing any of the engines listed in the charts as being Brockway models, use the instructions for the corresponding Continental series designation; for example, service instructions for the F6209 (Continental designation) is the same as the 24B (Brockway designation).

CYLINDER HEAD

1936-46 All: Cylinder heads should be tightened down by starting from the center, working outward toward the sides and to the ends. Draw down the nuts evenly and repeat the operation until all are normally tight. After the engine has been run sufficiently long to bring all the parts to normal operating temperature, a final tightening should be made.

NOTE—When using a torque indicating wrench, the final tightening should be within the torque values recommended by the wrench manufacturer. If two torque values are shown, use the lower limit for clean and oily threads, and the high limit for clean and dry threads. In any case, the threads should be free from rust or dirt, otherwise a false reading will be obtained due to the increased friction.

CAUTION—When the final tightening is made on overhead valve engines, check and adjust the valve clearance according to the recommendations given in the VALVE SYSTEM table.

ROCKER ARMS & PUSH RODS

Series R: On overhead valve engines, it is good practice to remove the push rods before taking off the cylinder head to prevent the push rods from being bent or twisted. Likewise when installing the head, replace the push rods after the head is in position.

Whenever the valve rocker arm shaft is disassembled, place all parts on the bench in their relative position to assure correct assembly. Before reassembling, check the rocker arms to be sure the ball ends are smooth and not pitted or rough. If used in this condition, it will be difficult to maintain valve clearances. Note that there is a cup type insert between the rocker arm and valve stem. Clearances will have to be checked between this piece and the end of the valve stem as there is no other flat surface in the valve train.

VALVE SEAT INSERTS

1936-46 All: Since these inserts are too hard to reface by the ordinary grinding methods, a high-speed grinding stone or a special lapping tool should be used to perform this operation. When using this equipment, be sure valve guides are clean and that the valve guide pilot is a snug fit in order to assure a concentric finish. Finished seats should be checked with a dial indicator and run-out should not exceed .0005".

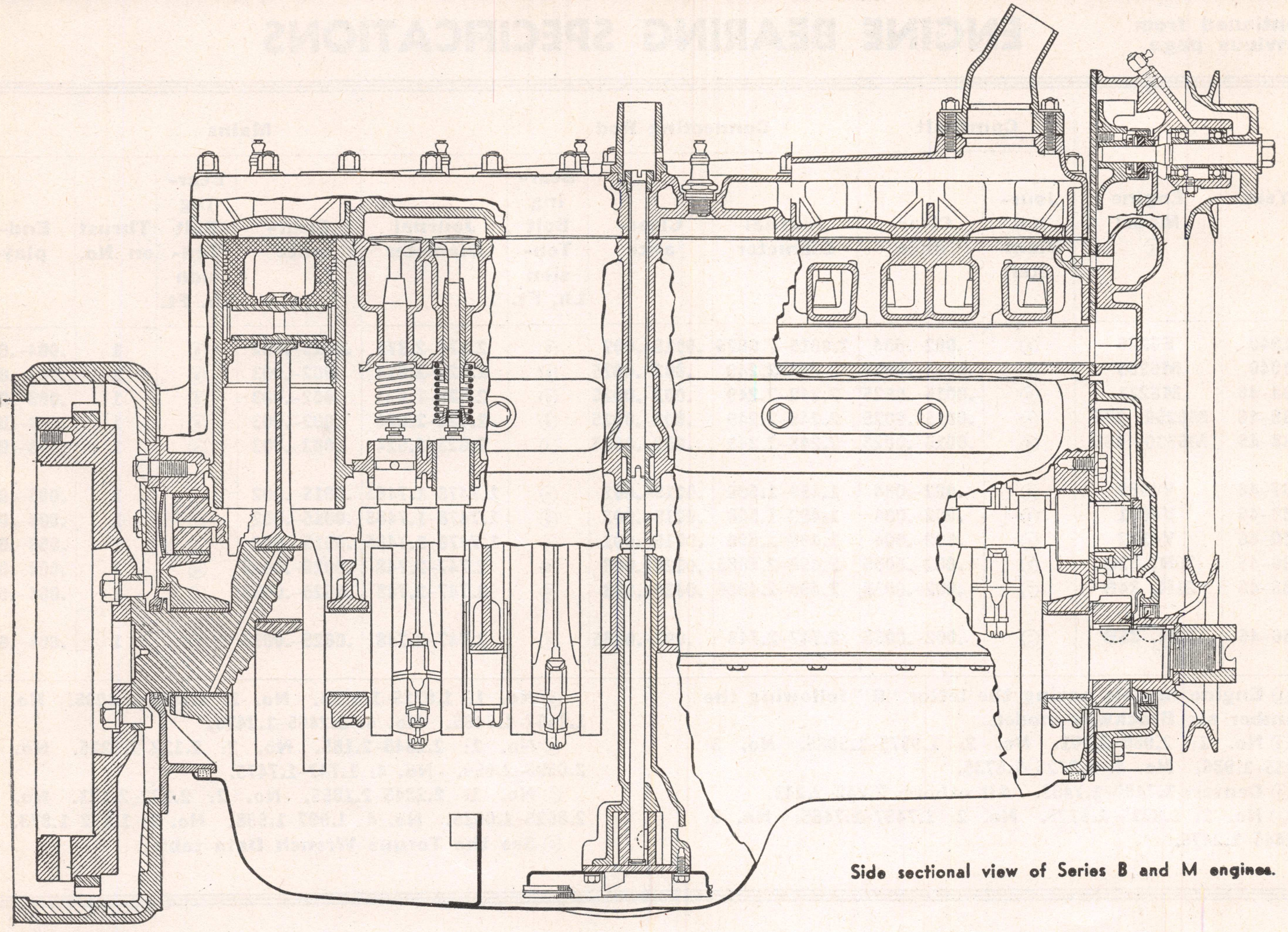
NOTE—Inserts are available with a diameter of 1/16" oversize. After pulling the old insert, enlarge the counterbore exactly 1/16" and insert the oversize seat. Then peen the cylinder block carefully around the periphery of the valve seat insert.

If it should be necessary to remove a valve seat insert, it can easily be done with a puller because the throat bore is slightly larger than the valve seat insert.

Inserts should be put in with an insert driver because they must go into the counterbore exactly square or they will cock and stick.

To remove an insert, if special equipment is not available, use a drill which is smaller in diameter than the insert width and drill two holes at opposite sides, but not all the

NOTE—For Continental engines developed since 1942, see page 915.



Side sectional view of Series B and M engines.

way through. Cut through the undrilled portion of the insert with a sharp chisel and remove the two pieces.

To install an insert, pack in "dry ice" for at least fifteen minutes to allow the metal to contract, and heat the exhaust valve port area gradually, if necessary, to permit this material to expand. Then press the insert into the cylinder head or block, as the case may be, using extreme care to see that it is not cocked or misaligned. When installed, finish the seats with the grinding or lapping equipment already mentioned.

VALVE STEM GUIDES

1936-46 All: When necessary to replace valve stem guides on L-head engines, remove the valves and springs, remove the tappet adjusting screws and lift out the tappets. On overhead valve engines, simply remove the valves and springs.

On all engines, valve stem guides should be removed and installed with a suitable puller. However, if this equipment is not available, use a drift, preferably one having a pilot which is the same size as the valve stem, to drive out the guide.

NOTE—On all engines, it is good practice to remove and install one guide at a time. When installing an intake guide, measure the depth of an intake guide not yet removed in order to determine the correct depth of the guide being installed. Similarly, this procedure should be followed when installing an exhaust guide. When installed, the guides should be reamed to provide a clearance within the limits given in the VALVE SYSTEM table.

VALVE TAPPETS & GUIDES

1936-46: Tappets should be a free fit in their guides without excessive side play. If the tappet face is scored due to too close an adjustment, it must be replaced.

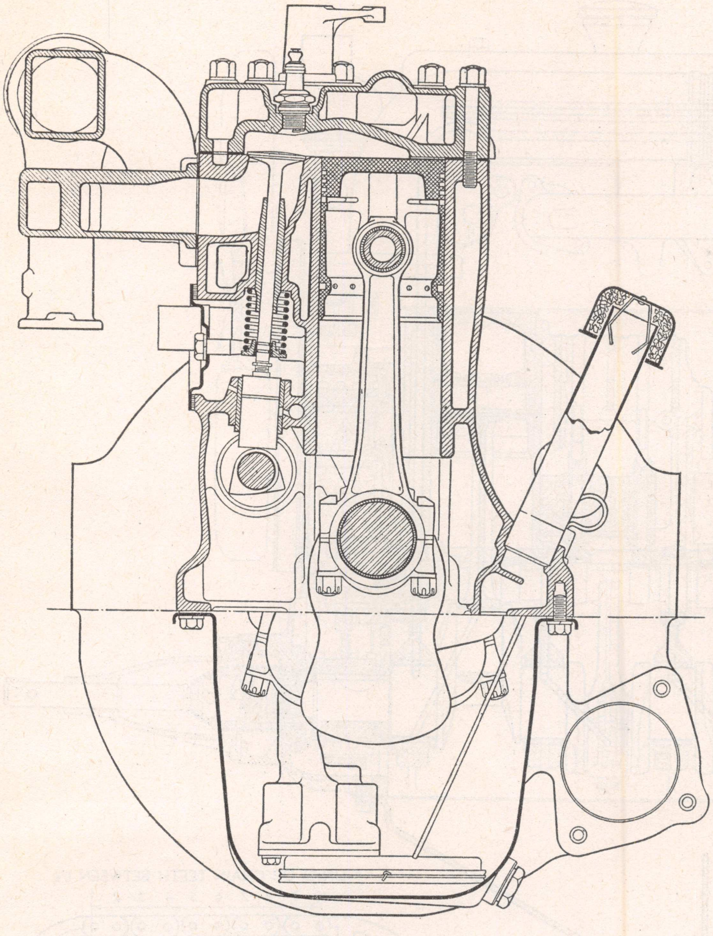
On some L-head engines, the tappets are assembled directly to guide holes cast in the cylinder block and can easily be removed without removing the oil pan or camshaft. Simply take off the cylinder head, remove the valves and springs and lift out the tappets. It may be necessary to remove the tappet adjusting screws.

Other L-head engines have removable bushings pressed in the block and tappets are removed in the same manner as described above. When replacing tappet guide bushings, be sure to line up the oil groove on the outside of the bushing with the oil feed hole in the crankcase.

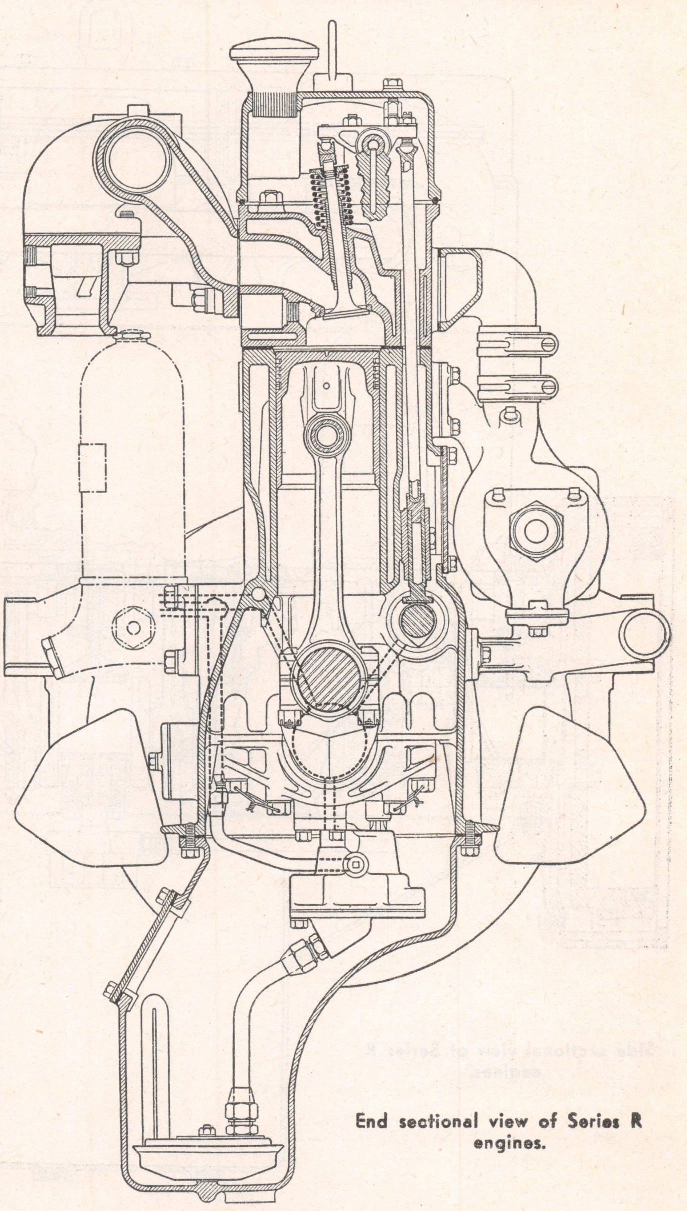
An examination of the engine being serviced will readily show which installation is used.

NOTE—If reaming is required to establish the correct tappet-to-guide clearance, it may be accomplished without removing the camshaft by using a reamer with a removable head. When using this tool, take off the reamer head, insert the pilot shaft through the valve guide hole and install the reamer head on the shaft through the valve cover opening. **Be sure to cover the camshaft with a clean rag to protect it from iron filings.** After the reaming operation is completed, carefully wipe out all chips and remove the rag from the camshaft. Make a careful inspection to see that all filings and dust are removed. If the reaming equipment necessitated the removal of valve stem guides, install new guides as directed under VALVE STEM GUIDES.

On overhead valve engines, the tappets are of the mushroom type, carried in tappet guide clusters bolted to the side of the cylinder block. When worn, it is usually easier to replace the entire tappet and cluster assembly rather than try to use old tappets with new clusters or vice versa.



End sectional view of Series B and M engines.



End sectional view of Series R engines.

NOTE—On overhead valve engines, the center valve tappet guide cluster is different than the others, and care should be exercised to see that they are assembled in the correct position.

VALVE TIMING

1936-46 All: With the engine at normal room temperature, and the No. 1 exhaust valve adjusted to the clearance for timing as given in the VALVE SYSTEM table, crank the engine until the "EX C" (exhaust closing) mark on the flywheel is directly in line with the pointer on the flywheel housing. In this position, the exhaust valve should have just closed.

NOTE—Be sure to check and adjust all tappets to the recommended running clearances given in the VALVE SYSTEM table, otherwise damage to the tappet faces, cam lobes and valves may result.

TIMING GEARS

1936-46 Series B, E, F, M and Y: Whenever these gears are removed or disturbed for any reason, it is important that they be assembled so that the similarly marked teeth are meshed, otherwise the valve timing will be incorrect.

These front end gears are available in several sizes, the standard size being stamped with the letter "S". If the gear is oversize, the oversize number is stamped within a circle, and if the gear is underside, the figure within the letter "U" denotes that many thousandths undersize.

If both the cam and crankshaft gears are to be replaced, the same size gears should be used. If only one gear is to be replaced, a gear slightly larger should be used to compensate for wear on the gear which is not replaced.

TIMING CHAIN

A6244 and C400: Install the chain so there are 9 links or 10 chain teeth between the "O" marks on the camshaft and crankshaft sprockets.

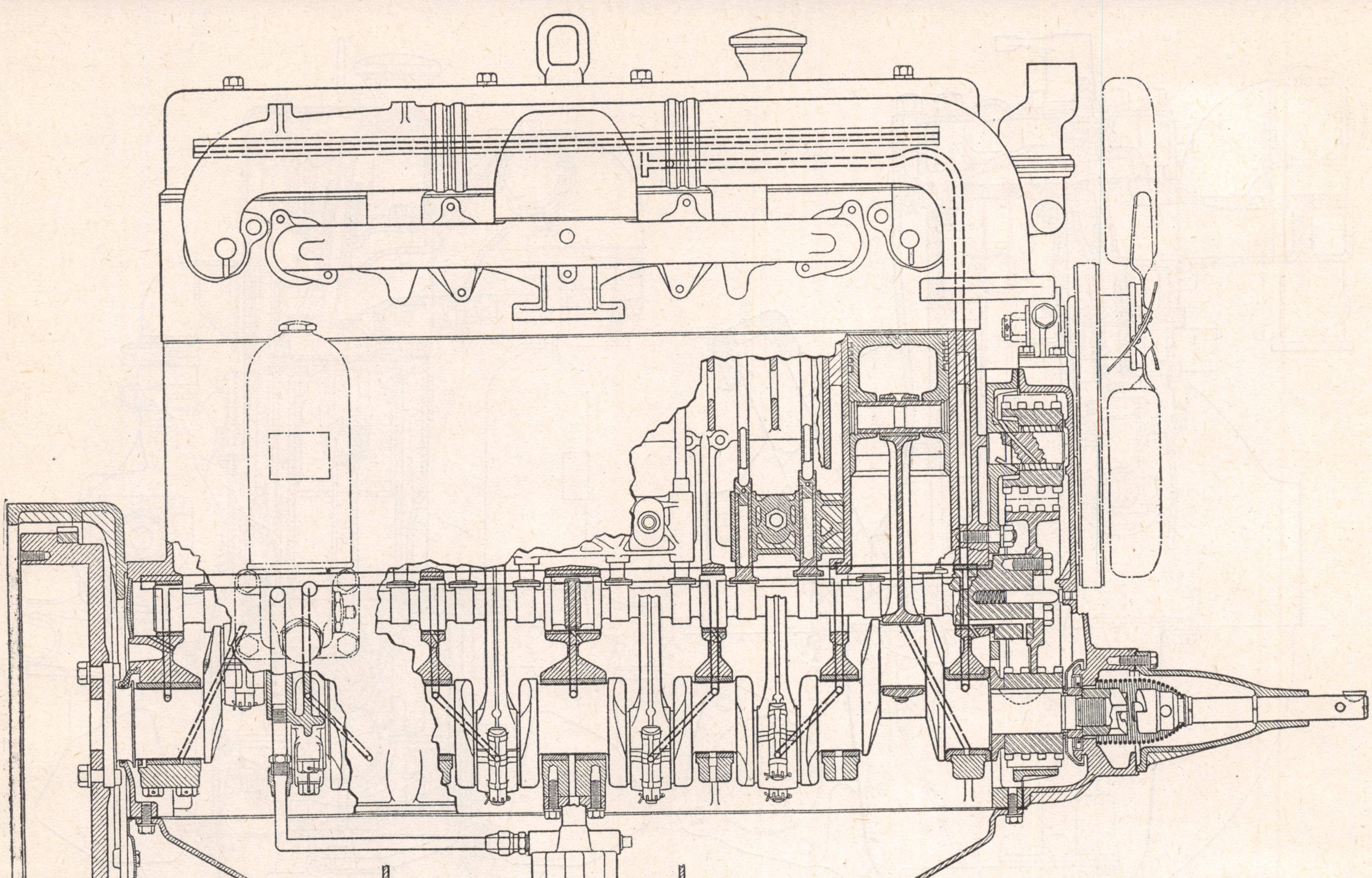
Series R: The chain is of the duplex type and wear is compensated for by an automatic spring take-up sprocket. When the take-up sprocket has reached its limit and the chain is too loose, it should be replaced, otherwise it will upset the valve timing. Install the chain so there are 4 links or 5 chain teeth between marks on camshaft and crankshaft sprockets.

Before removing the chain, set the engine in a manner described under VALVE TIMING and observe the position of the chain in relation to the sprockets. Then remove the old chain and install the new, being careful not to allow either the camshaft or the crankshaft to move from the set position.

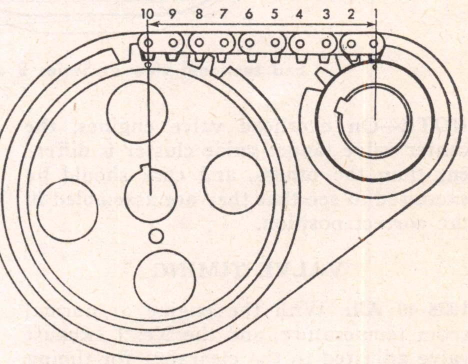
NOTE—After replacing the new chain, the idler sprocket spring should be wound up a minimum of 1¾ turns and then fastened to the slotted stud. The idler sprocket is carried on an eccentric bushing, being held in place by a flange. The bushing is secured in position by a washer, the adjusting spring and cotter pin.

ACCESSORY SPROCKETS

Series R: There are two accessory drive shafts, one on each side of the engine.



Side sectional view of Series R engines.



Showing position of sprocket marks for correct valve timing on Engines C-400 and A-6244

Facing the engine, the one at the left drives the generator and the one at the right, next to the camshaft, drives the other accessories. A spring idler is located between the generator sprocket and the crankshaft sprocket. However, in some engines, the top sprocket may be an idler, or, in other engines, it may drive the fan. Before removing the sprocket, observe how the chain is threaded between the camshaft sprocket and the two adjacent sprockets, one being the crankshaft and the other, the main accessory drive sprocket. This precaution should be taken in order to be sure the chain is assembled correctly.

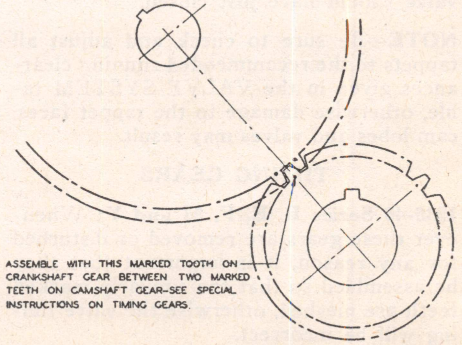
GENERATOR SPROCKET

Series R: This sprocket runs on a hollow extension of the generator mounting flange which is bolted to the crankcase part of the chain housing. The sprocket is held in position by a flanged drive shaft which passes through the hollow stud on which the sprocket turns. A spring-loaded thrust pin inserted in the front end of this drive shaft bears against an inspection plate on the front of the chain cover.

NOTE—If the chain cover is removed without first removing the inspection plate, this spring-loaded thrust pin may fly out. The inspection plate will have to be removed before the cover plate can be reassembled, therefore, it is always best to remove the inspection plate, the thrust pin and spring before attempting to remove the chain cover.

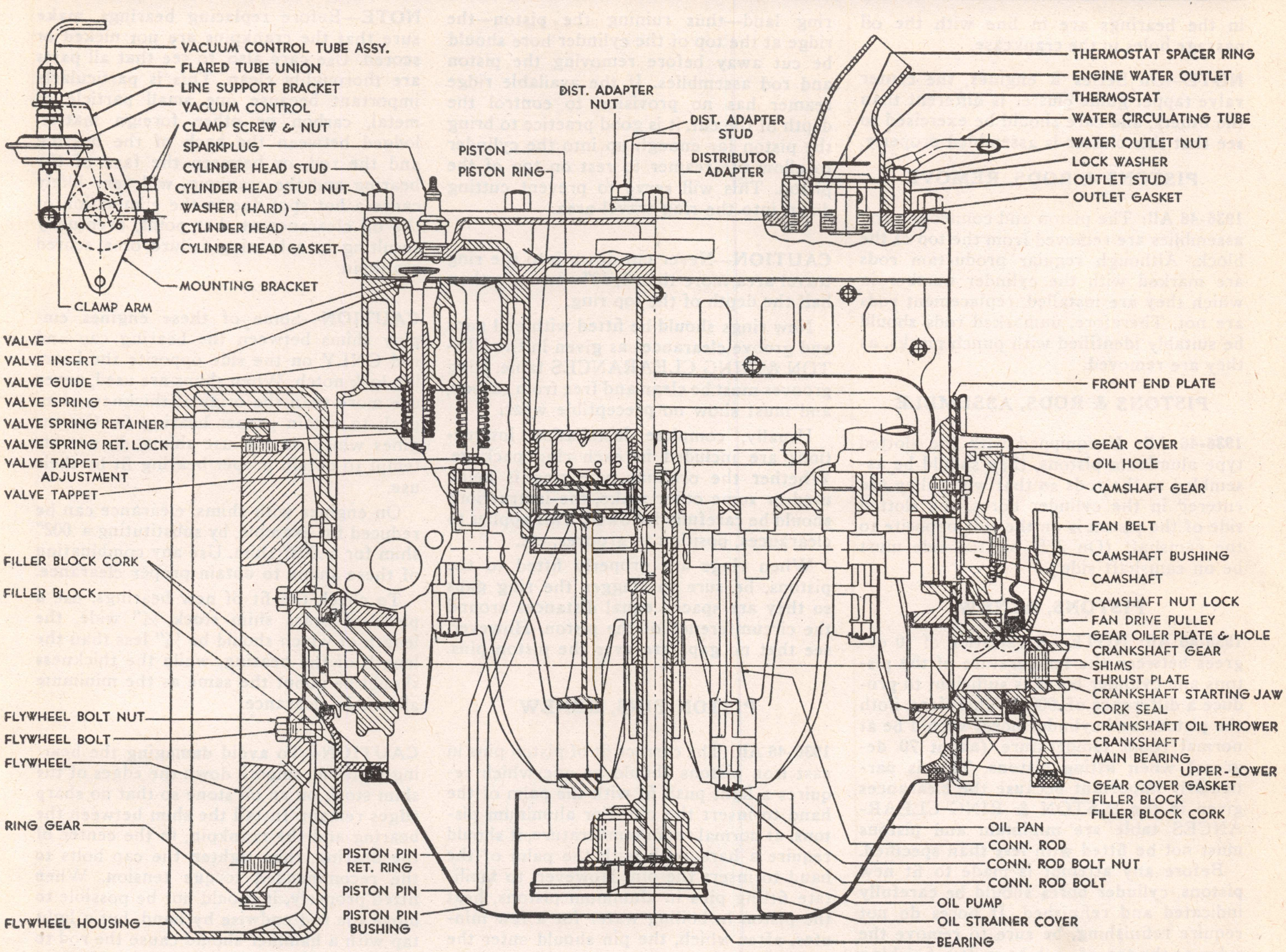
As soon as the chain is off the sprocket, the drive shaft can be withdrawn and the sprocket slipped off.

The generator can be removed by unbolting it from its mounting flange. The drive is a slip fit so removing the generator does not disturb any fit or adjustment of the chain sprocket.


ASSEMBLE WITH THIS MARKED TOOTH ON CRANKSHAFT GEAR BETWEEN TWO MARKED TEETH ON CAMSHAFT GEAR-SEE SPECIAL INSTRUCTIONS ON TIMING GEARS.

Showing position of timing gears for correct valve timing. Series B, E, F, M and Y engines.

NOTE—For Continental engines developed since 1942, see page 915.


VACUUM CONTROL TUBE ASSY.
FLARED TUBE UNION
LINE SUPPORT BRACKET
VACUUM CONTROL
CLAMP SCREW & NUT
SPARKPLUG
CYLINDER HEAD STUD
CYLINDER HEAD STUD NUT
WASHER (HARD)
CYLINDER HEAD
CYLINDER HEAD GASKET
MOUNTING BRACKET
CLAMP ARM
VALVE
VALVE INSERT
VALVE GUIDE
VALVE SPRING
VALVE SPRING RETAINER
VALVE SPRING RET. LOCK
VALVE TAPPET ADJUSTMENT
VALVE TAPPET
FILLER BLOCK CORK
FILLER BLOCK
FLYWHEEL BOLT NUT
FLYWHEEL BOLT
FLYWHEEL
RING GEAR
FLYWHEEL HOUSING
DIST. ADAPTER NUT
DIST. ADAPTER STUD
PISTON
PISTON RING
DISTRIBUTOR ADAPTER
PISTON PIN RET. RING
PISTON PIN
PISTON PIN BUSHING
THERMOSTAT SPACER RING
ENGINE WATER OUTLET
THERMOSTAT
WATER CIRCULATING TUBE
WATER OUTLET NUT
LOCK WASHER
OUTLET STUD
OUTLET GASKET
FRONT END PLATE
GEAR COVER
OIL HOLE
CAMSHAFT GEAR
FAN BELT
CAMSHAFT BUSHING
CAMSHAFT
CAMSHAFT NUT LOCK
FAN DRIVE PULLEY
GEAR OILER PLATE & HOLE
CRANKSHAFT GEAR
SHIMS
THRUST PLATE
CRANKSHAFT STARTING JAW
CORK SEAL
CRANKSHAFT OIL THROWER
CRANKSHAFT
MAIN BEARING
UPPER-LOWER
GEAR COVER GASKET
FILLER BLOCK
FILLER BLOCK CORK
OIL PAN
CONN. ROD
CONN. ROD BOLT NUT
CONN. ROD BOLT
OIL PUMP
OIL STRAINER COVER
BEARING

Side sectional view of Series F4 engines. Typical of Series F6.

CAMSHAFT SPROCKET

Series R: The camshaft sprocket is bolted to the end of the camshaft with three cap screws and also doweled so that it cannot be located incorrectly on reassembly. The camshaft end thrust is taken by a spring backed pin, in the front end of the camshaft, that presses against a hardened insert in the chain case cover.

ACCESSORY DRIVE SPROCKET

Series R: The accessory or water pump drive shaft is carried on a removable casting bolted to the crankcase. The accessory drive sprocket is mounted on the accessory drive shaft and pressed in place. After the chain is removed the sprocket may be pulled out with the accessory drive assembly.

If the accessory drive shaft is also used for a fan drive pulley, then the fan pulley must be removed before the timing chain cover can be removed. After the castellated nut and clamping washer have been removed, the fan belt pulley can be taken off with a hook type puller.

TIMING CASE COVER

Series R: It is not necessary to remove the oil pan to get the chain cover off. However, it is necessary to remove the fan, fan belt and drive pulley, where used, and the starting crank bracket. Then the removal of the cap screws will allow the cover to be taken off.

There are several combinations of this front end, but in any case, there are at least two shafts projecting through the cover which have oil seals. Be careful not to injure these seals when pulling the cover off. Watch out that the cover openings do not strike the shafts when it is replaced and that the shaft or hub, on which the oil seal bears, is not scored or rough. If there is any roughness, it should be polished off before replacing the cover.

1936-46 All except Series R: The starting crank jaws act as a nut to hold the fan drive pulley on the crankshaft. The hub of this pulley must be kept smooth because the oil seal bears against it. Take off the fan belt, nut and pulley. Then the timing cover can be unbolted and removed. In replacing the cover, it may be necessary to use a new oil seal. If so, be sure the inside feather edge of the seal is towards the engine and not toward the starting crank.

NOTE—Leather oil seals should be soaked in engine lubricating oil for at least an hour before they are installed—a longer soaking is desirable.

CAMSHAFT & BEARINGS

1936-46 All: Camshaft end thrust is controlled by a thrust plate behind the camshaft gear. End play should be held to about .005" and can be checked by forcing the camshaft back to the limit of its end play and inserting a feeler gauge between the thrust plate and the front end of the camshaft. If clearance is excessive, install a new thrust plate.

When necessary to replace bearings, they should be installed in sets and line reamed to provide a clearance within the limits given in the ENGINE BEARING SPECIFICATIONS table.

NOTE—Be sure that the oil passage holes are clean and open, and that the oil holes in the bearings are in line with the oil passage holes in the crankcase.

NOTE—On Series R engines, the center valve tappet guide cluster is different than the others, and care should be exercised to see that this cluster is assembled properly.

PISTONS & RODS, REMOVE

1936-46 All: The piston and connecting rod assemblies are removed from the top of the block. Although regular production rods are marked with the cylinder number in which they are installed, replacement rods are not. Therefore, unmarked rods should be suitably identified with punch marks, as they are removed.

PISTONS & RODS, ASSEMBLE

1936-46 All: If equipped with the slotted type aluminum pistons, they should be assembled to the rods so that when they are entered in the cylinder bores, the slotted side of the piston is on the side opposite to the camshaft (On 21R, slotted side must be on camshaft side.)

PISTONS, RENEW

1936-46 All: NOTE—A variation of 10 degrees between the temperature of the pistons and cylinder bores is sufficient to produce a difference of .0005". Therefore, both the pistons and cylinder bores should be at normal room temperature (about 70 degrees) when fitting pistons. This is particularly important because the clearances given in the PISTON & RING CLEARANCES table are minimum and pistons must not be fitted with less than specified.

Before any attempt is made to fit new pistons, cylinder bores should be carefully indicated and refinished. If bores do not require refinishing, be sure to remove the ridge at the top of each bore. If refinishing is required, it is good practice to do so in alternate cylinders due to the localized temperature build-up. After refinishing, cylinder bores should not be out-of-round or tapered more than .0005".

Before fitting pistons, wipe the cylinder walls and pistons to remove all chips, dirt or other foreign matter. The feeler ribbon used to check piston fit should be about 12" long and ½" wide. Consult the PISTON & RING CLEARANCES table for the thickness of shim to use, as well as the recommended pounds pull on a spring scale required to withdraw the feeler ribbon past the piston.

Insert the piston in the bore upside down and in its running position (see PISTON & ROD, ASSEMBLE). Place the feeler ribbon between the cylinder wall and the thrust side of the piston (opposite slotted side on aluminum pistons) in a position at right angles to the piston pin hole.

After assembling the piston to the connecting rod, check the assembly for alignment on a suitable jig.

PISTON RINGS, RENEW

1936-46 All: NOTE—To prevent the possibility of bending or breaking the second ring land—thus ruining the piston—the ridge at the top of the cylinder bore should be cut away before removing the piston and rod assemblies. If the available ridge reamer has no provision to control the depth of the cut, it is good practice to bring the piston far enough up into the cylinder to allow the reamer to rest on top of the piston. This will serve to prevent cutting down into the ring travel area.

CAUTION—Never cut down into the ring travel area more than 1/32"—or more than half the depth of the top ring.

New rings should be fitted with end gaps and groove clearances as given in the PISTON & RING CLEARANCES table. Ring grooves must be clean and free from carbon, and must show no preceptible wear.

Usually, complete installation instructions are included in each ring package. Whether the original type ring is being used or some other make, the instructions should be carefully followed. This applies to clearances, position in grooves, etc.

When rings are properly fitted to the pistons, be sure to stagger the ring gaps so they are spaced equal distances around the circumference of the piston. However, see that no gaps are over the piston pins.

PISTON PINS, RENEW

1936-46 All: The correct fit of piston pins in cast iron pistons should be one which requires a light push fit with the palm of the hand to insert the pin. For aluminum pistons, at normal room temperature, it should require a hard push with the palm of the hand to insert the pin. However, to facilitate fitting pins in aluminum pistons, heat the piston in boiling water for a few minutes, after which, the pin should enter the piston easily.

To check the fit of pins after installation, hold the piston in both hands and, for aluminum pistons, the weight of the rod should not be sufficient to allow it to fall. When using the same method on cast iron pistons, the rod should drop easily by its own weight.

PISTON PIN BUSHINGS

1936-46 All: New bushings should be pressed in place and reamed to provide a light push fit of the pin with the parts at normal room temperature.

CONNECTING ROD BEARINGS, RENEW

1936-46 Except C400: When bearings become worn, they can be replaced without removing the rod by simply taking off the bearing cap and replacing the upper and lower halves. Bearings should be replaced in sets and under no circumstances should rods or caps be filed, altered or mutilated in any way in an attempt to obtain proper bearing fit.

NOTE—Before replacing bearings, make sure that the crankpins are not nicked or scored. Use care also, to see that all parts are thoroughly clean. This is particularly important because one small particle of metal, carbon or other foreign matter, lodged between the back of the bearing and the rod, or between the face of the bearing and the crankpin, will very likely cause a hot spot due to the elimination of the oil clearance at that point, eventually resulting in a bearing failure or a scored crankpin.

CAUTION—Some of these engines employ shims between the bearing cap and rod ONLY on the side opposite the bearing lock notch. When shims are used, never use more than the original thickness shim pack to obtain proper bearing fit. On engines which do not use shims, do not attempt to obtain proper bearing fit by their use.

On engines with shims, clearance can be reduced for example, by substituting a .002" shim for a .003" shim. Use any combination of these shims to obtain proper clearance.

To check the fit of new bearings, use a piece of brass shim stock ¼" wide, the length of which should be ¼" less than the length of the bearing, while the thickness should be about the same as the minimum allowable clearance.

CAUTION—To avoid damaging the bearing material, smooth down the edges of the shim stock on an oil stone so that no sharp edges remain. Install the shim between the bearing and the crankpin, in the center of the bearing, then tighten the cap bolts to the recommended torque tension. When fitted properly, it should not be possible to move the rod endwise by hand, but a light tap with a hammer should cause the rod to move endwise. Then remove the shim and install the cap again, tightening the cap bolts with the torque wrench, after which, the rod should move endwise by hand. If the rod is too loose with the checking shim in place, the crankpin should be turned down and undersize bearings fitted.

NOTE—It is good practice to check the connecting rod bore for roundness. A special tool with an indicator gauge is available for this operation, and before using this instrument, be sure that there are no nicks, burrs or dirt on the contacting surfaces to prevent a true reading. If the rod bore is out-of-round more than .002" or .003", the rod should be replaced.

C400: These bearings are the spun type and are not replaceable. If bearings require adjustment, remove the same thickness of shims from each side until a metal-to-metal contact is established with the crankpin. The bearing may then be scraped to provide maximum bearing surface and sufficient shims installed on both sides to provide a clearance within the limits given in the ENGINE BEARING SPECIFICATIONS table.

NOTE—For Continental engines developed since 1942, see page 915.

MAIN BEARINGS, RENEW

1936-46: **NOTE**—Before replacing bearings, make sure that the crankshaft journals are not nicked or scored. Use care also, to see that all parts are thoroughly clean. This is particularly important because one small particle of metal, carbon, dirt or other foreign matter, lodged between the back of the bearing and the rod, or between the bearing face and the crankshaft journal, will very likely cause a hot spot due to the elimination of the oil clearance at that point, eventually resulting in a bearing failure or a scored journal.

NOTE—Series E and R engines have dowelled bearings which necessitates the removal of the crankshaft for their renewal.

When bearings of the notched insert type become worn, they can be replaced without removing the crankshaft in the following manner: Remove the bearing cap and take out the worn lower shell. A suitable tool can be made to remove the upper shell by using a cotter pin with the rounded end flattened to form a T shape. Insert the long end of the pin in the oil passage hole in the crankshaft journal and, by rotating the crankshaft in the reverse direction, the T-shaped head will contact the bearing and force it out.

To install, place a new upper shell on the crankshaft journal with the locating notch in the correct position and rotate the shaft to turn the shell in place. Then install the lower shell in the cap and replace the cap, tightening the cap bolts to the recommended torque tension.

NOTE—Bearings should be replaced in sets and under no circumstances should any attempt to be made to file, alter or otherwise mutilate the bearing caps to obtain proper bearing fit.

To check the fit of new bearings, use a piece of brass shim stock ¼" wide, the length of which should be ¼" less than the length of the bearing, while the thickness should be about the same as the minimum allowable clearance.

CAUTION—To avoid damaging the bearing material, smooth down the edges of the shim stock to remove sharp edges or turned over corners. And before inserting it in place, coat the shim on both sides with a light film of engine oil.

Then lay the shim lengthwise in the center of the bearing and install the bearing cap to the crankshaft, tightening the cap bolts to the recommended torque tension. Test the fit of the bearing by rocking the flywheel through an arc of 2"—not more than 1" in either direction. The bearing may be considered fitted properly if the shaft is movable with a fairly heavy drag.

NOTE—Remove the checking shim and replace the cap, but do not tighten the cap bolts, as this bearing must be loose in order to check the fit of the other bearings. It is good practice to fit bearings by starting at the center—or one of the intermediates on a four bearing job—then the rear bearing, front bearing, and finally, the intermediates.

CRANKSHAFT END PLAY

1936-46: The crankshaft end thrust is controlled by flanges on the front crankshaft main bearing. The clearance or end play between the crankshaft and the flanges of this bearing should be carefully controlled. Whenever end play becomes noticeably excessive it should be immediately adjusted. The adjustment should be made, not to prevent damage to the shaft but to the front main bearing, the rear face of which is the thrust face on all these engines.

The end play of the crankshaft is regulated by a removable thrust collar just to the rear of the crankshaft timing gear. There is a shim pack between this front thrust collar and the front main bearing. Excessive clearance can be reduced by removing the right number of shims. Take the timing gear or timing sprocket off the end of the crankshaft, remove the front thrust collar and remove enough shims to reduce the end play to the limits recommended. Then replace collar and timing gear or sprocket—being careful not to get the engine out of time when replacing the crankshaft timing gear or sprocket.

OIL SEALS

1936-46 Except R Series: The front oil seal is of the self-expanding type and is pressed into the front end of the timing cover. A new seal should be soaked in oil before installation. The fan pulley hub on which it bears should be smooth and free from scratches and the cover plate must be absolutely central with this hub and crankshaft otherwise premature wear will result and the seal will be ineffective. The seal must be inserted with the feather edge to the rear and then the fan pulley pressed into place and clamped with the starting crank jaw nut.

The rear oil seal between the rear bearing and the flywheel flange is sealed with a square cork insert that bears on the crankshaft. The oil seal is made in two parts—a ring which dovetails into the crankcase and seals the upper side of the crankshaft, and a bearing filler plate which bolts to the crankcase and bell housing. Both pieces are grooved to take the cork seal. Particular care must be taken to see that the inside edge of both pieces does not touch the oil thrower on the rear end of the crankshaft with the crankshaft pushed as far to the rear as the end play allows. The clearance can be checked with a feeler before the oil pan is put in position.

NOTE—The upper oil seal ring can be rotated into place without removing the crankshaft.

Series R: The front oil seal is on the inside of the timing chain cover and bears on a sleeve attached to the front end of the crankshaft. Be sure this sleeve is smooth so as not to damage a new oil seal when it is installed.

The rear oil seal is constructed in much the same way as that on the other engines except that there is so much clearance between the seal and the oil thrower that clearance need not be checked. The upper half of the oil seal is a semi-circular piece that is dovetailed into the crankcase so that it can be rotated into place without removing the crankshaft. The lower half of bearing filler, bolts to the crankcase and holds both pieces in place.

TORQUE WRENCH DATA

Torque and tension are distinctly different and must not be confused. Torque is **twist**, the standard unit of measure being **pounds feet. Tension** is straight pull, the unit of measure being **pounds**. Wrenches designed to measure the tightness of a nut are therefore torque wrenches.

No definite table of pounds feet can be given that will cover all applications. This is due to the difference in the quality of threads—rolled—machined or ground—as well as the quality of material in the bolt. There is also a decided difference between oiled and dry threads.

The following table is intended as a guide for cylinder head, connecting rod and main bearing nuts. Since these parts are usually heat treated they will naturally stand more pull than ordinary parts—**threads should be oiled.** The table shows the difference between oiled and dry threads, and also the difference between alloy and standard steel.

TENSION

Alloy Steels

Nut size	Limit in Pounds Feet
5/16—18	20 to 25
5/16—24	20 to 25
3/8 —16	30 to 35
3/8 —24	35 to 40
7/16—14	70 to 75
7/16—20	70 to 75
1/2 —13	100 to 110
1/2 —20	100 to 110
9/16—12	130 to 140
9/16—18	130 to 140
5/8 —11	145 to 155
5/8 —18	145 to 155

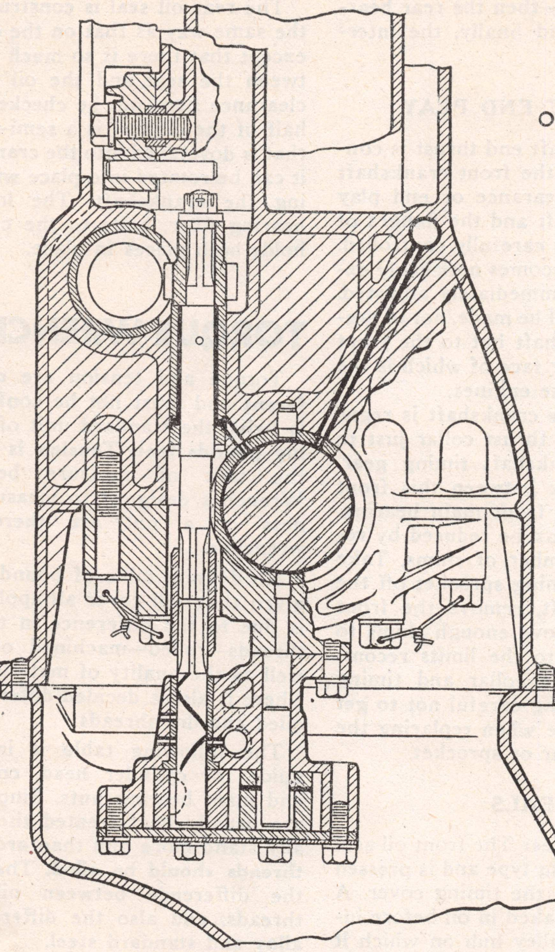
Standard Steels

Nut size	Limit in Pounds Feet
5/16—24	15 to 20
3/8 —24	25 to 30
7/16—20	50 to 55
1/2 —20	80 to 90

ENGINE OILING

OIL PUMP

1936-46: **NOTE**—On all engines, if the oil pressure drops below normal, do not remove the oil pump or oil pan until the oil gauge is checked with another gauge known to be accurate. Check the oil level and examine the condition of the oil. If the



Oil pump drive. Series R.

pressure continues to drop, remove and clean the oil pan thoroughly, and disassemble, clean and inspect the pump and oil pressure regulator.

CAUTION—Before replacing the oil pump and oil pan, the oil float, screen and tube should be thoroughly cleaned, being sure that all openings in the screen are free and clean. If the screen has been crushed, it is better to replace it rather than attempt to make a repair. When assembling the pump, dip the gears in fresh engine oil as a means of priming the pump.

NOTE—Clearance between the gears and cover may be checked by placing a steel scale across the face of the housing, and a feeler ribbon between the steel scale and gears. If clearance is excessive, it may be reduced by grinding the lower face of the housing, using an abrasive compound evenly distributed on a perfectly flat surface.

OIL PRESSURE REGULATOR

1936-46: Oil pressure is automatically controlled by a compression spring which controls the action of a relief or by-pass valve. Oil pressure should not be judged to be too high or too low until it is known whether the proper weight of oil is used, and the engine is warmed up to normal operating temperature.

As the engine bearings become worn, the oil pressure will be slightly lower due to more oil escaping around the bearings. It is not advisable to try to correct this slight pressure loss by an adjustment of the pressure regulator, because the extra amount of oil being thrown off by the worn bearings may already be over-oiling the cylinder walls.

On all engines except R series, the oil pressure regulator is located on the camshaft side of the crankcase opposite the center camshaft bearing. It is sealed by a hexagonal cap. The pressure is regulated by a spring that fits into the piston-type pressure relief valve. Different size springs are available to raise or lower the original pressure setting—12 to 18 lbs. when engine is idling and 35 to 40 lbs. at road speeds over 25 miles per hour.

Series R: The pressure regulator is located on the crankcase just behind the timing chain cover on the side opposite the camshaft. It is adjusted from the outside by turning the adjusting screw which sticks through a stuffing box in the regulator cap. Turning it clockwise increases the oil pressure. Removal of the cap gives access to the spring and piston-type oil pressure regulating valve.

OIL FILTER

1936-46: Several types of filters are used in these engines and usually, complete maintenance instructions accompany each filter in the form of a sticker pasted on the filter itself. If additional information is required, see the chapter devoted to OIL FILTERS elsewhere in this book.

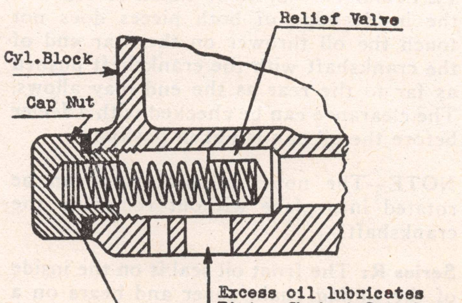
At frequent intervals, the filter should be drained to get rid of any solid matter which may have settled in the filter sump. Whenever this is done, be sure to add sufficient oil to the crankcase to compensate for the oil drained.

Filters should be checked every time the oil is changed and new filters inserted about every ten thousand miles of operation, or as indicated by oil color. If the dip stick shows that the oil is thick and very dirty, it indicates that the filter element requires cleaning or renewal.

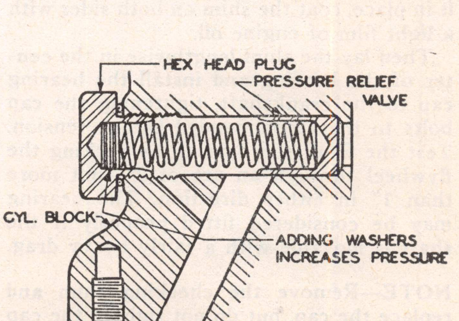
CRANKCASE VENTILATION

1936-46: The crankcase ventilator breather should be inspected at least every 2000 miles, and if a sludge formation is evident, remove the breather and clean it thoroughly in gasoline. Allow it to soak in the gasoline for about 30 minutes, then blow it out with compressed air, and at the same time, tap it lightly to dislodge any solid particles of sludge.

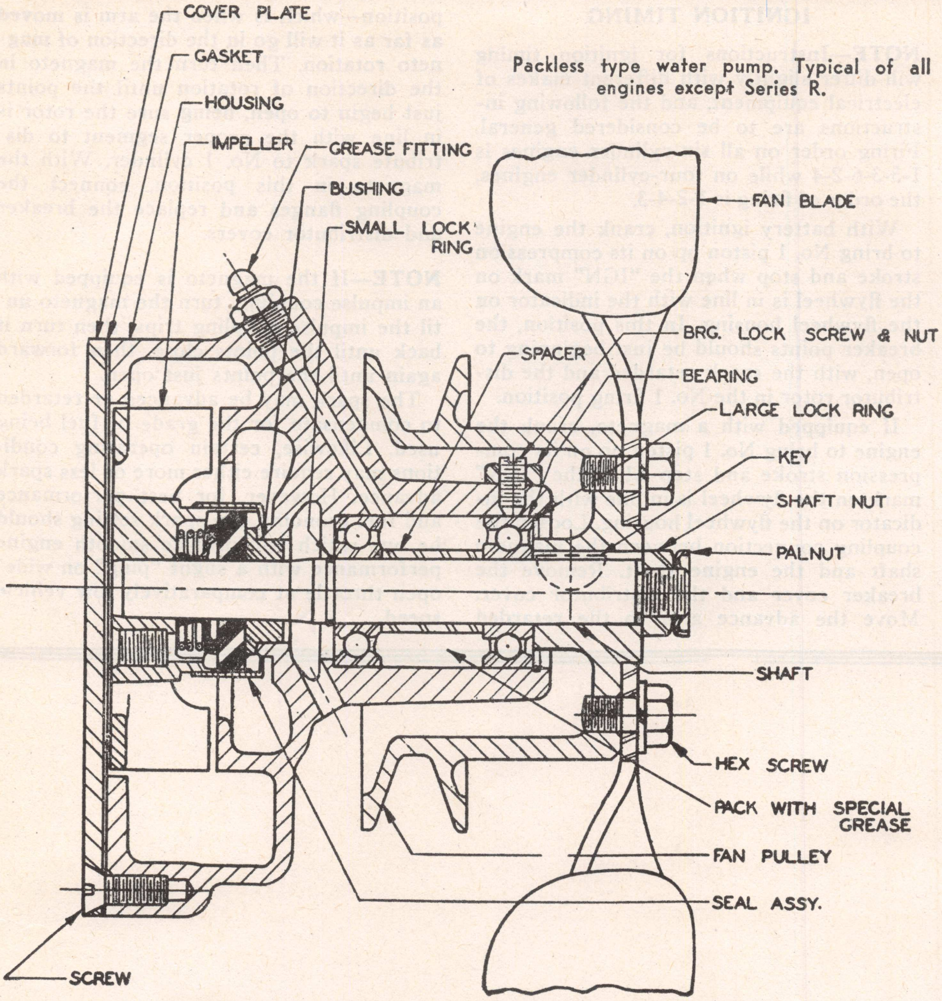
If the engine is fitted with an air cleaner, the latter should be removed and washed every 1,000 miles. After the element is washed, blow it dry with compressed air and, if the cleaner is of the oil-wetted type, dip the element in fresh engine oil before assembling. If it is of the oil-bath type,



Oil pressure relief valve. Engine C-400.



Oil pressure relief valve. Series F engines.



Packless type water pump. Typical of all engines except Series R.

wipe out the oil reservoir with a clean cloth and fill it to the proper level with fresh engine oil.

NOTE—The interval at which the ventilalator and air cleaner should be cleaned can only be determined by the type of service to which the vehicle is subjected. Vehicles operating in dusty or sandy areas require more frequent service than vehicles operating under more favorable conditions.

IMPORTANT—For vehicles operating in dust storm areas, the cleaner should be cleaned immediately after such storms occur.

COOLING SYSTEM

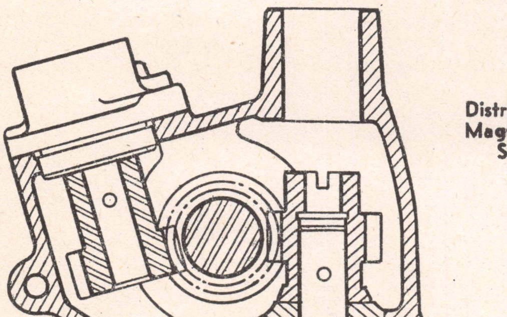
WATER PUMP, OVERHAUL

1936-46 Except R Series: The centrifugal water pump used on these engines is a front mounted ball-bearing, self-sealing type. It incorporates a carbon seal bearing against a stainless steel thrust face and should ordinarily give little trouble. The impeller is pressed on to the Nitralloy shaft and locked in place with a dog-tooth screw, obviating any chance of a loose impeller. The ball bearings are of the sealed type, packed at the factory. A pressure gun type of fitting with a low pressure pop-valve is assembled for greasing. This will require greasing only at very long intervals. The fan hub is locked to the bearing assembly by a nut on the front end of the shaft.

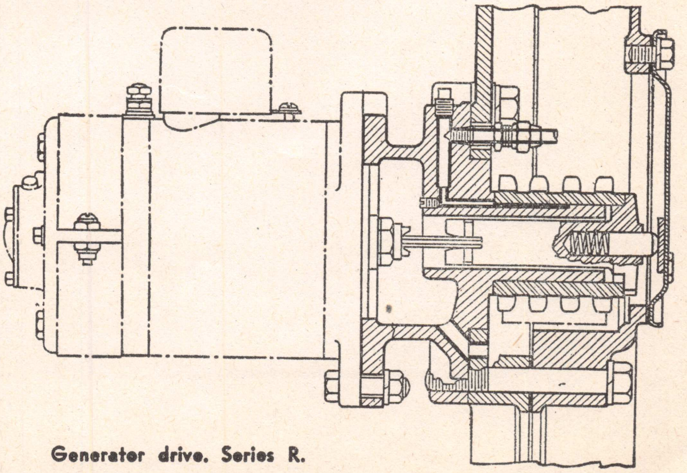
To dismantle the water pump, the following procedure should be followed:

1. Remove the six screws holding the cover or support to the body. The entire shaft and hub assembly can then be removed from the pump.
2. Remove impeller by loosening set screw.
3. The seal can be removed from the impeller by first removing the lock wire in the bore of the hub.
4. If you wish to remove the ball bearings, first remove fan hub and then the lock screw on top of the body.
5. To reassemble, reverse the procedure, noting remarks concerning the seal and impeller outlined above.

Series R: The pumps used on these engines are a separate assembly located on the camshaft side of the engine. The pump is bolted to the cylinder block, has a detachable flange coupling for the intake water hose and is driven by a flexible coupling. It can be removed without disturbing any



Distributor and Magneto drive. Series R.



Generator drive. Series R.

other accessories. There is one regular packing gland on the pump shaft. The other end of the pump is sealed with a cover plate which gives access to the pump impeller. The pump shaft is carried on a single plain bearing. To disassemble, it is only necessary to remove the rear cover. The shaft and centrifugal impeller then slips out. This pump should be lubricated with a good grade of calcium soap type grease in service and when reassembled.

FUEL SYSTEM

NOTE—For service information on Carburetors, Automatic Chokes, Carburetor Governors, Fuel Pumps, Air Cleaners and Gasoline Gauges, see the Table of Contents on page 1.

ELECTRIC SYSTEM

NOTE—For service information on Distributors, Magnetos, Generators, Generator Regulators, Starting Motors and Starting Switches, see the Table of Contents on page 1.

IGNITION TIMING

NOTE—Instructions for ignition timing will differ slightly with different makes of electrical equipment, and the following instructions are to be considered general. Firing order on all six-cylinder engines is 1-5-3-6-2-4 while on four-cylinder engines, the order of firing is 1-2-4-3.

With battery ignition, crank the engine to bring No. 1 piston up on its compression stroke and stop when the "IGN" mark on the flywheel is in line with the indicator on the flywheel housing. In this position, the breaker points should be just beginning to open, with the spark retarded and the distributor rotor in the No. 1 firing position.

If equipped with a magneto, crank the engine to bring No. 1 piston up on its compression stroke and stop when the "IGN" mark on the flywheel is in line with the indicator on the flywheel housing. Loosen the coupling connection between the magneto shaft and the engine shaft. Remove the breaker cover and the distributor cover. Move the advance arm to the retarded position—which is when the arm is moved as far as it will go in the direction of magneto rotation. Then turn the magneto in the direction of rotation until the points just begin to open, being sure the rotor is in line with the proper segment to distribute spark to No. 1 cylinder. With the magneto in this position, connect the coupling flanges and replace the breaker and distributor covers.

NOTE—If the magneto is equipped with an impulse coupling, turn the magneto until the impulse coupling trips, then turn it back until the points close, then forward again until the points just open.

The spark may be advanced or retarded to compensate for the grade of fuel being used. Likewise, certain operating conditions may require either more or less spark advance. However, for best performance and fuel economy, the spark setting should be one which will provide smooth engine performance with a slight "ping" on wide-open throttle at comparatively low vehicle speed.

DODGE GASOLINE ENGINES

Year	Engine Model ①	Number Cylinders and Valve Arrangement	Bore and Stroke	Displacement Cubic Inches	Compression Ratio	Taxable H. P.	Brake H. P. at R. P. M.	Maximum Torque at R. P. M. Pounds Feet	Oil Capacity Quarts
1936	T23, T25	6-L	3⅛x4⅜	201.30	5.8	23.44	70@3000	138@1200	6
	T26	6-L	3¼x4⅜	217.80	5.6	25.35	70@3000	150@1200	6
	T27	6-L	3⅜x4½	241.50	5.4	27.34	85@3200	170@1200	6
1937	T30, T38, T40	6-L	3⅜x4 1/16	218.06	6.5②	27.34	75@3000②	155@1200②	5
	T41	6-L	3⅜x4¼	228.12	5.8	27.34	78@3000	158@1200	5
	T42	6-L	3⅜x4½	241.50	5.8	27.34	85@3000	175@1200	5
	T43	6-L	3¾x5	331.34	5.2	33.75	100@2800	230@800	8
1938	T40, T58, T60	6-L	3⅜x4 1/16	218.06	6.5②	27.34	75@3000②	155@1200②	5
	T41, T48	6-L	3⅜x4¼	228.12	5.8	27.34	78@3000	158@1200	5
	T42	6-L	3⅜x4½	241.50	5.6	27.34	85@3000	175@1200	5
	T43	6-L	3¾x5	331.34	5.2	33.75	100@2800	230@800	8
1939	T68	6-L	3⅛x4⅜	201.30	6.7	23.44	70@3000	148@1200	5
	T70, T72	6-L	3¼x4⅜	217.76	6.5	25.35	77@3000	158@1200	5
	T74	6-L	3⅜x4 1/16	218.06	5.8	27.34	73@3000	150@1200	5
	T76	6-L	3⅜x4¼	228.12	5.8	27.34	78@2000	158@1200	5
	T78	6-L	3⅜x4½	241.50	5.6	27.34	85@3000	175@1200	5
	T80	6-L	3¾x5	331.34	5.2	33.75	100@2800	230@800	8
1940	T92	6-L	3⅛x4⅜	201.30	6.7	23.44	79@3000	154@1200	5
	T94, T96	6-L	3¼x4⅜	217.76	6.5	25.35	82@3000	166@1200	5
	T88, T98	6-L	3⅜x4¼	228.12	6.5	27.34	92@3000	176@1200	5
	T100	6-L	3⅜x4½	241.50	6.5	27.34	99@3000	188@1200	5
	T104	6-L	3¾x5	331.34	③	33.75	100@2800	230@800	8
1941	T112, T125	6-L	3⅛x4⅜	201.30	6.7	23.44	82½@3000	160@1200	5
	T114, T116	6-L	3¼x4⅜	217.76	6.5	25.35	85@3000	170@1200	5
	T118, T128	6-L	3⅜x4¼	228.12	6.5	27.34	92@3000	176@1200	5
	T120, T130	6-L	3⅜x4½	241.50	6.5	27.34	99@3000	188@1200	5
	T124	6-L	3¾x5	331.35	5.85	33.75	100@2800	240@800	8
1942-46	T112, T114, T125	6-L	3¼x4⅜	217.76	6.8	25.35	95@3600	172@1200	5
	T116	6-L	3¼x4⅝	230.20	6.8	25.35	105@3600	184@1300	5
	T118, T122	6-L	3 7/16x4¼	236.60	6.8	28.35	115@3800	190@1500	5
	T120, T130	6-L	3 7/16x4½	250.60	6.8	28.35	120@3800	200@1500	5
	T124	6-L	3¾x5	331.35	5.85	33.75	110@3200	240@800	8

① Engine model is identified as being the prefix to the engine serial number. For example, "T112-1001"; T112 is the engine model.

② For T40, compression ratio 5.8; brake H.P. 73@3000; torque 150@1200.

③ Standard 5.2; optional 5.8.

TUNE UP CHART

Year	Engine Model	Firing Order	Spark Plug Gap	Breaker Gap	Cam Angle, Degrees	Timing Mark Location	Spark Timing, Degrees	Tappet Clearance For Running, Hot Int.	Tappet Clearance For Running, Hot Exh.	Tappet Clearance For Timing, Intake	Battery Terminal Grounded
1936	T23, T25	153624	.025	.020	38	Vib. Damp.	3ATDC	.006	.010	.011	Positive
	T26	153624	.025	.020	38	Vib. Damp.	2ATDC	.006	.010	.011	Positive
	T27	153624	.025	.020	38	Vib. Damp.	TDC	.006	.010	.010	Positive
1937	T30, T38	153264	.025	.020	38	Vib. Damp.	TDC	.008	.012	.014	Positive
	T40	153624	.025	.020	38	Vib. Damp.	2BTDC	.008	.012	.014	Positive
	T41	153624	.025	.020	38	Vib. Damp.	4BTDC	.008	.012	.014	Positive
	T42	153624	.025	.020	38	Vib. Damp.	6BTDC	.008	.012	.014	Positive
	T43	153624	.025	.020	38	Vib. Damp.	2BTDC	.008	.012	.014	Positive

Continued on next page

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TUNE UP CHART

Year	Engine Model	Firing Order	Spark Plug Gap	Breaker Gap	Cam Angle, Degrees	Timing Mark Location	Spark Timing, Degrees	Tappet Clearance For Running, Hot Int.	Tappet Clearance For Running, Hot Exh.	Tappet Clearance For Timing, Intake	Battery Terminal Grounded
1938	T58, T60	153624	.025	.020	38	Vib. Damp.	TDC	.008	.012	.014	Positive
	T40	153624	.025	.020	38	Vib. Damp.	2BTDC	.008	.012	.014	Positive
	T41	153624	.025	.020	38	Vib. Damp.	4BTDC	.008	.012	.014	Positive
	T42	153624	.025	.020	38	Vib. Damp.	6BTDC	.008	.012	.014	Positive
	T43	153624	.025	.020	38	Vib. Damp.	2BTDC	.008	.012	.014	Positive
1939	T68, T70, T72	153624	.025	.020	38	Vib. Damp.	TDC	.006	.010	.011	Positive
	T74, T80	153624	.025	.020	38	Vib. Damp.	2BTDC	.008	.012	.014	Positive
	T76	153624	.025	.020	38	Vib. Damp.	4BTDC	.008	.012	.014	Positive
	T78	153624	.025	.020	38	Vib. Damp.	6BTDC	.008	.012	.014	Positive
1940	T92, T94, T96	153624	.025	.020	38	Vib. Damp.	TDC	.006	.010	.011	Positive
	T88, T98, T100	153624	.025	.020	38	Vib. Damp.	TDC	.008	.012	.014	Positive
	T104	153624	.025	.020	38	Vib. Damp.	①	.008	.012	.014	Positive
1941	T112, T125	153624	.025	.020	38	Vib. Damp.	TDC	.008	.010	.014	Positive
	T114, T116	153624	.025	.020	38	Vib. Damp.	TDC	.008	.010	.014	Positive
	T118, T128	153624	.025	.020	38	Vib. Damp.	TDC	.008	.012	.014	Positive
	T120, T130	153624	.025	.020	38	Vib. Damp.	TDC	.008	.012	.014	Positive
	T124	153624	.025	.020	38	Vib. Damp.	2ATDC	.008	.012	.014	Positive
1942–46	T112, T114, T125	153624	.025	.020	38	Vib. Damp.	3BTDC	.008	.010	.014	Positive
	T116	153624	.025	.020	38	Vib. Damp.	2ATDC	.008	.010	.014	Positive
	T118, T122	153624	.025	.020	38	Vib. Damp.	TDC	.008	.012	.014	Positive
	T120, T124, T130	153624	.025	.020	38	Vib. Damp.	2ATDC	.008	.012	.014	Positive

① With 5.2 head, 2 BTDC; with 5.8 head, 2ATDC.

VALVE SYSTEM

Year	Engine Model	Stem Clearance Intake	Stem Clearance Exhaust	Tappet Guide Clearance	Tappet Clearance Running Hot In-take	Tappet Clearance Running Hot Ex-haust	Tappet Clearance Timing In-take	Tappet Clearance Timing Ex-haust	Valve Spring Pressure Test Free Length, Inches	Valve Spring Pressure Test Pounds at Inches, Length	Valve Seat Angle Degrees
1936	T23, T26	.001–.003	.003–.005	.001–.003	.006	.010	.011	.012	2 1/16	77–83@1 7/16	45
	T25	.001–.003	.003–.005	.001–.003	.006	.010	.011	.012	2 1/16	75–81@1 7/16	45
	T27	.001–.003	.003–.005	.001–.003	.006	.010	.010	.010	2 7/16	104–110@1 11/16	45
1937	T30, T38, T40, T41, T42	.001–.003	.003–.005	.001–.003	.008	.012	.014	.014	2	101–109@1 13/32	45
	T43	.001–.003	.003–.005	.001–.003	.008	.012	.014	.014	3 5/8	90–98@2 3/4	45
1938	T58, T60, T40, T41, T42	.001–.003	.003–.005	.001–.003	.008	.012	.014	.014	2	101–109@1 13/32	45
	T43	.001–.003	.003–.005	.001–.003	.008	.012	.014	.014	3 5/8	90–98@2 3/4	45
1939	T68, T70, T72	.001–.003	.003–.005	.001–.003	.006	.010	.011	.012	2 1/16	77–83@1 7/16	45
	T74, T76, T78	.001–.003	.003–.005	.001–.003	.008	.012	.014	.014	2	101–109@1 13/32	45
	T80	.002–.004	.003–.005	.002–.004	.008	.012	.014	.014	3 5/8	90–98@2 3/4	45
1940	T92, T94, T96	.001–.003	.003–.005	.001–.003	.006	.010	.011	.012	2 1/16	77–83@1 7/16	45
	T88, T98, T100	.001–.003	.003–.005	.001–.003	.008	.012	.014	.014	2	107–115@1 3/8	45
	T104	.002–.004	.003–.005	.002–.004	.008	.012	.014	.014	3 5/8	90–98@2 3/4	45

Continued on next page

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VALVE SYSTEM

Year	Engine Model	Stem Clearance		Tappet Guide Clearance	Tappet Clearance				Valve Spring Pressure Test		Valve Seat Angle Degrees
					Running Hot		Timing				
		Intake	Exhaust		In-take	Ex-haust	In-take	Ex-haust	Free Length, Inches	Pounds at Inches, Length	
1941	T112, T114, T116, T125	.001-.003	.003-.005	.001-.003	.008	.010	.014	.014	2	107-115@1⅜	45
	T118, T120, T128, T130	.001-.003	.003-.005	.001-.003	.008	.012	.014	.014	2	107-115@1⅜	45
	T124	.002-.004	.003-.005	.002-.004	.008	.012	.014	.014	3⅝	90-98@2¾	45
1942-46	T112, T114, T116, T125	.001-.003	.003-.005	.001-.003	.008	.010	.014	.014	2	107-115@1⅜	45
	T118, T120, T122, T130	.001-.003	.003-.005	.001-.003	.008	.012	.014	.014	2	107-115@1⅜	45
	T124	.002-.004	.003-.005	.002-.004	.008	.012	.014	.014	3⅝	90-98@2¾	45

PISTON AND RING CLEARANCES

Year	Engine Model	Piston Skirt, Inches		Fitting Pistons with Shim and Spring Scale		Ring End Gap, Inch ①		Ring and Groove, Inch	
		Top	Bottom	Shim Thickness	Pounds Pull on Scale	Com-pression	Oil	Com-pression	Oil
1936	All	.0015	.0015	②	②	.007-.015	.007-.015	.002-.003	.002-.003
1937	T30, T38, T40, T41	.0005-.001	.0005-.001	.002	4 to 7	.007-.015	.007-.015	.0015-.003	.0015-.003
	T42	.002	.002	.002	4 to 7	.007-.015	.007-.015	.0015-.003	.0015-.003
	T43	.003	.003	.003	12 to 19	.007-.015	.007-.015	.0015-.003	.0015-.003
1938	T58, T60, T40, T41	.0005-.001	.0005-.001	.002	4 to 7	.007-.015	.007-.015	.0015-.003	.0015-.003
	T42	.002	.002	.002	4 to 7	.007-.015	.007-.015	.0015-.003	.0015-.003
	T43	.003	.003	.003	12 to 19	.007-.015	.007-.015	.0015-.003	.0015-.003
1939	T68	.0005-.001	.0005-.001	.002	4 to 7	.007-.015	.007-.015	.0015-.003	.0015-.003
	T70, T72	.0015	.0015	.002	10 to 16	.007-.015	.007-.015	.0015-.003	.0015-.003
	T74, T76, T78	.001	.001	.002	5 to 7	.007-.015	.007-.015	.0015-.003	.0015-.003
	T80	.003	.003	.003	4 to 7	.007-.015	.007-.015	.0015-.003	.0015-.003
1940	T88, T92, T98, T100	.002	.002	.002	5 to 7	.007-.015	.007-.015	.0015-.003	.0015-.003
	T94, T96	.0015	.0015	.0015	10 to 16	.007-.015	.007-.015	.0015-.003	.0015-.003
	T104	.003	.003	.003	12 to 19	.007-.015	.007-.015	.0015-.003	.0015-.003
1941	T112, T118, T120, T125, T128, T130	.002	.002	.002	5 to 7	.007-.015	.007-.015	.0015-.003	.0015-.003
	T114, T116	.0015	.0015	.0015	10 to 16	.007-.015	.007-.015	.0015-.003	.0015-.003
	T124	.003	.003	.003	12 to 19	.007-.015	.007-.015	.0015-.003	.0015-.003
1942-46	All	③	③	③	③	.007-.015	.007-.015	.0015-.003	.0015-.003

① Ring end gap clearances are for cylinder bores without taper. Fit rings in tapered bores with not less than the maximum figure given in the table.

② Piston should pass on a .001″ feeler and be tight on a .002″ feeler.

③ For engine T124, use 1941 specifications. All other 1942 engines have either steel-strut, U-slot or cast iron pistons. For steel-strut pistons, fit with a .0015″ feeler with a 10 to 17-pound pull on scale: U-slot pistons are fitted with a .002″ feeler with a 6 to 8-pound pull, while on cast iron pistons, use a .0015″ feeler with a 10 to 15-pound pull.

ENGINE BEARING SPECIFICATIONS

Year	Engine Model	Camshaft		Connecting Rod			Mains				
		Journal Diameter	Clearance	Journal Diameter	Clearance	Bearing Bolt Tension Lb. Ft.	Journal Diameter	Clearance	Bearing Bolt Tension Lb. Ft.	Thrust on No.	End-play
1936	T23	①	.0015–.003	1.9365–1.9375	.0005–.0025	53–57	2.249–2.250	.0015–.0025	75–80	4	.004–.008
	T25	①	.0015–.003	1.9365–1.9375	.001–.003	53–57	2.249–2.250	.0015–.0025	75–80	4	.004–.008
	T26	①	.0015–.003	2.0615–2.0625	.001–.003	53–57	2.499–2.500	.0015–.0025	75–80	4	.004–.008
	T27	②	.001–.0035	2.0615–2.0625	.001–.0025	53–57	2.499–2.500	.0015–.0025	75–80	4	.004–.008
1937	T30, T38, T40, T41, T42	①	.0015–.0035	2.0615–2.0625	.001–.003	53–57	2.499–2.500	.001–.002	75–80	4	.003–.007
	T43	③	.002–.004	2.3115–2.3125	.001–.003	53–57	2.999–3.000	.0015–.004	75–80	7	.004–.008
1938	T58, T60, T40, T41, T42	①	.0015–.0035	2.0615–2.0625	.001–.003	53–57	2.499–2.500	.001–.002	75–80	4	.003–.007
	T43	③	.002–.004	2.3115–2.3125	.001–.003	53–57	2.999–3.000	.0015–.004	75–80	7	.004–.008
1939	T68	①	.0015–.0035	1.9365–1.9375	.0005–.0025	53–57	2.249–2.250	.001–.002	75–80	4	.003–.007
	T70, T72	①	.0015–.0035	2.0615–2.0625	.001–.003	53–57	2.499–2.500	.001–.002	75–80	4	.003–.007
	T74, T76, T78	①	.0015–.0035	2.124–2.125	.001–.003	53–57	2.499–2.500	.001–.002	75–80	4	.003–.007
	T80	③	.002–.004	2.3115–2.3125	.001–.003	53–57	2.999–3.000	.0015–.004	75–80	7	.004–.008
1940	T92	①	.002–.004	2.3115–2.3125	.001–.003	53–57	2.249–2.250	.0015–.003	75–80	4	.003–.008
	T88, T94, T96 T98	①	.002–.004	2.0615–2.0625	.001–.003	53–57	2.499–2.500	.0015–.003	75–80	4	.003–.008
	T100	①	.002–.004	2.124–2.125	.001–.003	53–57	2.499–2.500	.0015–.003	75–80	4	.003–.008
	T104	③	.002–.004	2.3115–2.3125	.001–.003	53–57	2.999–3.000	.0015–.003	75–80	7	.003–.008
1941	T112, T125	①	.002–.004	1.9365–1.9375	.001–.003	53–57	2.249–2.500	.0015–.003	75–80	4	.003–.008
	T114, T116	①	.002–.004	2.0615–2.0625	.001–.003	53–57	2.499–2.500	.0015–.003	75–80	4	.003–.008
	T118, T120 T128, T130	①	.002–.004	2.124–2.125	.001–.003	53–57	2.499–2.500	.0015–.003	75–80	4	.003–.008
	T124	③	.002–.004	2.3115–2.3125	.001–.003	53–57	2.999–3.000	.0015–.003	75–80	7	.003–.008
1942–46	T112, T114, T116, T125	①	.002–.004	2.0615–2.0625	.001–.003	53–57	2.499–2.500	.0015–.003	75–80	4	.003–.008
	T118, T120, T122, T130	①	.002–.004	2.124–2.125	.001–.003	53–57	2.499–2.500	.0015–.003	75–80	4	.003–.008
	T124	③	.002–.004	2.3115–2.3125	.001–.003	53–57	2.999–3.000	.0015–.003	75–80	7	.003–.008

① No. 1, 2″. No. 2, 1 31/32″. No. 3, 1 15/16″. No. 4, 1¼″.

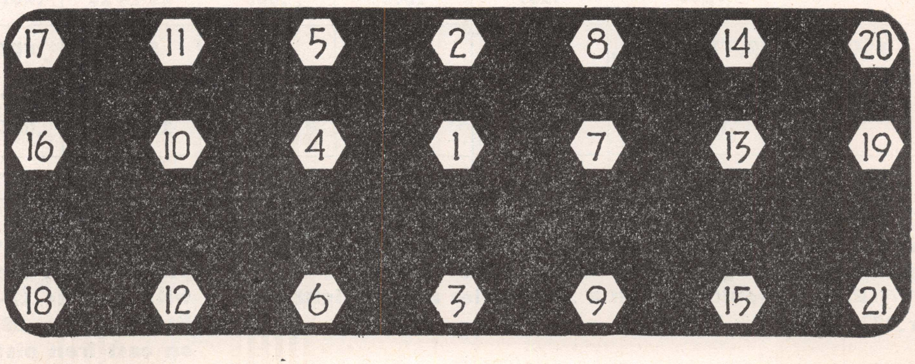
② No. 1, 2 1/16″. No. 2, 1 31/32″. No. 3, 1 15/16″. No. 4, 1⅝″.

③ No. 1, 2¼″. No. 2, 2 5/32″. No. 3, 2⅛″. No. 4, 1⅝″.

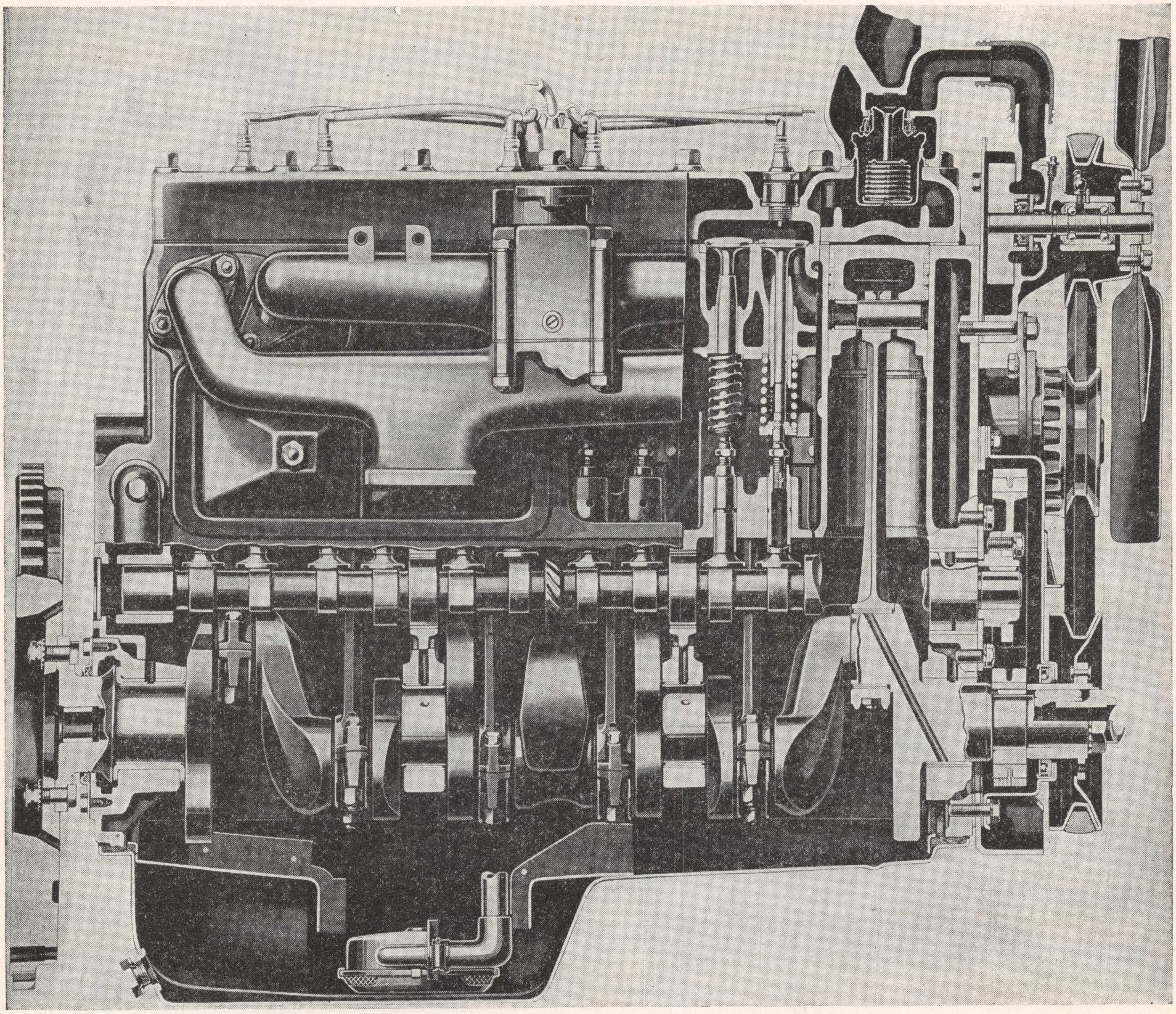
ENGINE

CYLINDER HEAD

1936-46 All: When installing a cylinder head, always use a new gasket. Make sure the gasket, cylinder head and cylinder block are clean and free from carbon and dirt. Tighten cylinder head nuts or capscrews in the sequence shown, drawing them down evenly, repeating the operation until they are tight. On engines with iron cylinder heads, make a final tightening after the engine has been run to bring it to operating temperature. When using a torque indicating wrench, the final tighten-



Cylinder head tightening sequence. 1936-46.



Side sectional view of engines T-118, T-120, T-122, T-128, T-130.

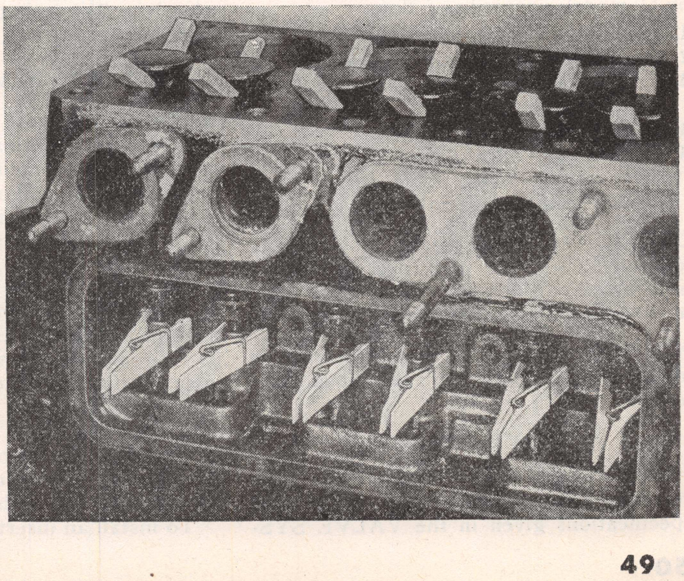
ing should be within these limits: cylinder head nuts 52.5 to 57.5 lbs.-ft., cylinder head capscrews (plain head) 65 to 70 lbs.-ft., cylinder head capscrews (cupped head) 67.5 to 72.5 lbs.-ft.

VALVES, REMOVE

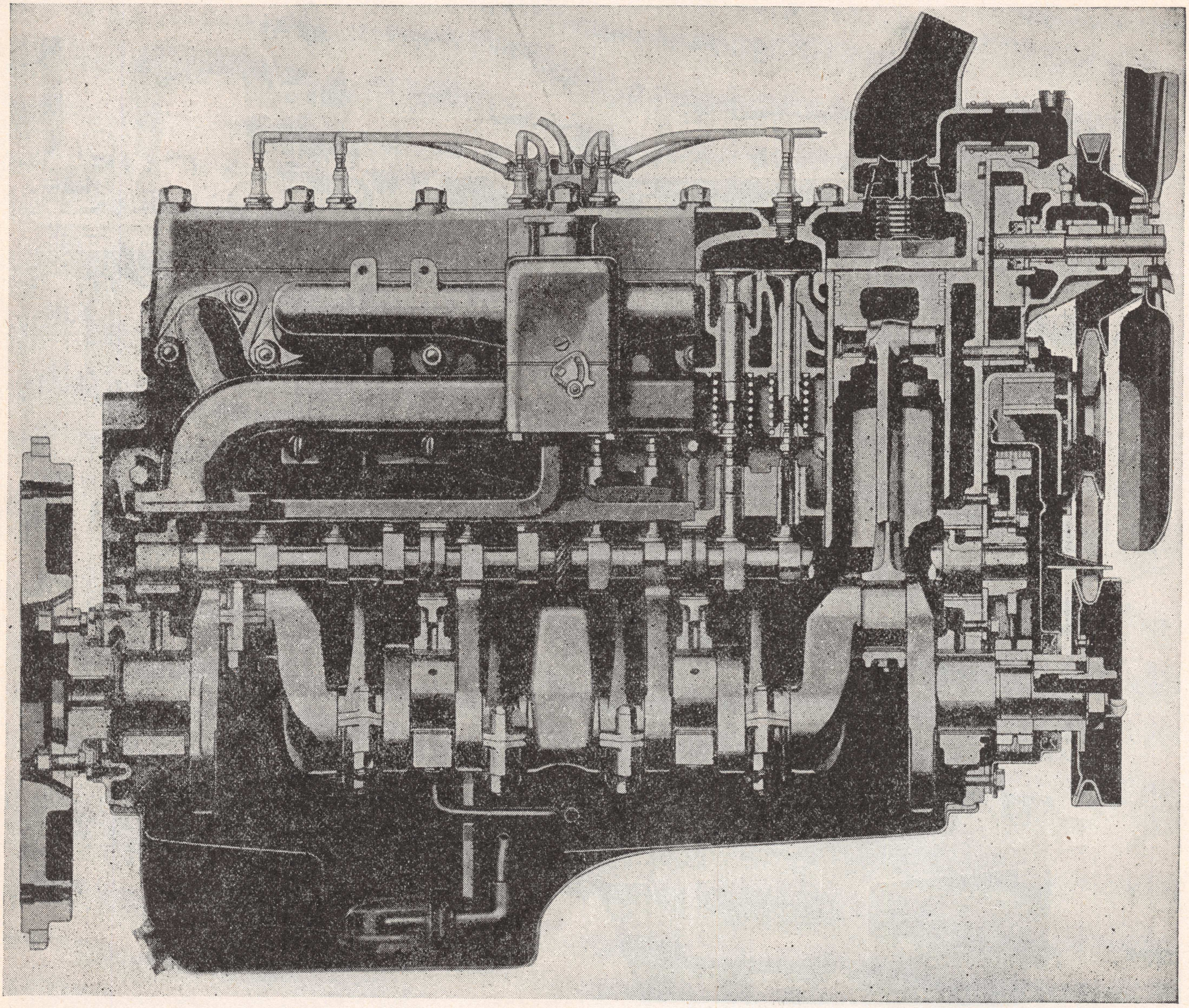
1936-39: To remove valves: (1) Drain water from radiator. (2) Remove cylinder head and gasket. (3) Remove valve cover plates. (4) Remove valve locks after compressing valve springs with valve compressor tool, and lift out valves.

CAUTION—Plug holes in cylinder block around valve tappets so that valve locks will not fall in oil pan when being removed from valves.

1940-46: To remove or grind valves on Cab-Over-Engine models, first remove the following parts: All floor boards, radiator shell, core and support assembly, fender and body tie bar, fender inspection shields



Method of holding up valves and tappets for camshaft removal. 1936-46 except engines T-43, T-80, T-104 and T-124.



Side sectional view of engines T-112, T-114, T-116, T-125.

and air cleaner and air cleaner tube. Then on all models proceed as follows:

1. Drain water from radiator.
2. Remove cylinder head and gasket.
3. Remove right front wheel and lower wheel housing panel.
4. Remove valve cover plates.
5. Remove valve locks after compressing valve springs with valve spring compressor and lift out valves.

CAUTION—Use care when removing valve locks to make sure that they do not fall into the oil pan through the oil drain holes in cylinder block around the valve tappets.

NOTE—A valve lock installing tool is available to facilitate replacement of valve locks.

VALVE SPRINGS

1936-46 All: Check valve springs whenever removed, and replace any that do not meet specifications given in the VALVE SYSTEM table. Install valve springs with closely coiled ends to the top against cylinder block.

EXHAUST VALVE SEAT INSERTS

1936-46: Since these inserts are too hard to reface by the ordinary grinding methods, a high-speed grinding stone or a special lapping tool should be used to perform this operation. When using this equipment, be sure valve guides are clean and that the valve guide pilot is a snug fit in order to assure a concentric finish. Finished seats should be checked with a dial indicator and run-out should not exceed .0005".

To remove an insert—if special equipment is not available—use a drill which is smaller in diameter than the insert width and drill two holes at opposite sides, but not all the way through. Cut through the undrilled portion of the insert with a sharp chisel and remove the two pieces.

To install an insert, pack in "dry ice" for at least fifteen minutes to allow the metal to contract, and heat the exhaust valve port area gradually, if necessary, to permit this material to expand. Then press the insert into the cylinder head, using extreme care to see that it is not cocked or misaligned, after which, peen securely. When installed, finish the seats with the grinding or lapping equipment already mentioned

NOTE—If a standard insert is too loose, a .010" oversize is availale. Suitable counter boring cutting tools should be used to cut the insert bore to accommodate the oversize insert.

VALVE STEM GUIDES

1936-46: A special tool is available to remove and install valve stem guides. After new guides are installed, ream them to provide the valve stem clearance given in the VALVE SYSTEM table. When installing guides, see that each new guide is pressed in so that the top of the guide is the correct distance from the top of the cylinder block as given below.

NOTE—On all engines, install the exhaust valve guides with the tapered end **down** and intake guides with the tapered end **up**. Position the guides so that the distance from the top face of the cylinder block to the top of the guide is ⅞" on all engines except T43, T80, T104 and T124; on these latter engines, the distance should be 11/16".

VALVE TAPPETS AND GUIDES

1936: Remove valve tappet cover plates and adjust valve tappets with engine at operating temperature to the clearances specified in VALVE SYSTEM table. For sustained high speed driving, .002" additional tappet clearance is recommended on the exhaust tappets.

All models have valve tappet guides integral with crankcase. Replacement tappets are available in .001, .008, .030, and .060-inch oversize. If such integral tappet guides are excessively worn, remove tappets, ream the guides and install oversize tappets. To remove these tappets take out the camshaft as described under CAMSHAFT, remove the oil pan and take the tappets out through the bottom of the engine. To ream the tappet guides, remove the cylinder head and valves in order to insert the reamer pilot.

1940-46: Remove valve tappet cover plates and adjust valve tappets, with engine at operating temperature, to the clearances specified in VALVE SYSTEM table.

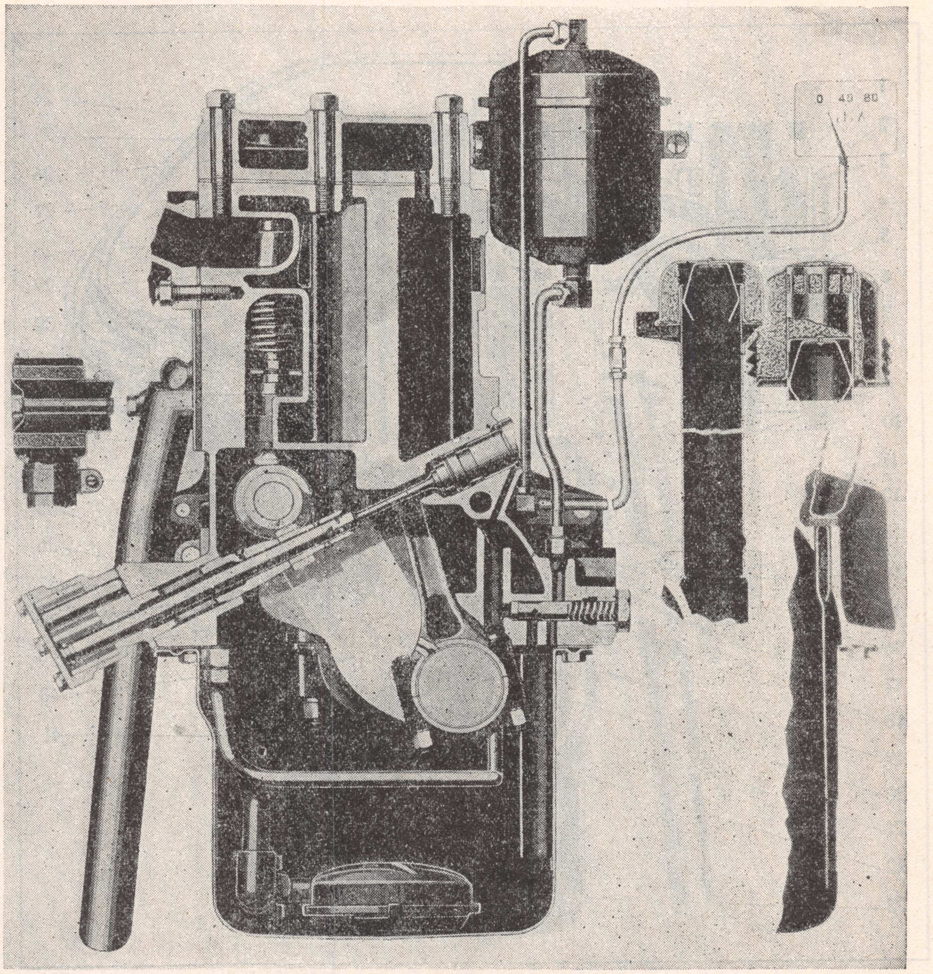
Engine models T43 and T80 have removable valve tappet guide assemblies and worn guides may be replaced. To take tappets out, remove valve cover plates, tappet guide retaining screws, dowels and guide assemblies. Other models have valve tappet guides integral with crankcase. If such integral tappet guides are excessively worn, ream the guides and install oversize tappets as described above.

1940-46: Remove valve tappet cover plates and adjust valve tappets, with engine at operating temperature, to the clearances specified in VALVE SYSTEM table. On all models except T104 and T124, the valve tappet screws are of the self-locking type, without lock nuts.

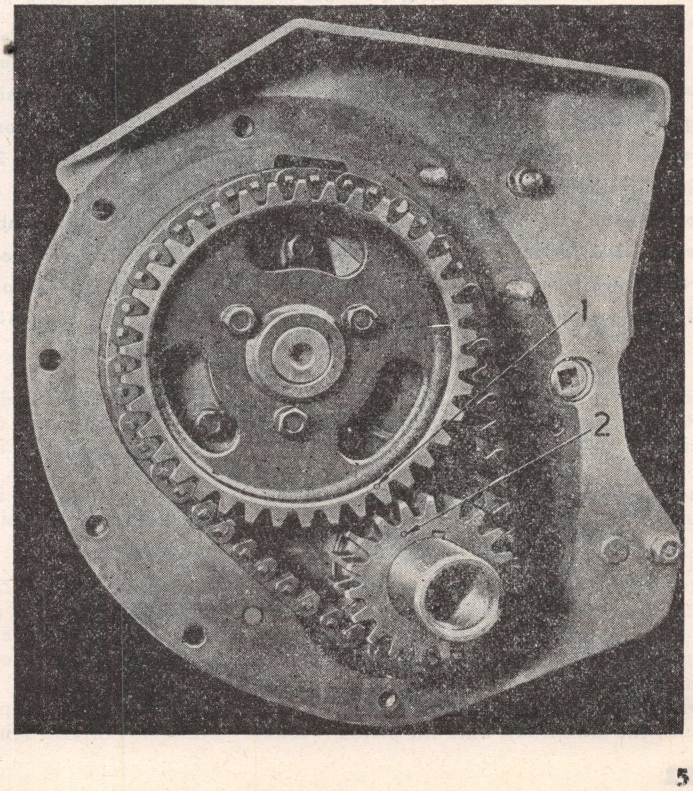
Engine models T104 and T124 have removable valve tappet guide assemblies and worn guides may be replaced. To take tappets out, (1) remove right front wheel and inspection shield. (2) Remove carburetor. (3) Remove valve tappet cover plates. (4) Turn the engine until the tappets in one of the banks are loose and remove tappets and guide assembly. Repeat this operation and remove the other valve tappet guide assembly. Other models have valve tappet guides integral with crankcase. If such integral tappet guides are excessively worn ream the guides and install oversize tappets as described above.

VALVE TIMING

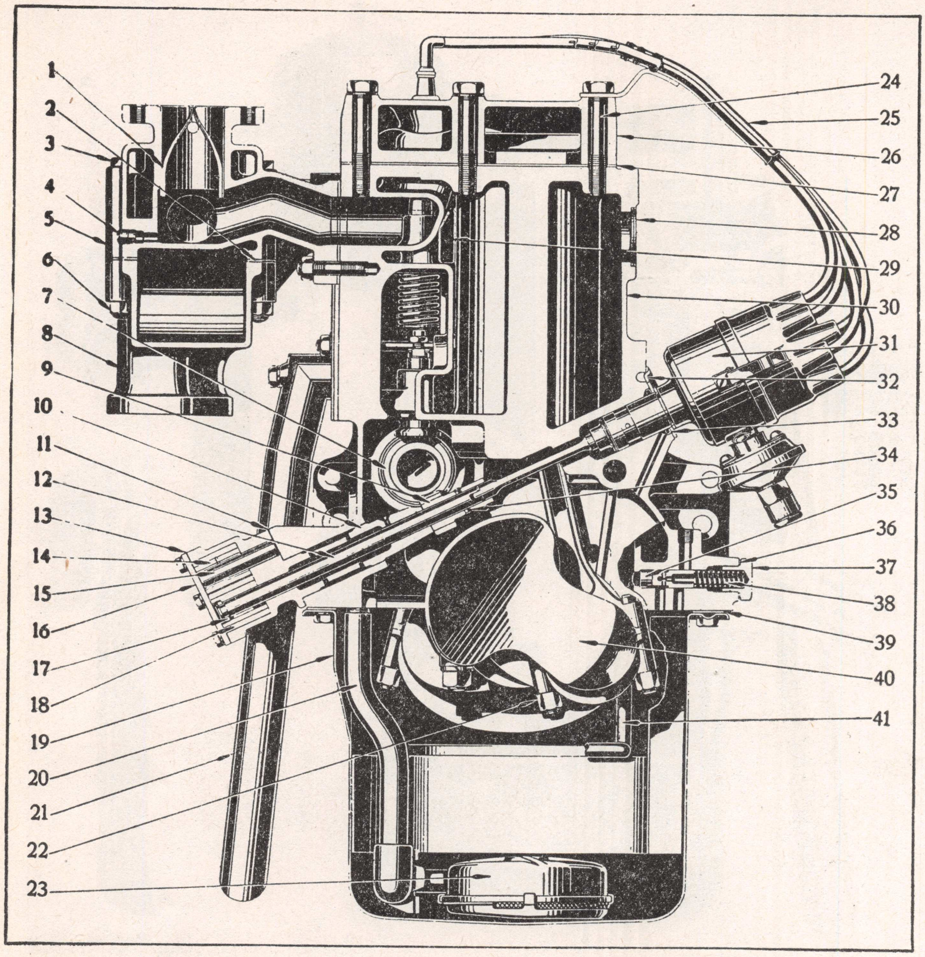
To check valve timing with piston travel, screw timing indicator into timing plug hole



Center sectional view of engines T-112, T-114, T-116, T-125.



Showing position of sprocket marks when valves are timed correctly. 1936-46.



Center sectional veiw of engines T-118, T-120, T-128, T-130.

1—Manifold fuel centralizer. 2—Intake to exhaust manifold gasket. 3—Intake to exhaust manifold screw. 4—Manifold drain plug. 5—Intake manifold. 6—Manifold screw nut. 7—Camshaft. 8—Exhaust manifold. 9—Oil pump and distributor drive gear. 10—Oil pump body. 11—Body gasket. 12—Oil pump drive shaft. 13—Pump cover gasket. 14—Oil pump idler gear and bushing. 15—Oil pump idler gear shaft. 16—Oil pump cover. 17—Oil pump drive gear retainer. 18—Oil pump drive gear. 19—Oil pan. 20—Oil pump suction pipe. 21—Crankcase ventilator outlet pipe. 22—Connecting rod cap bolt nut. 23—Oil pump strainer. 24—Cylinder head screw. 25—Ignition cable tube. 26—Cylinder head. 27—Cylinder head gasket. 28—Cylinder block core hole plug. 29—Cylinder block water distributor tube. 30—Cylinder block. 31—Distributor assembly. 32—Distributor lock plate. 33—Distributor oil retainer. 34—Oil pump and distributor drive gear pin. 35—Oil pressure relief valve plunger. 36—Oil pressure relief valve cap gasket. 37—Oil pressure relief valve cap. 38—Oil pressure relief valve spring. 39—Oil pan gasket. 40—Crankshaft. 41—Oil pump outlet pipe.

in cylinder head over front or rear cylinder. Also, degree marks are on crankshaft pulley rim.

With engine at normal room temperature, adjust valve tappets of cylinder having timing plug hole to the clearance for timing (engine cold) specified in the VALVE SYSTEM table. Crank engine slowly until No. 1 or No. 6 piston, as the case may be, comes up on exhaust stroke (exhaust valve open) to position specified for intake valve to open. At this point check to see that the intake valve tappet is tight against the valve stem if timing is correct. Continue to turn the crankshaft until the piston reaches the position specified for exhaust valve to close. At this point check to see that the exhaust valve tappet is just starting to leave the end of the valve stem if timing is correct. If valve timing is not right check setting of camshaft timing chain sprockets or timing gears.

1936: For engines T23, T25 and T26, intake opens 6° after TDC and exhaust closes 8° after TDC. For T27 engine, intake opens at TDC and exhaust closes 2° after TDC.

1937-38: Adjust tappets and check No. 1 cylinder. For all engines except T43, intake opens T.D.C., exhaust closes 2 degrees or .002" A.T.D.C.

For T43, intake opens 6 degrees or .017" A.T.D.C., exhaust closes 8 degrees or .030" A.T.D.C.

1939: For engines T68 and T70, intake opens 6 degrees or .0153" A.T.D.C., exhaust closes 8 degrees or .0271" A.T.D.C.

Model T74, intake opens 8 degrees or .0247" B.T.D.C., exhaust closes 2 degrees or .0015" A.T.D.C.

Model T76, intake opens 8 degrees or .0261" B.T.D.C., exhaust closes 2 degrees or .0016" A.T.D.C.

Model T78, intake opens 8 degrees or .0281" B.T.D.C., exhaust closes 2 degrees or .0018" A.T.D.C.

Model T80, intake opens 6 degrees or .0170" A.T.D.C., exhaust closes 8 degrees or .0301" A.T.D.C.

1940: Adjust tappets and check No. 6 cylinder. On Model T88, remove center floor board to install timing indicator.

Models T92, T94, intake opens 6 degrees or .015" A.T.D.C., exhaust closes 8 degrees or .027" A.T.D.C.

Models T88, T98, T100, intake opens 12 degrees or .059" B.T.D.C., exhaust closes 6 degrees or .015" A.T.D.C.

Model T104, intake opens 6 degrees or .017" A.T.D.C., exhaust closes 8 degrees or .030" A.T.D.C.

1941: Adjust tappets and check No. 6 cylinder. On Cab-Over-Engine models, remove center floor board to install timing indicator.

Models T112, T114, T125, before engine serial No. T125-1460 intake opens 12 degrees B.T.D.C., exhaust closes 6 degrees A.T.D.C. After engine serial No. T125-1459 intake opens 9 degrees or .034" B.T.D.C. exhaust closes 9 degrees or .034" A.T.D.C.

Models T118, T122, T120, T128, T130, intake opens 12 degrees or .059" B.T.D.C., exhaust closes 6 degrees or .015" A.T.D.C.

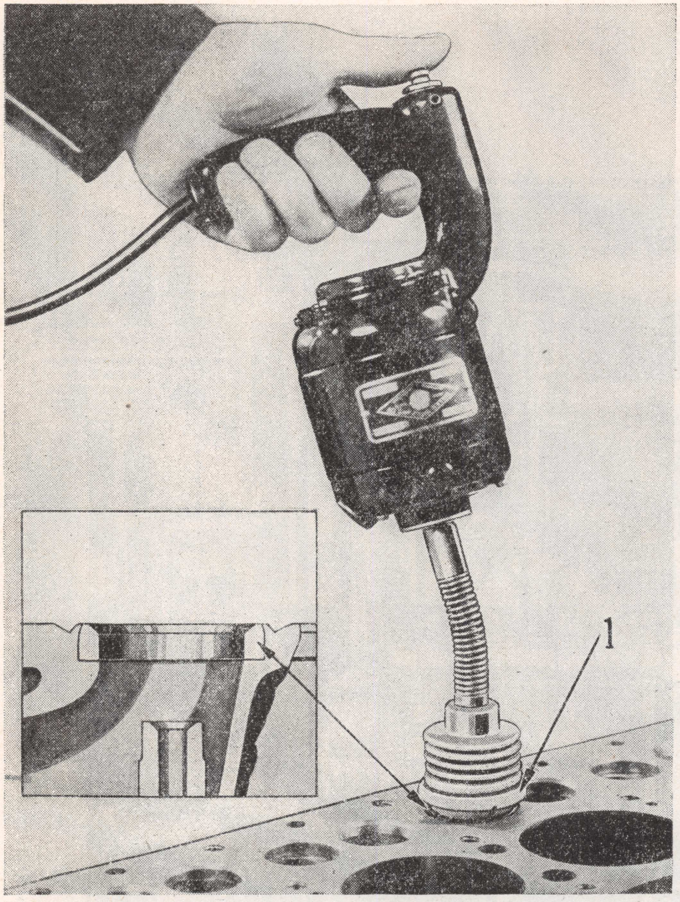
Model T124, intake opens 6 degrees or .017" A.T.D.C., exhaust closes 8 degrees or .030" A.T.D.C.

1942-46: T112, T114, T118, T125, T120, T122, T128, T130, intake opens 12 degrees B.T.D.C., exhaust closes 6 degrees A.T.D.C. Model T124 intake opens 6 degrees A.T.D.C., exhaust closes 8 degrees A.T.D.C.

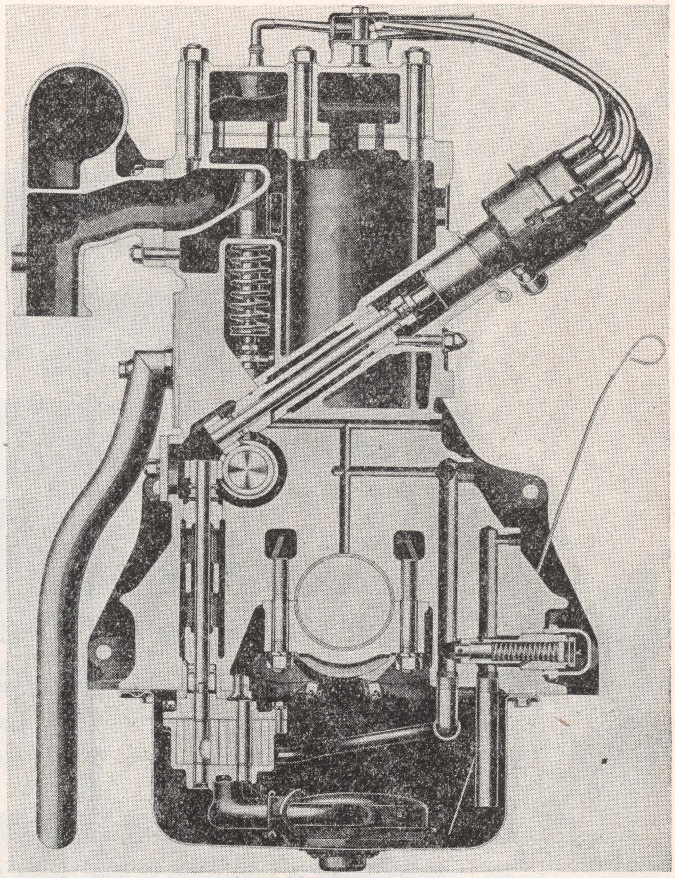
TIMING CHAIN AND SPROCKETS

1936-46: The timing chain has no adjustments. To remove timing chain or sprockets, remove crankshaft pulley, support the engine under the front end, then remove front engine support and chain case cover. Remove camshaft sprocket hub bolts and lift off camshaft sprocket and timing chain. To remove crankshaft sprocket use suitable puller. To assemble, reverse the procedure—place the timing chain over the sprockets and with the chain in place, bolt the camshaft sprocket to its hub.

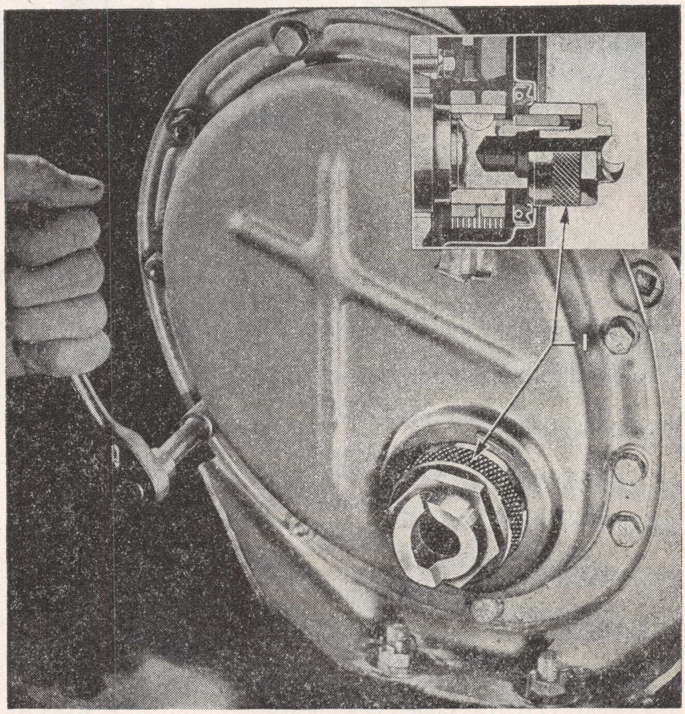
CAUTION—Be certain that the timing marks on the crankshaft and camshaft sprockets are immediately opposite each



Grinding exhaust valve seat inserts. 1936-46.



Center section view of engine T-124.



Chain case cover centering tool is to be held by the starting crank jaw while tightening cover. Tighten jaw finger tight only. 1936-46.

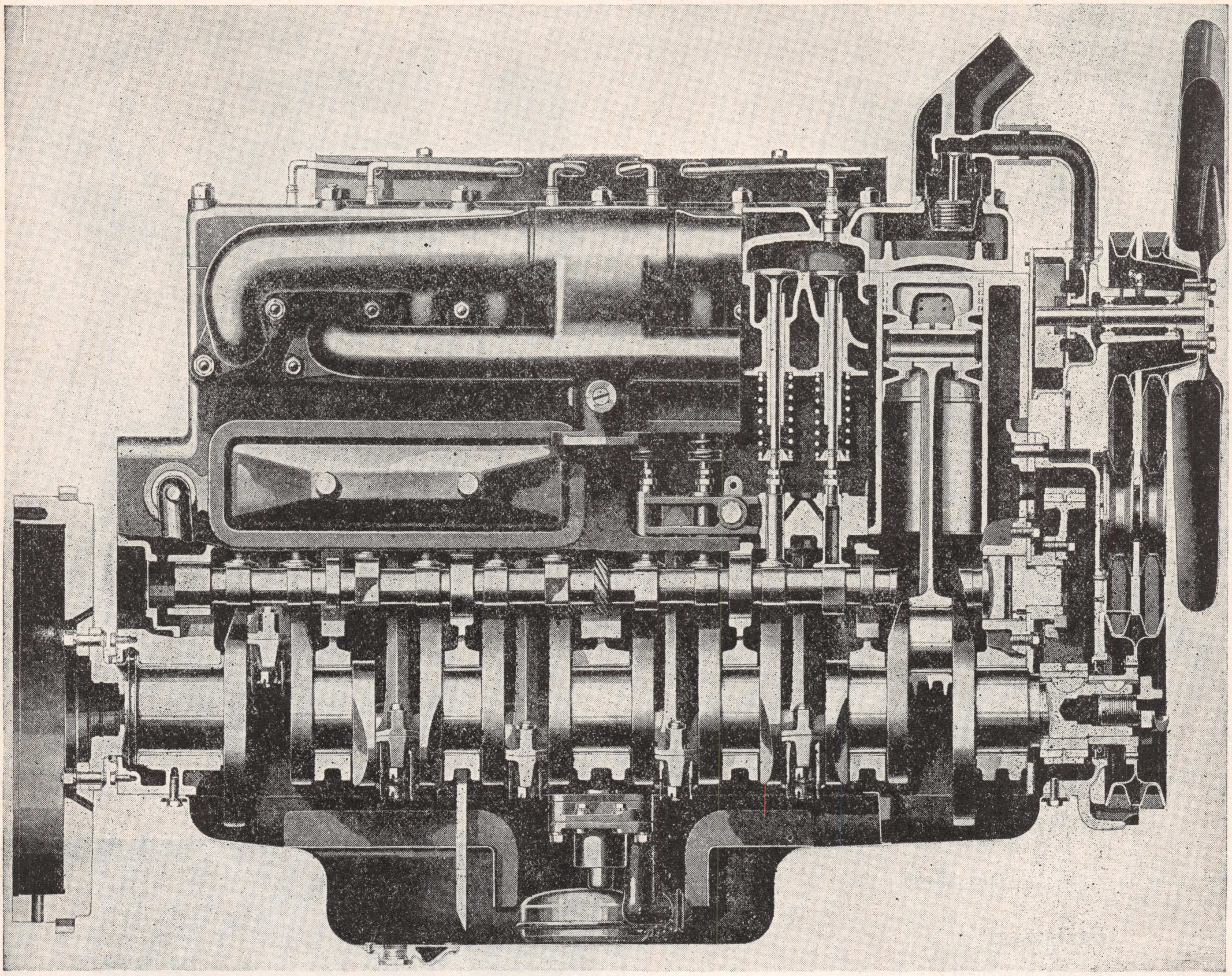
other and on a straight line between the sprocket centers.

CAMSHAFT

1936-46: To remove camshaft or thrust plate, drain cooling system and remove fuel pump, oil pump and valve tappet cover plates. Remove crankshaft pulley, front engine support, timing chain case cover, camshaft sprocket, and timing chain as explained under TIMING CHAIN AND SPROCKETS. Unless tappet guide assemblies are removable (see below), remove cylinder head and raise valves. Hold them up by inserting two wooden wedges under each valve head, at opposite points, to prevent cocking or warping of the valve head. Lift the valve tappets so they clear the cams and hold them up with spring type clothes pins. Then remove camshaft thrust plate screws and withdraw the camshaft, rotating it if the cams meet any obstruction. Press off the thrust plate and collar in an arbor press.

Models T43, T80, T104 and T124, have removable valve tappet and guide assemblies, and oil pump in base. On these models remove tappet and guide assemblies—see VALVE TAPPETS AND GUIDES—leaving cylinder head intact.

Remove the crankshaft pulley, oil pan, oil pump and screen. Remove the oil pump drive shaft by removing the upper support screw. Also remove tlhe distributor. Remove the distributor drive shaft by removing the bushing retainer screw, then remove the inspection hole cover on the right side of the engine at the center below the valve tappet cover plates, and push the shaft out through the distributor shaft opening. Then having removed fuel pump, timing chain, etc., as on other models, remove camshaft thrust plate screws and withdraw the camshaft.



Side sectional view of engine T-124.

NOTE—On Models T104 and T124, remove the hood and headlamps, then remove radiator shell, core and fenders as an assembly.

To install the camshaft, reverse the foregoing operations, using new gaskets. Reset the ignition timing and check the valve tappet clearance with the engine hot.

End play should be .002" to .006" **except** Models T27, T43, T80, in which case, end play should be .003" to .005".

CAMSHAFT BEARINGS

1936-46: Camshaft bearings (except rear) are removable but seldom have to be replaced. If the bearing clearance is excessive according to ENGINE BEARING SPECIFICATIONS table, new bearings may be pressed in place after the camshaft and defective bearings have been removed. Replacement bearings are finished to such close limits when manufactured that they do not require reaming, scraping or burnishing.

PISTONS & RODS, REMOVE

1936-46: On all engines, pistons and rods are removed from the top of the cylinder block. Although regular production rods are marked with the cylinder number in which they are installed, replacement rods are not; therefore, unmarked rods should be suitably identified with punch-marks, as removed.

PISTON & ROD, ASSEMBLE

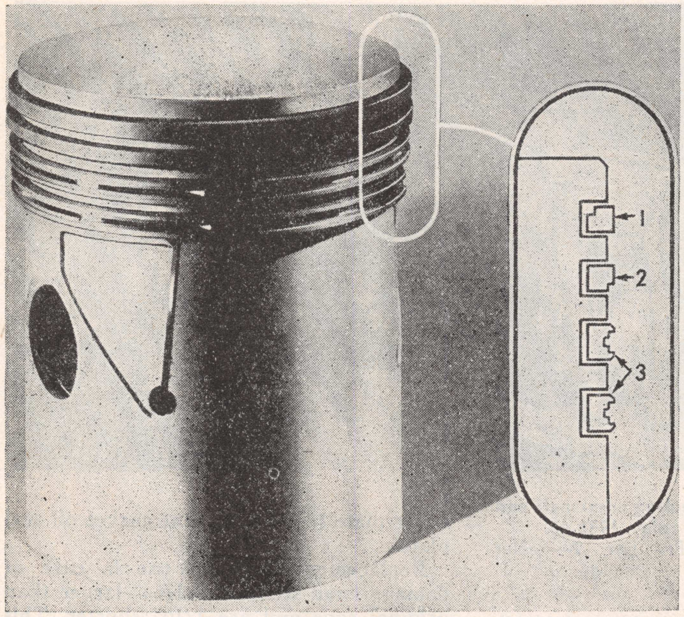
1936-46: When correctly assembled, the oil spray hole in the upper half of the connecting rod must be on the camshaft side of the engine with the T-slot side of the piston opposite to the camshaft side.

PISTONS, RENEW

1936-46 All: NOTE—A variation of 10 degrees between the temperature of the pistons and cylinder bores is sufficient to produce a difference of .0005". Therefore, both the pistons and cylinder bores should be at normal room temperature (about 70 degrees) when fitting pistons. This is particularly important because the clearances given in the PISTON & RING CLEARANCES table are minimum and pistons must not be fitted with less than specified.

Before any attempt is made to fit new pistons, cylinder bores should be carefully indicated and refinished. If bores are out-of-round in excess of .002" or tapered in excess of .0015", they should be refinished. If bores do not require refinishing, be sure to remove the ridge at the top of each bore. If refinishing is required, it is good practice to do so in alternate cylinders due to the localized temperature build-up. Cylinder bores should not be out-of-round or tapered more than .0005" when refinished.

Before fitting pistons, wipe the cylinder walls and pistons to remove all chips, dirt or other foreign matter. The feeler ribbon used to check piston fit should be about 12" long and ½" wide. Consult the PISTON & RING CLEARANCES table for the thickness of shim to use, as well as the recom-



Piston ring installation. 1941-46.

Checking side clearance in piston groove. 1936-46.

mended pounds pull on a spring scale required to withdraw the feeler ribbon past the piston.

Insert the piston in the bore upside down and in its running position (see PISTON & ROD, ASSEMBLE). Place the feeler ribbon between the cylinder wall and the thrust side of the piston (opposite slotted side) in a position at right angles to the piston pin hole.

After assembling the piston to the connecting rod, check the assembly for alignment on a suitable jig.

Check the size of stock pistons by measuring with a micrometer across the piston pin support ribs on the piston skirt. Pistons are available in .003", .005", .010", .015", .023", .025", .030", .040", .050", and .060" oversize.

Pistons with skirts semi-finished are available in two sizes, namely: for cylinder bores from standard to .023" oversize, and for cylinder bores from .025" to .050" oversize. Piston ring grooves and heads of these pistons are completely finished so that only the skirts require finishing. Ring grooves and heads for .025" to .050" oversize are larger than for standard to .023" oversize, so do not attempt to use the former to make a finished piston in the latter size range.

These semi-finished pistons must be finished elliptical with proper cam grinding equipment. They must not be finished circular. In operation, expansion takes place on the narrow or pin diameter, causing the piston to assume a shape more nearly conforming to that of the cylinder bore.

PISTON RINGS, RENEW

1936-46 All: NOTE—To prevent the possibility of bending or breaking the second ring land—thus ruining the piston—the ridge at the top of the cylinder bore should be cut away before removing the piston and rod assemblies. If the available ridge reamer has no provision to control the depth of the cut, it is good practice to bring the piston far enough up into the cylinder to allow the reamer to rest on top of the piston. This will serve to prevent cutting down into the ring travel area.

CAUTION—Never cut down into the ring travel area more than 1/32"—or more than half the depth of the top ring.

New rings should be fitted with end gaps and groove clearances as given in the PISTON & RING CLEARANCES table. Ring grooves must be clean and free from carbon, and must show no perceptible wear. Always abide by the instructions accompanying each set of rings.

Install rings with gaps staggered around piston circumference but with no gaps over piston pins. A piston ring installing tool is available to facilitate placing rings in grooves, and a piston installing tool is available to facilitate placing pistons in cylinder bores. Piston rings are available in the following oversizes: .003, .005, .010, .015, .020, .025, .030, .040, .050 and .060 inch.

PISTON PINS, RENEW

1936-39: Fit piston pins in bronze bushings in connecting rods with a tight thumb push at normal room temperature.

Heat pistons in boiling water and fit piston pins to pistons with a tight thumb push fit at 130 degrees F., except 1936 Model T26 which should be fitted at 160 degrees; T27 at 120 degrees.

Piston pins are available .003, .005 and .008 inch oversize.

1940: Fit piston pins in connecting rod bushings with a tight thumb push at normal room temperature. Heat pistons to 130 degrees F., to insert pins. Piston pins are available .003 and .008 inch oversize.

1941-46: Fit piston pins in connecting rod bushings with a tight thumb push at normal room temperature. Heat pistons to 100 degrees F., to insert pins. Piston pins are available .003 and .008 inch oversize.

CONNECTING ROD BEARINGS, RENEW

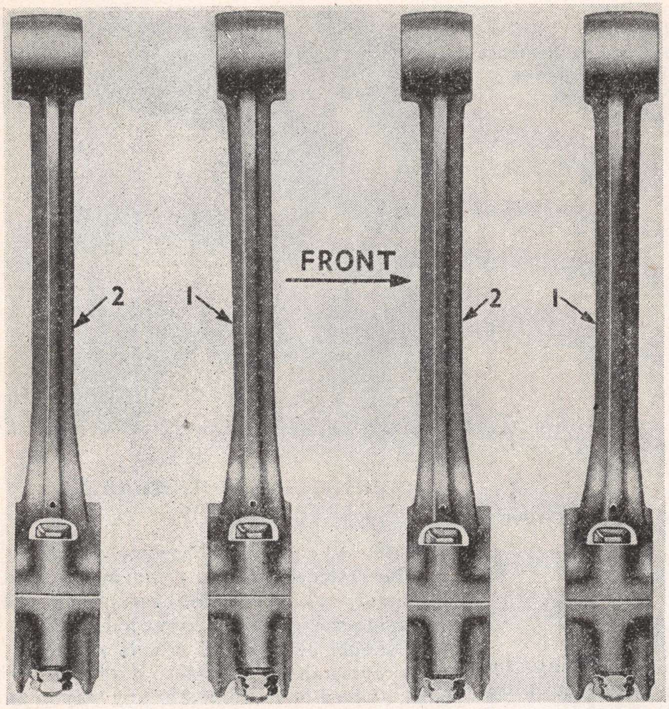
1936-46: When bearings become worn, they can be replaced without removing the rod by simply taking off the bearing cap and replacing the upper and lower halves. Bearings should be replaced in sets and under no circumstances should rods or caps be filed, altered or mutilated in any way in an attempt to obtain proper bearing fit.

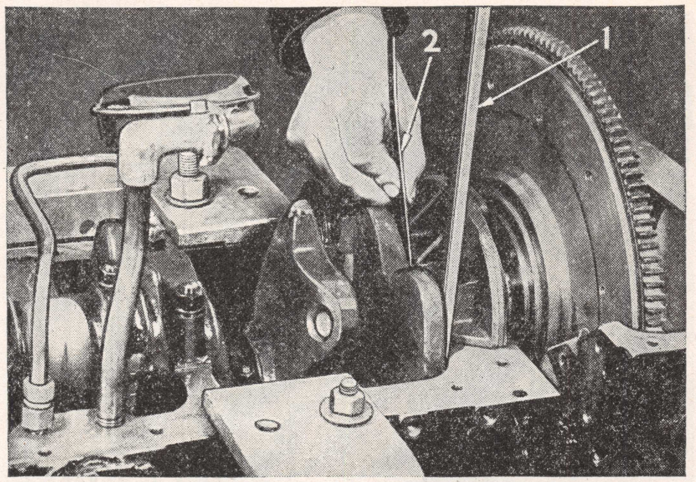
NOTE—Before replacing bearings, make sure that the crankpins are not nicked or scored. Use care also, to see that all parts are thoroughly clean. This is particularly important because one small particle of metal, carbon or other foreign matter, lodged between the back of the bearing and the rod, or between the face of the bearing and the crankpin, will very likely cause a hot spot due to the elimination of the oil clearance at that point, eventually resulting in a bearing failure or a scored crankpin.

To check the fit of new bearings, use a piece of brass shim stock ¼" wide, the length of which should be ¼" less than the length of the bearing, while the thickness should be about the same as the minimum allowable clearance.

CAUTION—To avoid damaging the bearing material, smooth down the edges of the shim stock on an oil stone so that no sharp edges remain. Install the shim between the bearing and the crankpin, in the center of the bearing, then tighten the cap bolts to the recommended torque tension. When fitted properly, it should not be possible to move the rod endwise by hand, but a light tap with a hammer should cause the rod to move endwise. Then remove the checking shim and install the cap again, tightening the cap bolts with the torque wrench, after which, the rod should move endwise by hand. If the rod is too loose with the checking shim in place, the crankpin should be turned down and undersize bearings fitted.

On 1936-39 engines, .010" undersize bearings are available while on 1940-46 engines, bearings of .002", .010" and .012" undersizes are available. The .002" undersize is used with a standard crankshaft which is slightly worn while the .012" undersize is used with a .010" undersize shaft slightly worn.





Checking crankshaft end play. 1936-46. 1—Pry bar. 2—Feeler gauge.

Connecting rod identification. Engines T-112, T-114, T-116, T-125. 1—Rods for No. 1, 3 and 5 cylinders. 2—Rods for No. 2, 4 and 6.

NOTE—It is good practice to check the connecting rod bore for roundness. A special tool with an indicator gauge is available for this operation, and before using this instrument, be sure that there are no nicks, burrs or dirt on the contacting surfaces to prevent a true reading. If the rod bore is out-of-round more than .002" or .003", the rod should be replaced.

MAIN BEARINGS, RENEW

1936-46: NOTE—Before replacing bearings, make sure that the crankshaft journals are not nicked or scored. Use care also, to see that all parts are thoroughly clean. This is particularly important because one small particle of metal, carbon, dirt or other foreign matter, lodged between the back of the bearing and the rod, or between the bearing face and the crankshaft journal, will very likely cause a hot spot due to the elimination of the oil clearance at that point, eventually resulting in a bearing failure or a scored journal.

When bearings become worn, they can be replaced without removing the crankshaft in the following manner: Remove the bearing cap and take out the worn lower shell. A suitable tool can be made to remove the upper shell by using a cotter pin with the rounded end flattened to form a T shape. Insert the long end of the pin in the oil passage hole in the crankshaft journal and, by rotating the crankshaft in the reverse direction, the T-shaped head will contact the bearing and force it out.

To install, place a new upper shell on the crankshaft journal with the locating notch in the correct position and rotate the shaft to turn the shell in place. Then install the lower shell in the cap and replace the cap, tightening the cap bolts to the recommended torque tension which will be found in the ENGINE BEARING SPECIFICATIONS table.

NOTE—Bearings should be replaced in sets and under no circumstances should any attempt be made to file, alter or otherwise mutilate the bearing caps to obtain proper bearing fit.

To check the fit of new bearings, use a piece of brass shim stock ¼" wide, the length of which should be ¼" less than the length of the bearing, while the thickness should be about the same as the minimum allowable clearance.

CAUTION—To avoid damaging the bearing material, smooth down the edges of the shim stock to remove sharp edges or turned over corners. And before inserting it in place, coat the shim on both sides with a light film of engine oil.

Then lay the shim lengthwise in the center of the bearing and install the bearing cap to the crankshaft, tightening the cap bolts to the recommended torque tension. Test the fit of the bearing by rocking the flywheel through an arc of 2"—not more than 1" in either direction. The bearing may be considered fitted properly if the shaft is movable with a fairly heavy drag.

NOTE—Remove the checking shim and replace the cap, but do not tighten the cap bolts, as this bearing must be loose in order to check the fit of the other bearings. It is good practice to fit bearings by starting at the center, then the rear bearing, front bearing, and finally, the intermediates.

NOTE—To permit removal of the front main bearing cap on 1936-39 engines, first take off crankshaft pulley and timing chain cover, then remove screw from timing case cover plate to oil pan front gasket oil seal plate.

Replacement caps for use in case of damage have stud holes 1/64" larger than original caps and are 1/16" shorter. This permits fitting by shimming or filing as required to adjust for variations between replacement caps and the original caps which are line-reamed in place. Never file, dress down or shim original bearing caps.

NOTE—To replace main bearings on 1940-46 engines, remove oil pan, clutch housing pan, and oil suction pipe and screen assembly. To permit removal of the front main bearing cap on all except Models T104 and T124, remove the two screws from the timing chain case cover to the oil pan front gasket oil seal plate, then remove the oil pan gasket seal plate. On Models T92, T94, T96, T112, T114, T116 and T125, these screws can be reached with a special wrench from the underside of the engine. On Models T88, T122, T128 and T130, first remove the radiator shell and core with its supports; on Models T98, T100 and T120, remove radiator shell, fenders and core as a complete assembly.

Disconnect oil line from main bearing cap to cylinder block and take off bearing caps using a puller for Models T104 and T124.

Replacement caps for use in case of damage have stud holes 1/64" larger than original caps and are 1/16" shorter. This permits fitting by shimming or filing as required to adjust for variations between replacement caps and the original caps which are line-reamed in place. Never file, dress down or shim original bearing caps.

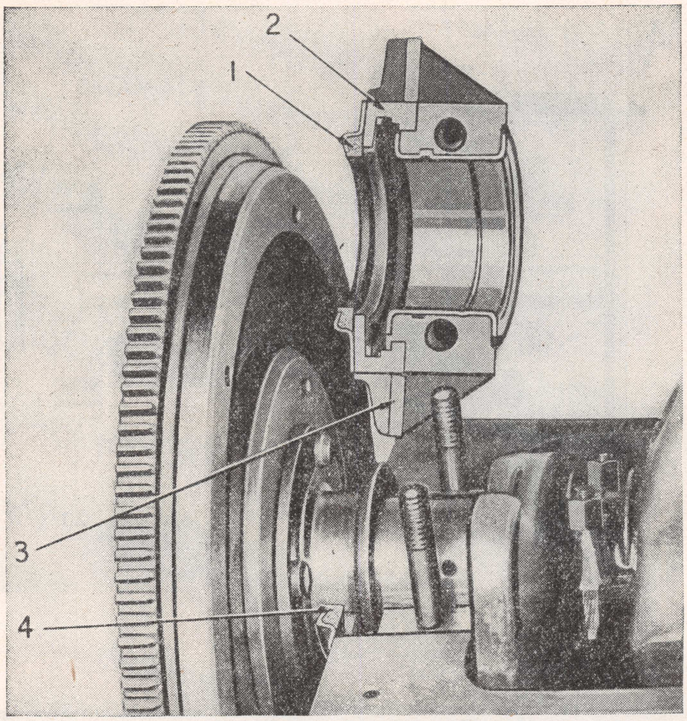
CRANKSHAFT END THRUST

1936-46: Crankshaft end thrust is controlled by flanges on the rear main bearing.

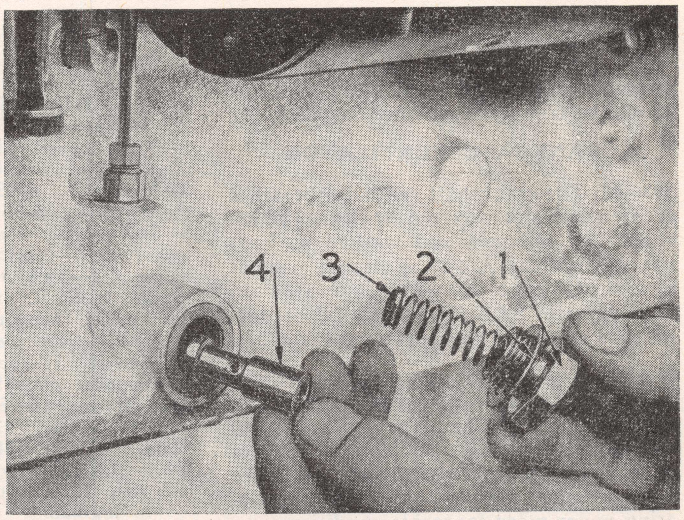
Through normal wear, this clearance will seldom become excessive but whenever new bearings are fitted, check the end play carefully and if necessary, the bearing flanges may be dressed down to provide the desired clearance.

REAR MAIN BEARING OIL SEAL

1936-46: The rear main bearing support is provided with packing which forms an oil



Crankshaft rear oil seal. 1940-46 except T-104 and T-124 engines. 1—Rear bearing oil seal. 2—Cap gasket. 3—Bearing cap oil seal. 4—Rear bearing oil seal.



Oil pressure relief valve. 1936-46 except T-43, T-80, T-104 and T-124 engines.
1—Cap. 2—Gasket. 3—Spring. 4—Plunger.

seal at the outer end of the shaft. In addition, an oil slinger, integral with crankshaft, deflects the major portion of the oil into the groove of the bearing cap and support.

NOTE—If it is necessary to replace the packing in the upper half of the rear main bearing, the crankshaft must be removed from the engine and the packing installed in the same manner as described below for the lower half of the bearing.

To install, insert the packing in the groove of the bearing cap and use a smooth, rounded tool to work the packing from each end towards the center of the cap, to force, and shape the packing in the groove. Then cut off the overlapping ends of the packing flush with the surface of the cap.

NOTE—Make sure that the packing is **not** pulled out of the groove when cutting off the ends. A special seal compressor, or a round block of wood of the same diameter as the crankshaft flange may be used to hold the packing firmly in position.

ENGINE OILING

OIL PUMP, OVERHAUL

1936-46: Oil pumps are located externally on the right side of engines **except** on Models T43, T80, T104 and T124, which have oil pumps in the oil pan base. Oil pumps are gear type driven from crankshafts by spiral drive gears which also drive distributors **except** on the models mentioned above.

On all engines having the external type pump, disassemble as follows: (On Cab-Over Engine models, remove the right engine splash pan.)

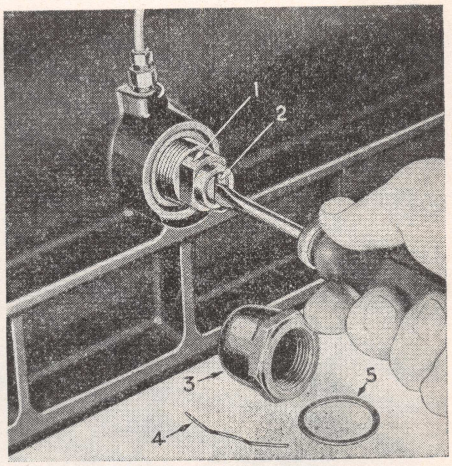
Lift off the distributor cap and turn the crankshaft until the rotor is in firing position for No. 1 cylinder. Keep the engine in this position while the pump is off. Remove capscrews in pump body and drop pump. Remove the pump cover and oil pump idler gear. Remove pin from oil pump and distributor drive gear and pull shaft out of housing. Press oil pump drive gear off shaft. To assemble, reverse operations and install new gaskets. Check ignition timing.

NOTE—If, for any reason, the crankshaft has been moved with the pump off, rotate the crankshaft until No. 1 cylinder is on firing position. Set the distributor rotor on No. 1 and install the oil pump, maintaining the same position for the rotor. Then reset ignition timing with an indicator.

On Models T43, T80, T104 and T124, disassemble oil pump as follows: Remove oil pan to reach pump. Remove cap screws in pump body and drop pump. Remove the pump cover. Remove oil pump idler gear and oil pump drive gear with shaft. Press oil pump drive gear off shaft. To assemble, reverse operations and install new gaskets. It is not necessary to check ignition timing when installing oil pumps on these engines.

OIL PRESSURE REGULATOR

1936-46: To adjust oil pressure on Models T43, T80, T104 and T124, remove oil pressure relief valve cap and lock wire, then turn slotted relief valve spring retainer clockwise to increase pressure and counterclockwise to reduce pressure.



Oil pressure relief valve. Engines T-43, T-80, T-104, T-124.

To change oil pressure on other models, replace oil pressure relief valve spring, using a heavier spring, which is available and is painted green, to increase pressure or a lighter spring, painted red, to reduce pressure. Standard springs are not painted. If a spring is replaced for any other reason, use a spring of the same color as the one replaced.

Normal oil pressure is 30 to 45 lbs. at speeds above 30 m.p.h. When checking pressure be sure oil is of proper viscosity and engine is at normal operating temperature.

CAUTION—Before adjusting oil pressure, check oil system for broken lines, leaky connections, clogged pump or strainer, worn pump gears, thick pump cover gasket, loose main or connecting rod bearing, defective gauge, improper viscosity or temperature of oil, etc.

NOTE—Inaccurate gauge readings may be caused by an accumulation of oxide which

sometimes plugs the small hole on the oil gauge connection. This may be reopened with a fine wire to restore the gauge to its original state of efficiency. The gauge line should be free from oil when installed.

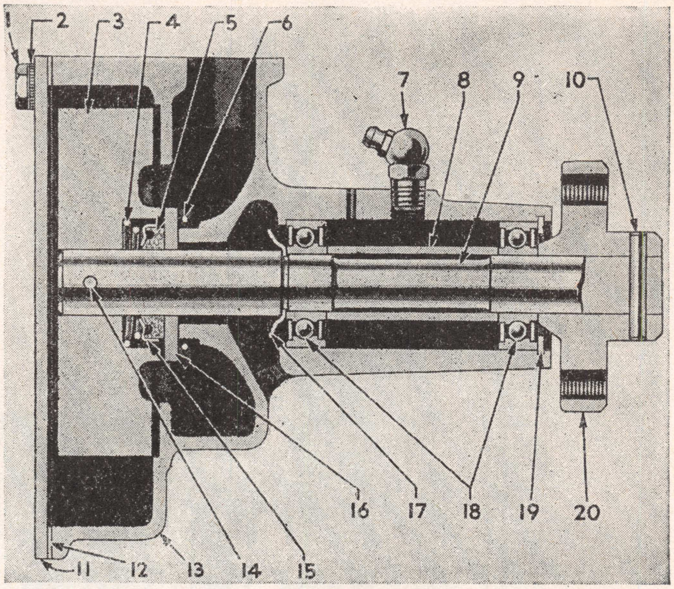
CRANKCASE VENTILATOR

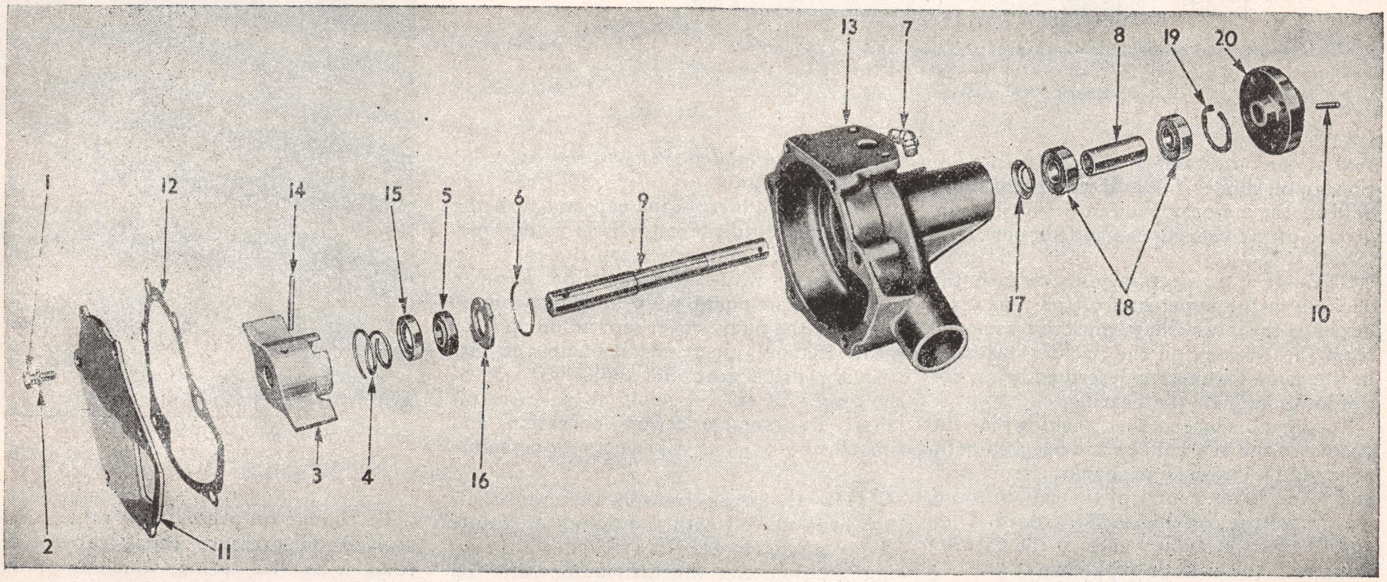
1936-46: The crankshaft ventilator breather is fitted with an oil-wetted air cleaner which should be removed and washed at least every 1000 miles. After the cleaner element is washed, blow it dry with compressed air, then dip it in SAE 50 engine oil. The outlet tube should be cleaned every 2000 miles.

NOTE—The interval at which the ventilator and air cleaner should be cleaned can only be determined by the type of service to which the vehicle is subjected. Vehicles operating in dusty or sandy areas require more frequent service than vehicles operating under more favorable conditions.

IMPORTANT—For vehicles operating in dust storm areas, cleaner should be cleaned immediately after such storms occur.

WATER PUMP. Engines T-80 and T-104.
1—Body cover plate screw. 2—Lockwasher. 3—Impeller. 4—Seal thrust spring. 5—Seal. 6—Seal retainer washer lock ring. 7—Lubricant nipple. 8—Bearing spacer. 9—Shaft. 10—Fan pulley hub pin. 11—Body cover plate. 12—Gasket. 13—Body. 14—Impeller pin. 15—Seal retainer. 16—Seal retainer washer. 17—Water thrower. 18—Bearings. 19—Bearing lock ring. 20—Fan pulley hub.





WATER PUMP. Engines T-80 and T-104.

1—Body cover plate screw. 2—Lockwasher. 3—Impeller. 4—Seal thrust spring. 5—Seal. 6—Seal retainer washer lock ring. 7—Lubricant nipple. 8—Bearing spacer. 9—Shaft. 10—Fan pulley hub pin. 11—Body cover plate. 12—Gasket. 13—Body. 14—Impeller pin. 15—Seal retainer. 16—Seal retainer washer. 17—Water thrower. 18—Bearings. 19—Bearing lock ring. 20—Fan pulley hub.

OIL FILTER

1936-46: Replace the oil filter when oil becomes black and dirty, usually about every 10,000 miles. If the filter becomes clogged, the oil will by-pass around the filter and circulate to the bearings but will not be filtered. Check oil passage through filter as follows: Run engine at idling speed. Remove return pipe connection at end of filter. A steady flow of clean oil should pass from the filter at this point. If there is not a steady flow of oil, the filter probably is clogged. The oil filter is designed to remove solid particles from the oil, but is not intended to remove fluids of crankcase dilution, such as acid, water or gasoline.

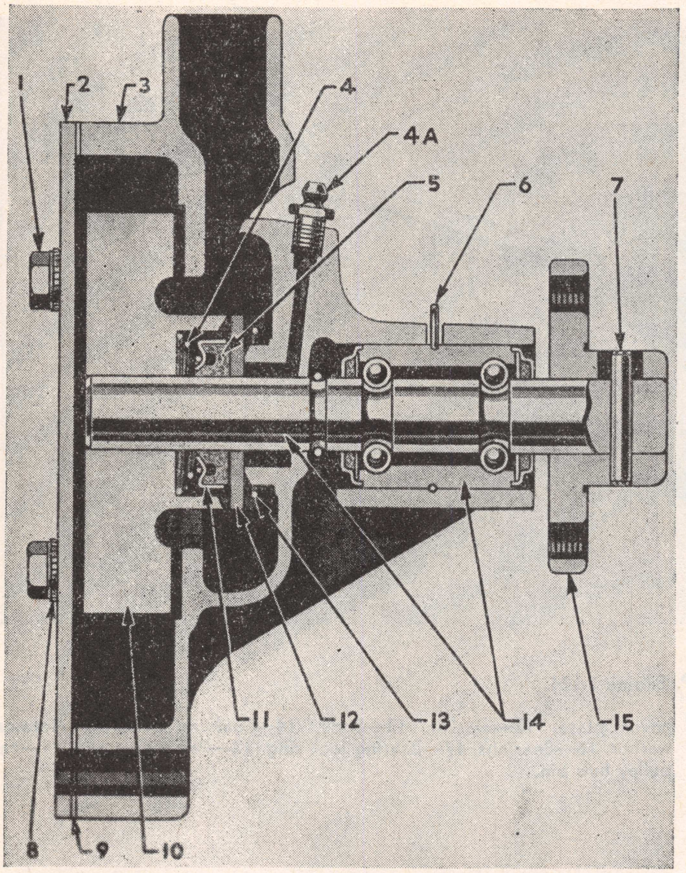
COOLING SYSTEM

WATER PUMP, R & R

1936-39 All: To remove water pump, drain cooling system, loosen generator bracket pivot bolt and adjusting locking bolt, then take belt off water pump pulley. Remove capscrews which hold fan blade assembly hub, thus removing pulley and fan. Remove capscrews which hold by-pass hose elbow to pump body (top and side). Remove capscrews which hold water pump body to cylinder block and lift off pump.

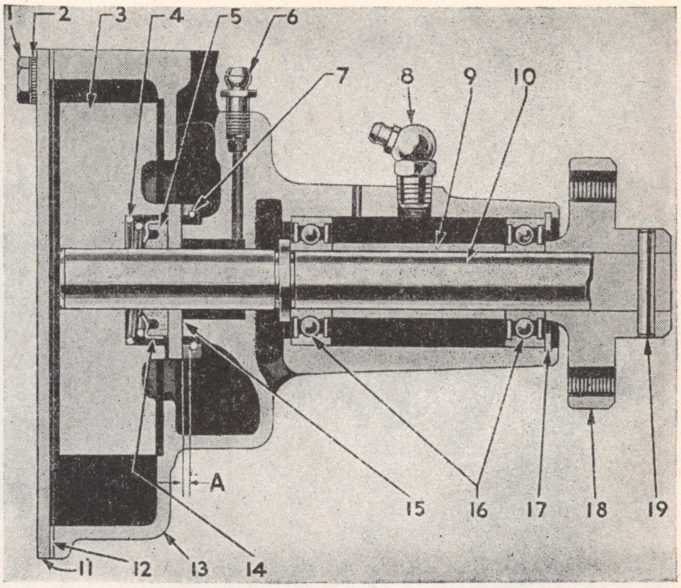
To install water pump, remove all traces of old gaskets, then reverse the foregoing operations, using new gaskets with shellac to seal the joints. Lubricate the pump and adjust belt.

1940 Model T92: To remove water pump, drain cooling system, loosen generator bracket pivot bolt and remove belt. Disconnect water pump by-pass hose and engine inlet hose. Remove capscrews holding pump body to cylinder block and lift off water pump assembly. Remove fan blades, pulley and by-pass elbow. To install pump reverse



WATER PUMP. Engines T-88, T-98 and T-100.

1—Body cover plate screw. 2—Body cover plate. 3—Body. 4—Seal spring. 4A—Lubricant nipple. 5—Seal. 6—Shaft bearing lock ring. 7—Fan pulley hub pin. 8—Lockwasher. 9—Gasket. 10—Impeller. 11—Seal retainer. 12—Seal retainer washer. 13—Retainer washer lock ring. 14—Shaft and bearing. 15—Fan pulley hub.



WATER PUMP. Engine T-124. NOTE—Dimension A should be a minimum of 3/32".

1—Body cover plate screw. 2—Lockwasher. 3—Impeller. 4—Seal thrust spring. 5—Seal. 6—Lubricant nipple. 7—Seal retainer washer lock ring. 8—Bearing lubricant nipple. 9—Bearing spacer. 10—Shaft. 11—Body cover plate. 12—Gasket. 13—Body. 14—Seal retainer. 15—Retainer washer. 16—Bearings. 17—Bearing lock ring. 18—Fan pulley hub. 19—Fan pulley hub pin.

the foregoing operations, lubricate pump and adjust belt.

1940 Model T88: To remove water pump, first remove the radiator shell assembly. Then drain the cooling system and remove the radiator core with its supports and braces as an assembly. Remove the fan blades. Loosen the generator pivot bolt and remove the fan belt and pulley. Remove the nuts which hold the water pump to the cylinder block and pull off the pump. To install pump, reverse the foregoing operation, lubricate pump and adjust belt.

1940—Models T94, T96, T98, T100, T104: To remove water pump, drain cooling system, loosen generator pivot bolt and remove belt. Remove fan blades. Remove thermostat housing and thermostat. Disconnect engine inlet hose. Remove the nuts which hold water pump to cylinder block. Slide the pump on the studs toward the radiator core and remove the lower center and lower left studs, using stud pliers, except on Models T94 and T96 where this is unnecessary. On Model T104 remove the two upper studs. Then lift off water pump assembly. To install pump, reverse the foregoing operations, lubricate pump and adjust belt.

1941-46 All: To remove water pump, drain cooling system, loosen generator bracket pivot bolt and remove belt. Disconnect water pump by-pass hose and engine inlet hose. Remove capscrews, nuts, or studs which hold pump body to cylinder block and lift off water pump assembly. Remove fan blades, pulley and by-pass elbow.

NOTE—On Models T122, T128, T130, remove the radiator shell. On Model T116, there are studs in place of capscrews. Remove nuts and lock-washers and slide pump assembly forward and off the studs. On Model T124, remove the two upper studs.

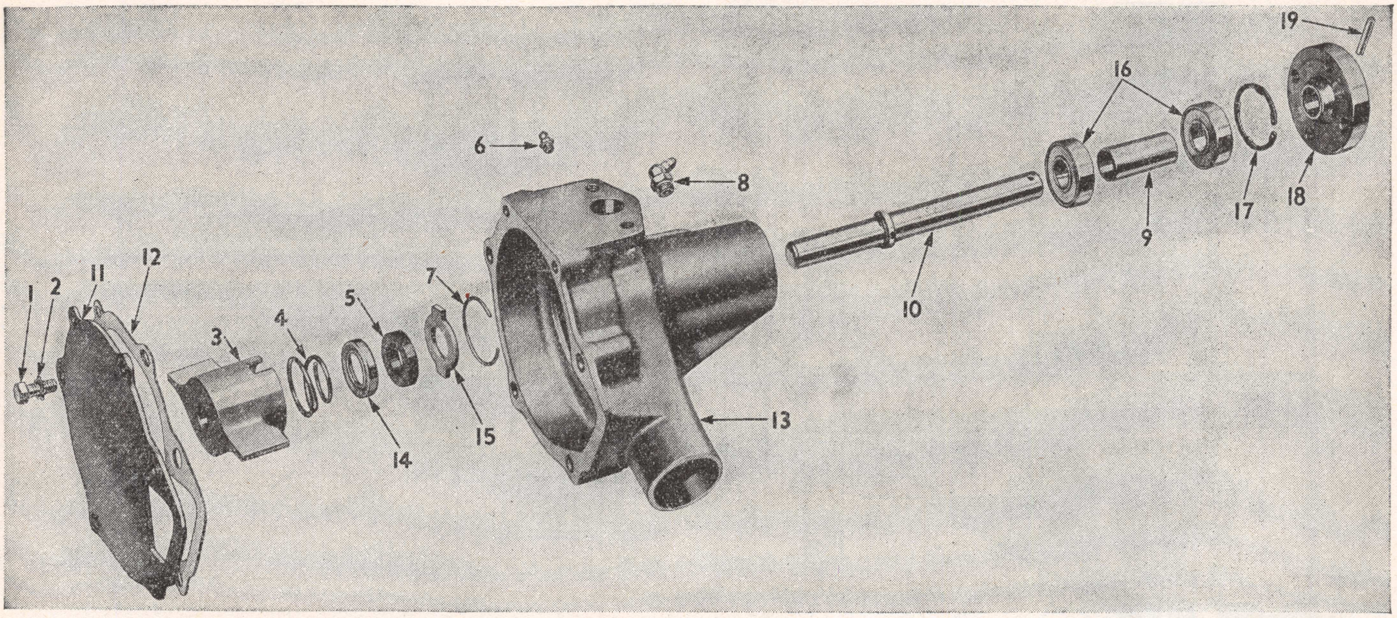
To install pump, reverse the foregoing operations, lubricate pump and adjust belt. When lubricating pump, rotate the shaft to insure complete lubrication.

WATER PUMP, OVERHAUL

1936-46 Models T23, T30, T38, T58, T60, T68, T70, T72, T92, T94, T96, T112, T114, T116 and T125: To disassemble water pump after removal from engine, drive pin out of fan pulley hub and pull hub off shaft by means of puller. Remove cover plate screws and take off cover plate. Pull impeller and shaft assembly out of pump body. Drive out pin which holds impeller to shaft and pull off the impeller—unless new shaft, impeller and seal assembly is to be installed. Drive front bushing pin into shaft hole of bushing to permit removal of bushings. Remove front and rear bushings by pulling them out toward the front with puller.

When assembling pump, first insert the pump shaft thrust washer in the pump body, then press in new bushings. Line-burnish the bushings and reface the pump body where the seal retainer washer bears. A special tool is available for the purpose. Turn the burnisher in an even clockwise direction until a smooth full cut has been taken on the pump body, then continue turning the burnisher clockwise as it is being removed, to prevent leaving a ridge on the body.

Next, unless new shaft, impeller and seal assembly are installed, press impeller on shaft until back of impeller is flush with end of shaft. Do not pin impeller to shaft. Arrange water pump seal parts on shaft in order as follows: thrust spring, seal retainer, seal (use special sleeve shaped tool to protect seal when sliding it over shaft), seal retainer washer, seal retainer lock ring. Slide shaft assembly through rear bushing, thrust washer and front bushing, aligning shaft and washer. Push the impeller and shaft assembly into pump, compressing seal and spring so that distance between lock ring and seal retainer washer, viewed through water inlet, is not less than 3/32". With impeller in this posi-



WATER PUMP. Engine T-124.

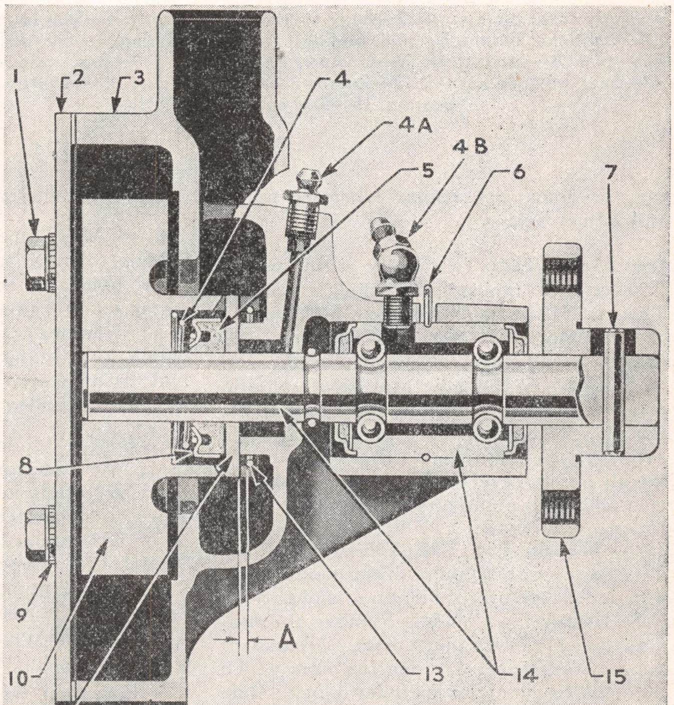
1—Body cover plate screw. 2—Lockwasher. 3—Impeller. 4—Seal thrust spring. 5—Seal. 6—Lubricant nipple. 7—Seal retainer washer lock ring. 8—Bearing lubricant nipple. 9—Bearing spacer. 10—Shaft. 11—Body cover plate. 12—Gasket. 13—Body. 14—Seal retainer. 15—Retainer washer. 16—Bearings. 17—Bearing lock ring. 18—Fan pulley hub. 19—Fan pulley hub pin.

tion on shaft, drill shaft and insert impeller pin.

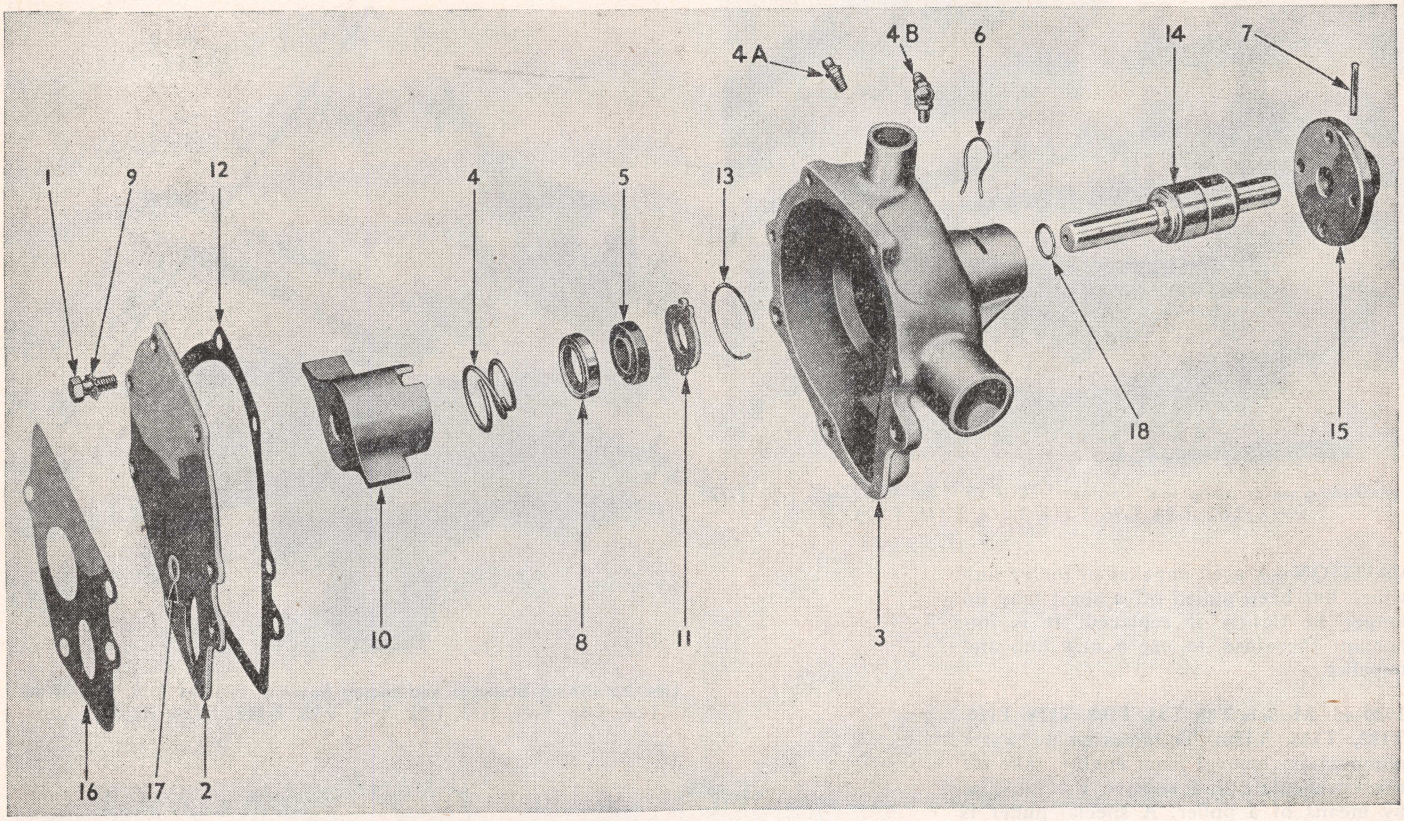
Mark the other end of the shaft, unless it is a new one, showing the direction of the hub pin hole. Then press a new (unused) fan pulley hub onto the pump shaft, leaving a clearance between hub and bushing of .003" measured with feeler gauge, for shaft end-play. Drill a new hub pin hole through hub and shaft at a right angle with the old hole in the shaft as shown by mark, and insert hub pin.

CAUTION—A used pulley hub which has been pulled off the shaft may no longer fit tightly if replaced. The hub must fit tightly; therefore, a new hub should be used.

1936-38 Models T25, T26, T40, T41, T42, T48 (First Type): To disassemble water pump after removal from engine, drive pin out of fan pulley hub and pull hub off shaft by means of puller. Remove cap screws which hold front bearing retainer to pump body and lift off oil seal, bearing retainer and shims. Remove cover plate screws and take off cover plate. Drive pin out of impeller hub and pull off the impeller. Push impeller end of pump shaft through and out of pump body. Remove roller bearing rear cup with puller. Remove inner seal locking ring from pump body and pull out inner seal toward front end of pump body. Remove roller bearing cones by pulling toward front end of pump shaft. Remove plain rear bearing from pump body by means of bearing puller. Remove locking ring from bore of impeller hub and lift out thrust plate, seal and thrust spring.



WATER PUMP. Engines T-118, T-120, T-122, T-128, T-130. NOTE—Dimension A should be a minimum of 3/32". 1—Body cover plate screw. 2—Body cover plate. 3—Body. 4—Seal thrust spring. 4A—Seal lubricant nipple. 4B—Bearing lubricant nipple. 5—Seal. 6—Shaft bearing lock ring. 7—Fan pulley hub pin. 8—Seal retainer. 9—Lockwasher. 10—Impeller. 11—Seal retainer. 12—Gasket. 13—Seal retainer washer lock ring. 14—Shaft and bearing. 15—Fan pulley hub.



WATER PUMP. Engines T-118, T-120, T-122, T-128, T-130.

1—Body cover plate screw. 2—Body cover plate. 3—Body. 4—Seal thrust spring. 4A—Seal lubricant nipple. 4B—Bearing lubricant nipple. 5—Seal. 6—Shaft bearing lock ring. 7—Fan pulley hub pin. 8—Seal retainer. 9—Lockwasher. 10—Impeller. 11—Seal retainer. 12—Gasket. 13—Seal retainer washer lock ring. 14—Shaft and bearing. 15—Fan pulley hub. 16—Gasket. 17—Washer. 18—Water thrower.

To assemble pump, reverse foregoing operations. If installing a new fan pulley hub, impeller or shaft, be sure to locate properly the fan pulley hub and impeller before drilling for the locking pins. Press the fan pulley hub tightly against the front roller bearing inner race to make certain that the rear bearing race is tight against the shoulder on the shaft. Then drill the locking pin hole and insert pin so neither end extends above the surface of the pulley hub. Shims between pump body and the bearing retainer washer should allow free rolling of the shaft and not more than .003" endplay. The rear end of the plain rear bearing must be just below the end of the boss in the pump body so that the thrust plate will bear against the end of the boss and not against the end of the bearing.

1936-39 Models T25, T26, T40, T41, T42, T48, T74, T76, T78 (Second Type): To disassemble water pump after removal from engine, drive pin out of fan pulley hub and pull hub off shaft by means of puller. Remove cover plate screws and take off cover plate. Remove impeller by means of puller. Remove locking ring from bearing retainer. Withdraw pump shaft and bearing. Press front end of shaft through bearing. Remove locking ring from bore of impeller hub and lift out thrust plate, seal and thrust spring.

To assemble pump, reverse foregoing operations. If installing a new fan pulley hub, impeller or shaft, be sure the outer face of the impeller and the front face of the fan pulley hub are flush with the ends of the shaft when the hole is drilled for the locking pin. Insert pin so neither end extends above the surface of the pulley hub.

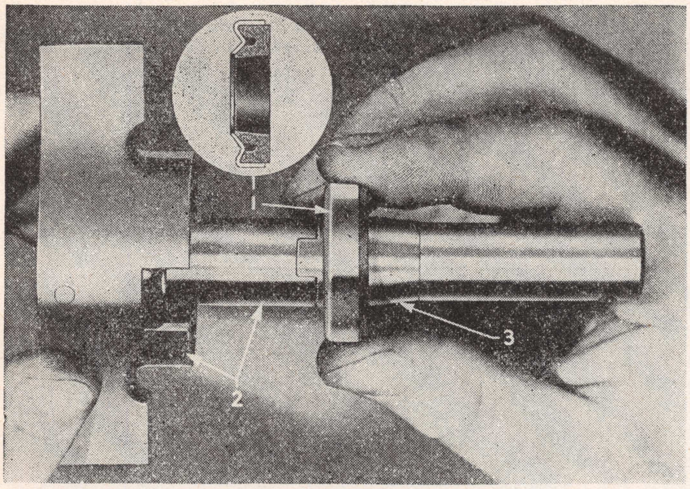
NOTE—The T74, T76 and T78 engine water pump seal differs from earlier designs. When installing this type seal with the impeller fastened to shaft, use a special sleeve-shaped tool to protect the inner surface when sliding it over the shaft. With this seal, the surface of the pump body—where the seal retainer washer bears—was originally finished at an angle of 85 degrees, but more recent practice is to finish the body with a 90-degree cutter to form a perfectly flat face.

1937-40 Models T43, T80 and T104: To disassemble water pump after removal from engine, drive pin out of fan pulley hub and pull hub off shaft by means of puller. Remove cover plate screws and take off cover plate. Drive out pin which holds impeller to the shaft. Remove impeller by means of puller. Remove front bearing lock ring. Push or drive rear end of pump shaft through and out of the body. Use puller to remove bearings and spacer from pump shaft. Remove water thrower from pump shaft. Remove locking ring from bore of impeller hub and lift out thrust plate, seal and thrust spring.

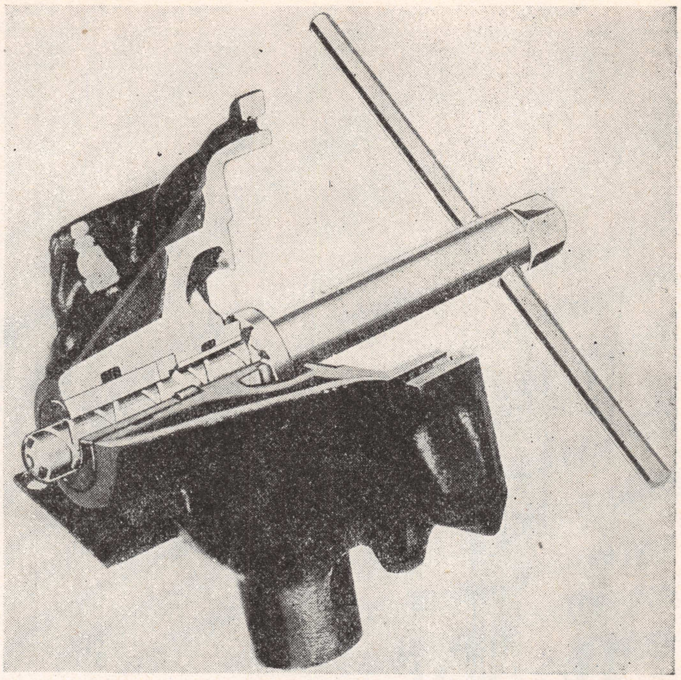
To assemble pump, reverse foregoing operations. Pin the hub of the impeller flush with the end of the shaft. Press the fan pulley solid against the bearing before drilling shaft for pin. Insert pin so neither end extends above the surface of the pulley hub.

1941-46 Model T124: To disassemble water pump after removal from engine, drive pin out of fan pulley hub and pull hub off shaft by means of puller. Remove cover plate screws and take off cover plate. Remove impeller by means of puller. Remove front bearing lock ring and withdraw shaft, bearings and spacer.

To assemble pump, reverse foregoing operations. Reface the pump body where the seal retainer washer bears with a 90-degree cutter to form a perfectly flat face. Assemble new seal parts in a new (unused) impeller and press impeller on pump shaft. Install shaft with end-play .0025" to .0045" measured with a feeler gauge between the pump body and fan pulley hub.



Installing water pump seal. Engines T-30, T-38, T-58, T-60, T-68, T-70, T-72, T-92, T-94, T-96, T-112, T-114, T-116, T-125.



Line burnishing bushings and facing housing. Engines T-30, T-38, T-58 T-60, T-68, T-70, T-72, T-92, T-94, T-96, T-112, T-114, T-116, T-125.

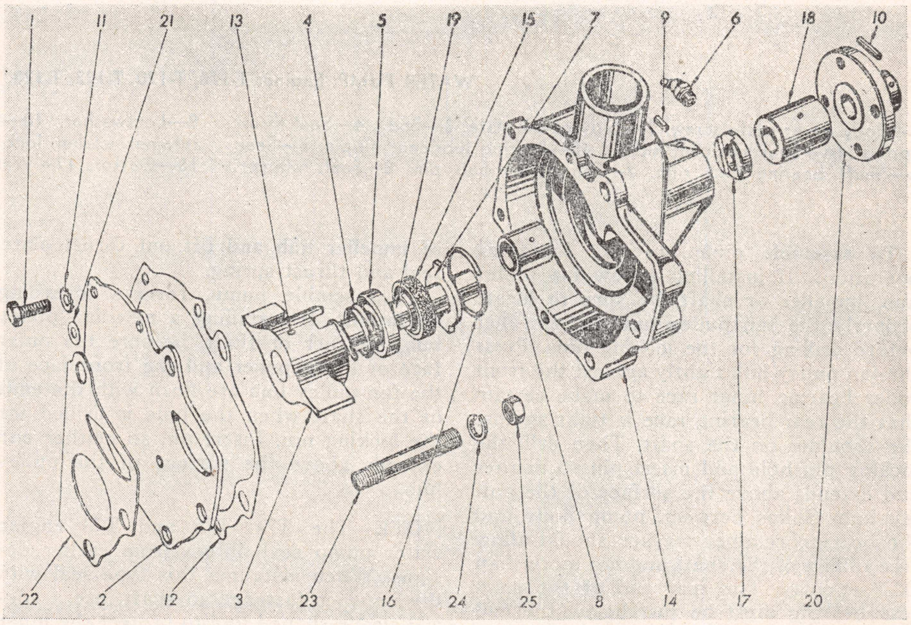
CAUTION—A used impeller or pulley hub which has been pulled off a shaft may no longer fit tightly if replaced. It is important therefore, to use a new hub and impeller.

1940-46: Models T88, T98, T100, T118, T120, T122, T128, T130: To disassemble water pump after removal from engine, take off the cover plate and remove the impeller by means of a puller. A special puller is available for the purpose. Release the seal parts assembled in the impeller by removing the seal retainer washer lock ring. Drive the pin out of the fan pulley hub and pull hub off shaft by means of puller. Remove the shaft bearing lock ring and pull the shaft and bearing assembly out of the housing.

To assemble pump, reverse the foregoing operations. Reface the pump body where the seal retainer bears with a 90-degree cutter to form a perfectly flat face. Assemble new seal parts in a new (unused) impeller and press impeller on pump shaft, so that distance between lock ring and seal retainer washer, viewed through water inlet, is not less than 3/32". Install pulley hub flush with the end of the shaft. End-play should be .0025" to .0045" measured with a feeler gauge between pump body and fan pulley hub.

NOTE—The shaft and bearing are made up and are available as an assembly for replacements.

CAUTION—A used impeller or pulley hub which has been pulled off a shaft may no longer fit tightly if replaced. It is important, therefore, to use a new (unused) hub and impeller.



WATER PUMP. Engines T-30, T-38, T-58, T-60, T-68, T-70, T-72, T-92, T-94, T-96, T-112, T-114. T-116, T-125.

1—Screw. 2—Body cover plate. 3—Impeller. 4—Seal thrust spring. 5—Seal retainer. 6—Lubricant nipple. 7—Washer. 8—Rear bushing. 9—Front bushing pin. 10—Fan pulley hub pin. 11—Lockwasher. 12—Gasket. 13—Impeller pin. 14—Body. 15—Seal. 16—Lock ring. 17—Thrust washer. 18—Front bushing. 19—Shaft. 20—Fan pulley hub. 21—Washer. 22—Gasket. 23—Stud. 24—Lockwasher. 25—Stud nut.

ENGINE WATER THERMOSTAT

1936-46: To remove thermostat, which is located in cylinder water outlet elbow, disconnect the engine outlet hose and the by-pass hose connection at the water pump. Then remove the capscrews which hold the cylinder head water outlet elbow to the cylinder head and lift the elbow up to expose the thermostat. If necessary, remove the water hose from the elbow at the top of the radiator. The thermostat has no adjustment. Replace units that fail to operate.

On 1936-38 engines, thermostats start to open at 150 to 155 degrees F. and are fully open at 172 to 174 degrees F. On 1939-46 engines, thermostats start to open at 157 to 162 degrees F. and are fully open at 183 to 187 degrees F.

NOTE—On 1940-46 Models T92, T94, T96, T112, T114, T116 and T125, be sure to install upper circular gasket as well as lower gasket at cylinder block. The thermostat used on T112, T114, T116 and T125 engines has four by-pass ports. Install this unit with ports toward the front and rear of engine.

ENGINE WATER THERMOMETER

1936-46: Replace complete water temperature indicator (thermometer) assembly consisting of cylinder head bulb, tube and instrument panel dial, in the event of failure. This unit will be damaged by temperature above 250 degrees F. If the indicator on instrument panel has a permanent set from such high temperature and does not return to 100 degrees F. with engine cold, but returns to 130 degrees F. or less, it may be possible to correct the instrument by bending the link which connects the operating tube to the pointer. After this adjustment, immerse the cylinder head bulb in water at approximately 140 degrees F. and 212 degrees F. to test action.

ELECTRIC SYSTEM

NOTE—For service information on Distributors, Generators, Generator Regulators, Starting Motors and Starting Switches, see the Table of Contents on page 1.

IGNITION TIMING

1936-46: With the breaker gap set to the clearance given in the TUNE UP CHART, crank the engine to bring No. 1 piston up on its compression stroke and stop when the "IGN" mark on the crankshaft pulley or vibration damper is in line with the indicator.

Locate No. 1 spark plug wire on the distributor cap, place the cap in position on the distributor and mark the housing opposite No. 1 terminal so that its relative position will be known when the cap is removed.

With the octane selector set midway between advance and retard, loosen the distributor body clamp and rotate the distributor until the points close. Then rotate the distributor in the opposite direction until the points just begin to open. Tighten the clamp bolt.

NOTE—For best results, use a Neon timing light or a conventional test lamp to check the timing. Advance or retard the octane selector to compensate for the grade of fuel being used. For best performance and fuel economy, this setting should be one which will provide smooth engine performance with a slight "ping" on wide-open throttle at comparatively low vehicle speed.

ENGINES GASOLINE FORD

Year	Engine Model	Number Cylinders and Valve Arrangement	Bore and Stroke	Displacement Cubic Inches	Compression Ratio	Taxable H. P.	Brake H. P. at R. P. M.	Maximum Torque at R. P. M. Pounds Feet	Oil Capacity Quarts
1936	V-8	8-L	3.062x3.75	221.00	5.87	30.01	90@3800	156@2200	5
1937-38	V-8, 60	8-L	2.60 x3.20	136.00	6.60	21.63	60@3500	92@2500	4
	V-8, 90	8-L	3.062x3.75	221.00	5.87	30.01	90@3800	156@2200	5
1939-40	V-8, 60	8-L	2.60 x3.20	136.00	6.60	21.63	60@3500	92@2500	4
	V-8, 90	8-L	3.062x3.75	221.00	6.30	30.01	90@3800	156@2200	5
	V-8, 100	8-L	3.187x3.75	239.00	5.90	32.50	100@3800	176@2000	5
1941-46	4 Cyl.	4-L	3.187x3.75	119.50	6.10	16.20	40@3200	84@1600	5
	6 Cyl.	6-L	3.30 x4.40	226.00	6.70	26.10	90@3300	180@1200	5
	V-8, 90	8-L	3.062x3.75	221.00	6.30	30.01	90@3800	156@2200	5
	V-8, 100	8-L	3.187x3.75	239.00	6.40	32.50	100@3800	176@2000	5

Engine and Serial Number Location—Stamped on top of clutch housing.

TUNE UP CHART

Year	Engine Model	Firing Order	Spark Plug Gap	Breaker Gap	Cam Angle, Degrees	Timing Mark Location	Spark Timing, Degrees	Tappet Clearance For Running, Cold Int.	Tappet Clearance For Running, Cold Exh.	Tappet Clearance For Timing, Intake	Battery Terminal Grounded
1936-40	V-8, 90	15486372	.025	.014-.016	②	None	4BTDC	.012	.015①	.012	Positive
1937-40	V-8, 60	15486372	.025	.014-.016	②	None	4BTDC	.012	.015①	.012	Positive
1939-40	V-8, 100	15486372	.025	.014-.016	②	None	4BTDC	.012	.015①	.012	Positive
1941-46	V-8, 90	15486372	.025	.014-.016	②	None	4BTDC	.012	.015	.012	Positive
	4 Cyl.	1243	.025	.020	34	None	4BTDC	.012	.015	.012	Positive
	6 Cyl.	153624	.030	.014-.016	40	None	4BTDC	.014①	.014①	.012	Positive
	V-8, 100	15486372	.025	.014-.016	②	None	4BTDC	.012	.015	.012	Positive

① Plus or minus .001". BTDC—Before top dead center.

② Cam angle 22½° for each set but 35° total for both.

VALVE SYSTEM

Year	Engine Model	Stem Clearance Intake	Stem Clearance Exhaust	Tappet Guide Clearance	Tappet Clearance Running Hot Intake	Tappet Clearance Running Hot Exhaust	Tappet Clearance Timing Intake	Tappet Clearance Timing Exhaust	Valve Spring Pressure Test Free Length, Inches	Valve Spring Pressure Test Pounds at Inches, Length	Valve Seat Angle, Degrees
1936-40	V-8, 90	.0015-.0035	.0015-.0035	.0005-.0025	.011-.012 C	.011-.012 C	.011-.012	.011-.012	2 7/16	76-80@1.83	45
1937-40	V-8, 60	.0015-.0035	.0015-.0035	.0005-.0025	.011-.012 C	.011-.012 C	.011-.012	.011-.012	2 3/8	48-52@1.79	45
1939-40	V-8, 100	.0015-.0035	.0015-.0035	.0005-.0025	.011-.012 C	.011-.012 C	.011-.012	.011-.012	2 7/16①	76-80@1.83	45
1941-46	4 Cyl.	.0015-.0035	.0015-.0035	.0005-.0025	.010-.012 C	.014-.016 C	.015	.015	2 7/16①	76-80@1.83	45
	6 Cyl.	.0015-.0035	.0015-.0035	.0005-.0025	.013-.015 C	.013-.015 C	.015	.015	2 7/16①	76-80@1.83	45
	V-8, 90	.0015-.0035	.0015-.0035	.0005-.0025	.010-.012 C	.014-.016 C	.015	.015	2 7/16①	76-80@1.83	45
	V-8, 100	.0015-.0035	.0015-.0035	.0005-.0025	.010-.012 C	.014-.016 C	.015	.015	2 7/16①	76-80@1.83	45

C—Cold. ① 1942-46, 2½".

PISTON AND RING CLEARANCES

Year	Engine Model	Piston Skirt, Inches		Fitting Pistons with Shim and Spring Scale		Ring End Gap, Inch ①		Ring and Groove, Inch	
		Top	Bottom	Shim Thickness	Pounds Pull on Scale	Com-pression	Oil	Com-pression	Oil
1936–42	V-8, 90	④	④	④	6 to 10	.012–.017	.012–.017	.0015–.003	.0015–.003
1937–40	V-8, 60	⑤	⑤	⑤	7 to 12	.012–.017	.012–.017	.0015–.003	.0015–.003
1939–46	V-8, 100	②	②	②	6 to 10	.012–.017	.012–.017	.0015–.003	.0015–.003
1941–46	4 Cyl.	③	③	③	7 to 12	.012–.017	.012–.017	.0015–.003	.0015–.003
1941–46	6 Cyl.	④	④	④	6 to 12	.012–.017	.012–.017	.0015–.003	.0015–.003

① Clearances are for cylinder bores without taper. Fit rings in tapered bores with not less than the maximum dimension given in the table.

② Steel pistons, .003″; aluminum pistons, .0025″.

③ With cylinder sleeves, .003″; without sleeves, .0025″.

④ For cylinders equipped with sleeves and aluminum pistons, .0025″; without sleeves, .002″.

⑤ With cylinder sleeves, .0025″; without sleeves, .002″.

ENGINE BEARING SPECIFICATIONS

Year	Engine Model	Camshaft		Connecting Rod			Mains				
		Journal Diameter	Clearance	Journal Diameter	Clearance	Bearing Bolt Tension Lb. Ft.	Journal Diameter	Clearance	Bearing Bolt Tension Lb. Ft.	Thrust on No.	End-play
1936	V-8, 90	1.797	.001–.003	1.998–1.999	①	50–55	②1.998–1.999	.001–.0025	65–75	3	.002–.006
1937–38	V-8, 90	1.797	.001–.003	1.998–1.999	①	50–55	2.398–2.399	.001–.0025	65–75	3	.002–.006
1937–39	V-8, 60	1.498	.0005–.0025	1.598–1.599	①	45–50	1.998–1.999	.0006–.0031	65–75	3	.002–.006
1939–42	V-8, 90	1.797	.001–.003	1.998–1.999	①	50–55	2.498–2.499	.001–.0025	65–75	3	.002–.006
1939–46	V-8, 100	1.797	.001–.003	2.138–2.139	①	50–55	2.498–2.499	.001–.0025	65–75	3	.002–.006
1940	V-8, 60	1.498	.0005–.0025	1.698–1.699	①	45–50	2.098–2.099	.0006–.0031	65–75	3	.002–.006
1941–46	4 Cyl.	1.797	.001–.003	③	.0008–.0029	50–55	2.248–2.249	.0005–.003	65–75	3	.002–.006
1941–46	6 Cyl.	1.797	.001–.003	2.234–2.235	.0008–.0029	50–55	2.498–2.499	.001–.0025	65–75	3	.002–.006

① As these bearings float in the connecting rod bore, there should be .001″ oil clearance between the connecting rod bore and the bearing back and another .001″ clearance between the crankpin and the bearing face.

② For large bearing crankshaft, use 1937 dimensions.

③ 1941, 2.093″–2.094″, 1942-46, 2.220″.

ENGINE

CYLINDER HEAD TIGHTENING

1936-46 All: To prevent gasket failure, cylinder distortion, excessive oil consumption, loss of compression and poor performance, cylinder head nuts should be tightened gradually and evenly. As no particular tightening sequence is recommended by the manufacturer, the nuts should be tightened from the center outward.

When using a torque wrench, the final tightening, after the engine has been run sufficiently long to bring all the parts to normal operating temperature, should be as given in the following chart:

V8, 90 & 100 H.P. cast iron	50 lbs. ft.
V8, 90 & 100 H.P. aluminum	40 lbs. ft.
V8, 60 H.P. aluminum	30 lbs. ft.
Six cylinder engines	50 lbs. ft.
Four cylinder engines	50 lbs. ft.

NOTE—On engines equipped with aluminum cylinder heads, check the tension after the engine has been run and cooled, and while it is still cool.

CYLINDER HEAD REPLACEMENT

1936-38 V8's: When replacing cylinder heads on these engines, be sure to install heads having the correct shape combustion chambers. With flat top pistons, use the head with the small combustion chamber which does not cover the entire area of the cylinder bore. With domed top pistons, install the head which has a combustion chamber covering the entire area of the cylinder bore.

CYLINDER HEAD GASKETS

1936-46 All: Cylinder head gaskets are marked with the word "Front" and should be so installed. Improper installation of head gaskets will block some of the water passages causing improper water circulation with the consequent over-heating of the engine.

On V8 engines, the gaskets are interchangeable between both banks of cylinders.

VALVE SEAT INSERTS

1936-46 All: Since these inserts are too hard to reface by the ordinary grinding methods, a high-speed grinding stone or a special lapping tool should be used to perform this operation. When using this equipment, be sure the valve guide bores are clean and that the valve guide pilot is a snug fit in order to assure a concentric finish. Finished seats should be checked with a dial indicator and run-out should not exceed .0005".

To remove an insert when special equipment is not available, use a drill which is smaller in diameter than the insert width and drill two holes at opposite sides, but not all the way through. Cut through the undrilled portion of the insert with a sharp chisel and remove the two pieces.

To install an insert, pack in "dry ice" for at least fifteen minutes to allow the metal to contract, and heat the valve port area gradually if necessary, to permit this material to expand. Then press the insert into the cylinder block, using extreme care to see that it is not cocked or misaligned. When installed, finish the seats with the grinding or lapping equipment already mentioned.

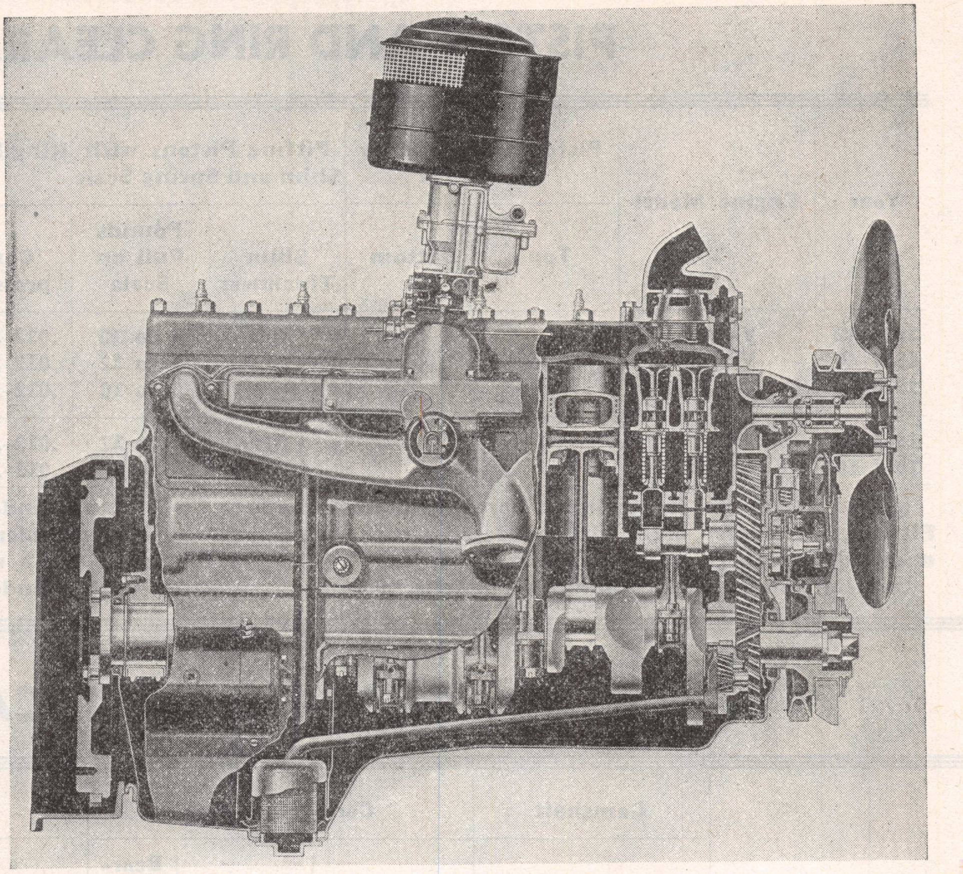
VALVES & VALVE GUIDES

1936-46 All: The valve, valve guide, spring and retainer are assembled and installed in the engine as a unit. To remove the assembly, insert a bar type valve lifter through the valve spring and to the flange on the lower end of the valve guide bushing. Using the top of the valve chamber as a fulcrum, pull down on the valve guide and withdraw the guide retainer. Then, with the valve lifter tool, push the assembly up and remove it from above. If the guides are stuck to the extent that they cannot be removed by this method, a puller is available which is used to break them loose, after which, they can be removed.

NOTE—Disassemble each valve unit separately, being sure to keep the valve guide bushing halves paired properly. Since the relationship between the outside diameter of the valve guide bushing and the inside diameter is held to very close limits, it is important that they be kept in pairs as originally installed. If valve guide halves are installed otherwise, excessive clearance will very likely result, causing noisy valves, lack of power and excessive oil consumption.

The clearance between the valve stem and valve guide should be maintained at from .0025" to .0045", and if the inside diameter of the valve guide becomes worn to a dimension greater than .315", a new guide should be installed.

NOTE—When replacing the valve and guide assemblies in the block, be sure to have the joint in the valve guide bushing at right angles to the camshaft.



1941-46 SIX CYLINDER ENGINE.

VALVE CLEARANCE, CHECK & ADJUST

1936-46 All: Since there is no means of adjusting valve-to-tappet clearance when these engines are assembled, this operation must be performed after the valves are refaced, and before assembling the guides and springs.

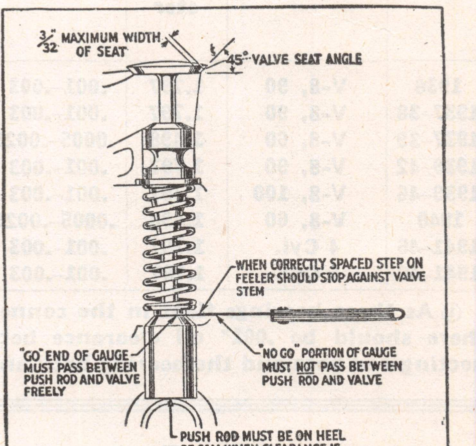
To check the clearance, turn the crankshaft until the valve being checked is fully closed, which is when the tappet is resting on the heel of the cam. Slip a feeler between the valve stem and the tappet, and if the clearance is not within the limits given in the VALVE SYSTEM table, remove the valve and grind the end of the stem, being sure that the stem is ground perfectly square.

VALVE TAPPETS

1936-46 All: Whenever the valve assemblies are removed for servicing, the tappets should be taken out, cleaned and examined. If the top of the tappet is pitted, or if the side clearance is in excess of the recommendations given in the VALVE SYSTEM table, replace the tappet.

VALVE TIMING

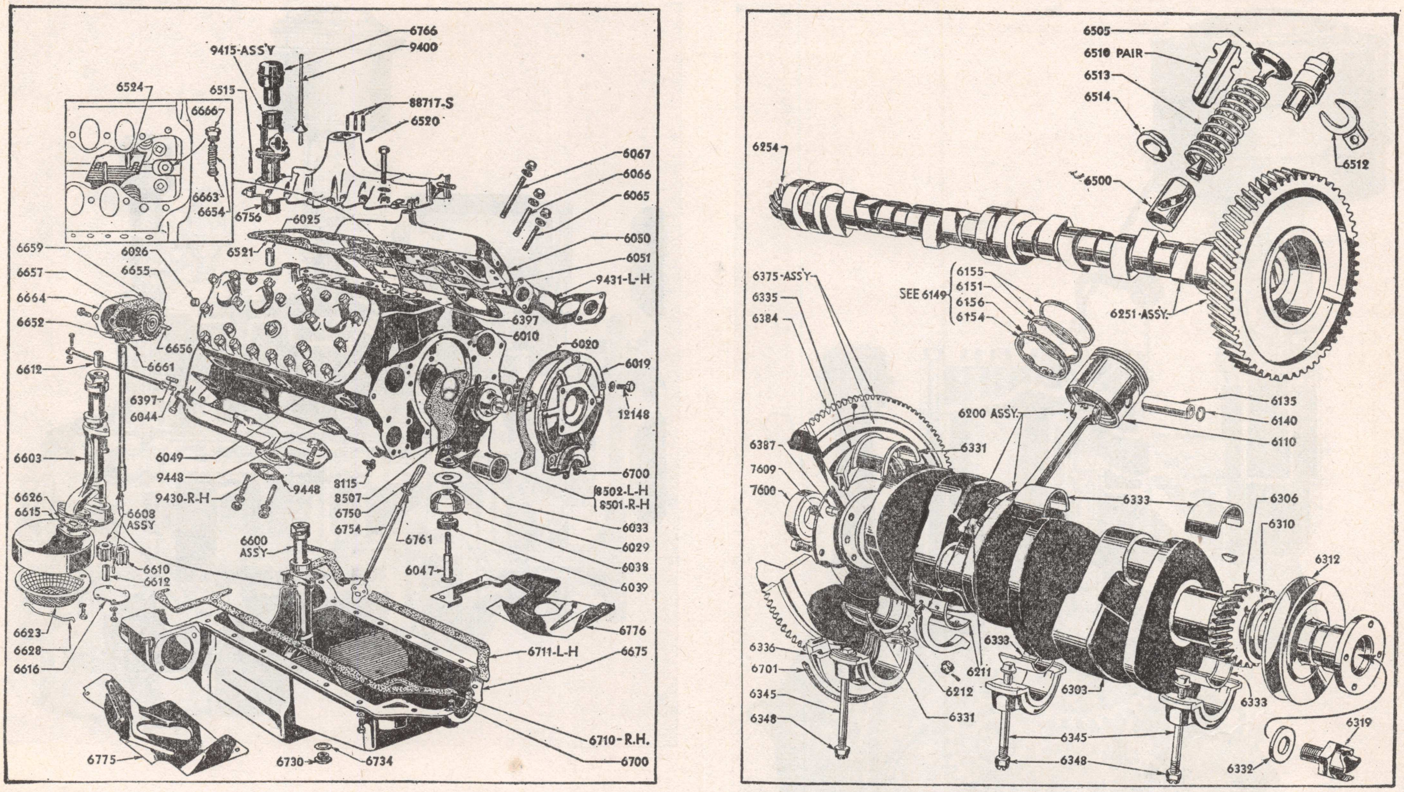
1936-46 All: There are no marks on the flywheel. When the timing marks on the camshaft and crankshaft gears are meshed, the valve timing is correct provided the valve clearance is as given in the VALVE SYSTEM table.


3/32" MAXIMUM WIDTH OF SEAT
45° VALVE SEAT ANGLE
WHEN CORRECTLY SPACED STEP ON FEELER SHOULD STOP AGAINST VALVE STEM
"GO" END OF GAUGE MUST PASS BETWEEN PUSH ROD AND VALVE FREELY
"NO GO" PORTION OF GAUGE MUST NOT PASS BETWEEN PUSH ROD AND VALVE
PUSH ROD MUST BE ON HEEL OF CAM WHEN CLEARANCE IS CHECKED

1936-46 ALL. Valve data.

Grind the valve stem if the clearance is insufficient. If the clearance is too great, the valve seat must be ground in enough to obtain the correct clearance.

NOTE—The following data are for use when the engine has been entirely disassembled and the timing gear marks are not legible or have been obliterated:


6766
9400
9415-ASS'Y
6524
6515
88717-S
6520
6666
6663
6654
6756
6025
6067
6066
6065
6659
6026
6521
6050
6051
6657
6655
9431-L-H
6664
6652
6397
6010
6656
6020
6019
6612
6661
6397
6044
12148
6603
6049
9448
9430-R-H
9448
8115
8507
6750
6754
6761
6700
8502-L-H
8501-R-H
6626
6615
6608 ASSY
6600 ASSY
6033
6029
6038
6039
6047
6610
6612
6623
6628
6616
6776
6711-L-H
6675
6710-R.H.
6700
6775
6730
6734
6505
6510 PAIR
6513
6514
6512
6254
6500
6375-ASS'Y
6335
6384
SEE 6149
6155
6151
6156
6154
6251-ASS'Y.
6200 ASSY.
6135
6140
6110
6387
6331
7609
7600
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6306
6310
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6336
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6701
6211
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6345
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6348
6319
6332

Exploded view of V8 engines. Basic part numbers are shown.

Engine Model	Intake Opens, Degrees BTDC	Exhaust Closes, Degrees ATDC
1936, V8	9.5	6.5
1937-46, V8, 90, 100	TDC	6.0
1937-39, V8, 60	9.5	6.5
1941-46, Four	6.0	6.0
1941-46, Six	3.0	6.5

CAMSHAFT GEAR

1936-46 All: During 1940 production of 90 and 100 H.P. engines and all engines thereafter, a bolted-on type camshaft gear is used, while prior to this time, a pressed-on type gear was used. If both the camshaft and gear is to be replaced on 90 and 100 H.P. engines equipped with the pressed-on type, the bolted-on type may be substituted. If, on these latter engines, the gear only is to be replaced, the camshaft will have to be removed and the gear pressed off. When pressing on the new gear, be sure that the notch on the gear is in line with the mark on the camshaft. See CAMSHAFT, REMOVE.

With the bolted-on type, it is not necessary to remove the camshaft when replacing the gear. The four screw holes are unevenly spaced which makes it impossible to install the gear incorrectly.

When timing gears are installed correctly, the marks on both gears are meshed.

CAMSHAFT, REMOVE

1936-46 All: After the valves and tappets have been removed from the block, insert a screwdriver behind the camshaft gear to start the shaft forward, after which, pull out the shaft, using extreme care not to allow the cam lobes to damage the camshaft bearings as the shaft is being withdrawn.

NOTE—If it is desired to remove the camshaft without taking off the cylinder head (or heads), remove the valve chamber cover and oil baffles. Then use a bar type valve lifter to pull down the valve spring in order to pull out the valve guide retainer. Now, raise the valve assembly enough so that the opening in the side of the valve tappet is above the boss in the valve chamber. Raise all the tappets in this manner and insert the valve guide retainers in these openings which will hold the tappets up, permitting the camshaft to be withdrawn.

CAMSHAFT BEARINGS

1936-46 All: The camshafts in all engines are supported in replaceable, steel-backed babbitt-lined bearings which, if suitable equipment is used for their installation, require no fitting or reaming.

NOTE—When replacing bearings, be sure that the oil holes in the bearings are in line with the oil holes in the block.

Camshaft end play is automatically controlled by the timing gear cover plate which bears against the hub of the camshaft and prevents endwise movement.

TIMING GEAR COVER

1936-46 All: The timing gear cover plate carries an oil seal which should be renewed every time the cover is removed. Take out the old packing from the groove and clean out the groove thoroughly. Then, before installing the new packing, soak it in oil for about 30 minutes to swell the fabric so that the sealing will be effective immediately.

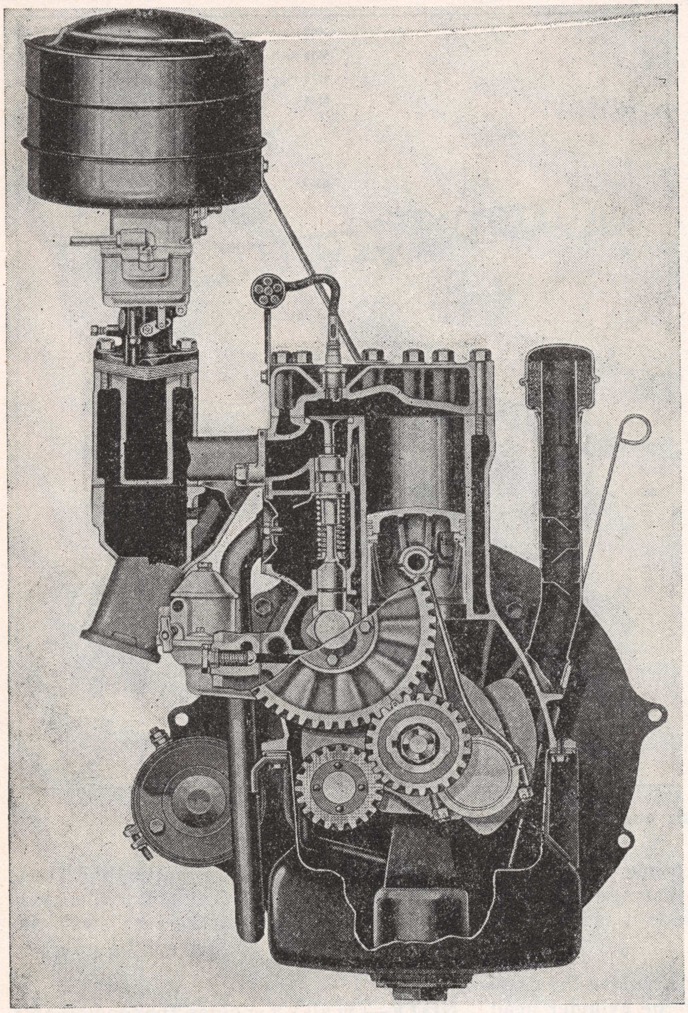
NOTE—On all V8 engines, the top bolt hole in the timing gear cover carries a bolt having a shoulder which is designed to provide a closer fit and to facilitate proper alignment of the cover and correct distributor location. When assembling the cover to the engine, install the top bolt first as the shoulder acts as a dowel. After installing all the bolts and making sure the cover is flush with the block on both sides, tighten all the bolts evenly.

PISTONS & RODS, REMOVE

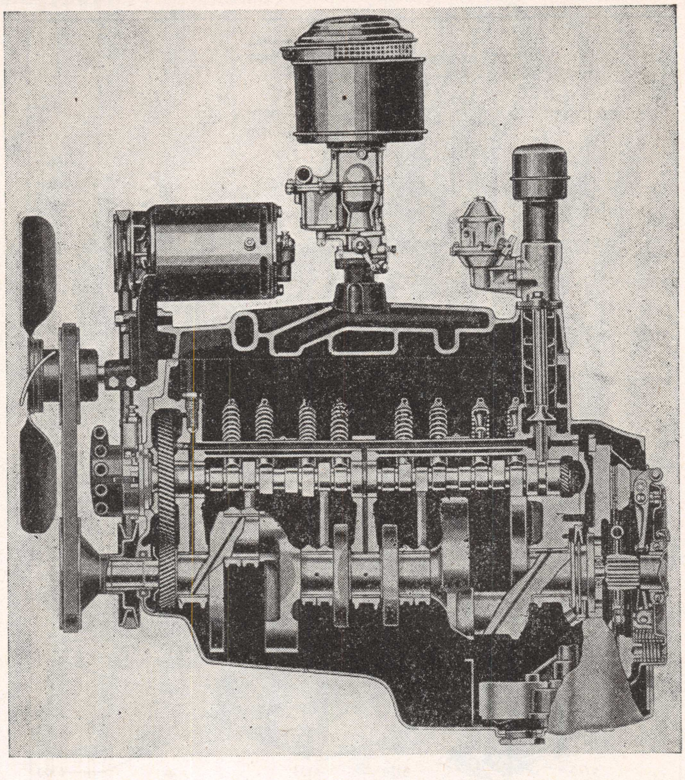
NOTE—The following procedure is specifically for 1942 V8 models but in general can be applied to all engines, disregarding of course, any item which is not pertinent to the particular model being serviced.

1936-46 All: Drain the oil from the engine and open the radiator drain plugs and drain the cooling system. Remove both front engine mounting bolts and washers and loosen the lower radiator hose connections at the engine. After removing the hood, disconnect the battery cables (if battery is under hood) and lift out the battery and clamp frame. Take off the carburetor air cleaner and disconnect the starter cable from the starting motor. Remove the upper right hand hose.

NOTE—To prevent dirt from entering the carburetor, close the choke valve in the carburetor.



1941-46 SIX-CYLINDER ENGINE.



1942-46 V8 ENGINE.

Loosen the spark plug wire conduit and move it out of the way. Take off the upper left hand hose and push the spark plug wires on this side of the engine out of the way. If equipped with an oil filter, remove it at this time. If the ignition coil is mounted on the valve chamber cover, remove both the coil and its bracket.

Set the transmission in low gear. Remove the oil filter inlet line at the engine (if equipped) and disconnect the wires from the heat indicator unit in the cylinder head. Disconnect the oil level gauge tube at the oil pan and remove the oil filter discharge line (if equipped).

Lift off the cylinder head or heads and gaskets. Disconnect the exhaust pipe flange (both sides of the engine on V8's).

Use a wooden block between the oil pan and the jack and raise the engine as far as possible. Then, after removing the large steel washer on the front rubber support, insert a wooden block, 1½" thick, between the engine mounting and rubber support, after which, remove the jack. Raise the front end of the vehicle with a chain hoist until the front wheels are clear of the floor.

On the V8's, loosen the clamp and pull off the exhaust cross pipe. Remove the cap screw which fastens the small bracket to the starter, and the screws which fasten the starter to the oil pan and take out the starter.

On all engines, disconnect the oil pan from the transmission case and unhook the brake pedal return spring. Take out the long capscrew on the top, over the starter drive housing, and all the screws which fasten the oil pan to the crankcase, after which, lower the pan and maneuver it until it is free. It may be necessary to turn the front crankshaft counter-balance out of the way, and also the radius rod ball cap (if equipped) may have to be disconnected and held down with a block.

On the V8 90 and 100 H.P. engines, remove the locking wire and capscrew which fastens the oil pump to the crankcase and pull out the pump. On V8 60's, Sixes and Fours, remove the nuts from the No. 1 main bearing cap (also No. 3 cap on Sixes) and pull off the caps and oil pump.

Remove the cotter pins and nuts from the rods which are most accessible and force these rods up in the cylinder until free of the cap. A handy tool for this purpose can be made by cutting off one end of an old connecting rod. Push the rod up until the piston is out of the cylinder bore. Turn the crankshaft until the next set of rods are accessible and repeat the above procedure.

NOTE—Except on some 1936 engines, the rod bearings on all V8 engines are floating type liners which remain on the crankpin journals when the rods are removed. Before removing the liners from the shaft, mark each bearing half with the crankpin number to which it belongs so that, if they are to be re-used, the original assembly will be maintained. After removing the bearing liners, lower the vehicle and remove the pistons and rods from the engine. On the Fours and Sixes, the bearings are provided with notches to hold them stationary in the caps and rods.

PISTONS & RODS, ASSEMBLE

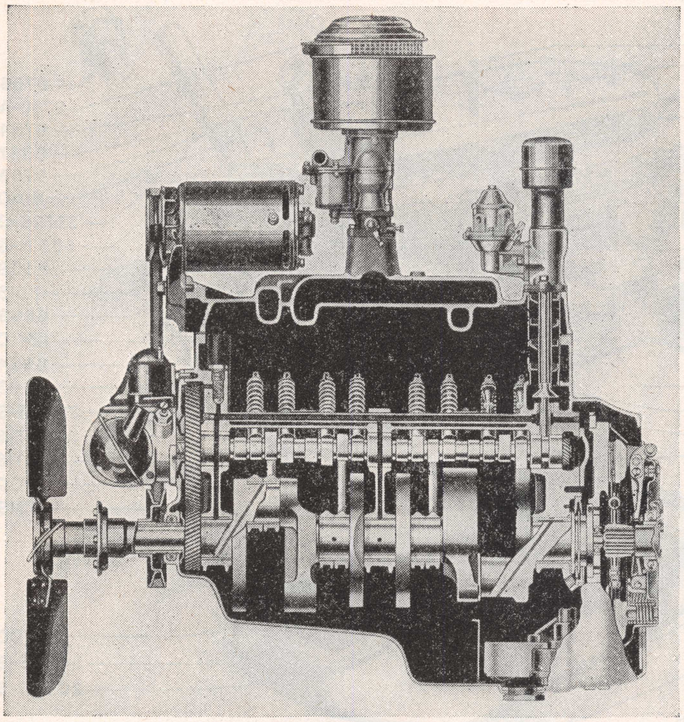
1936-46 All: All Ford pistons are stamped with an arrow and when installed in the bores, the arrow should point toward the front of the engine. The rods are marked with an arrow on the bearing cap which must also face the front of the engine when installed.

On all V8 engines, the rods are marked L-1-2-3-4 for the left bank and R-1-2-3-4 for the right bank, and should be so installed.

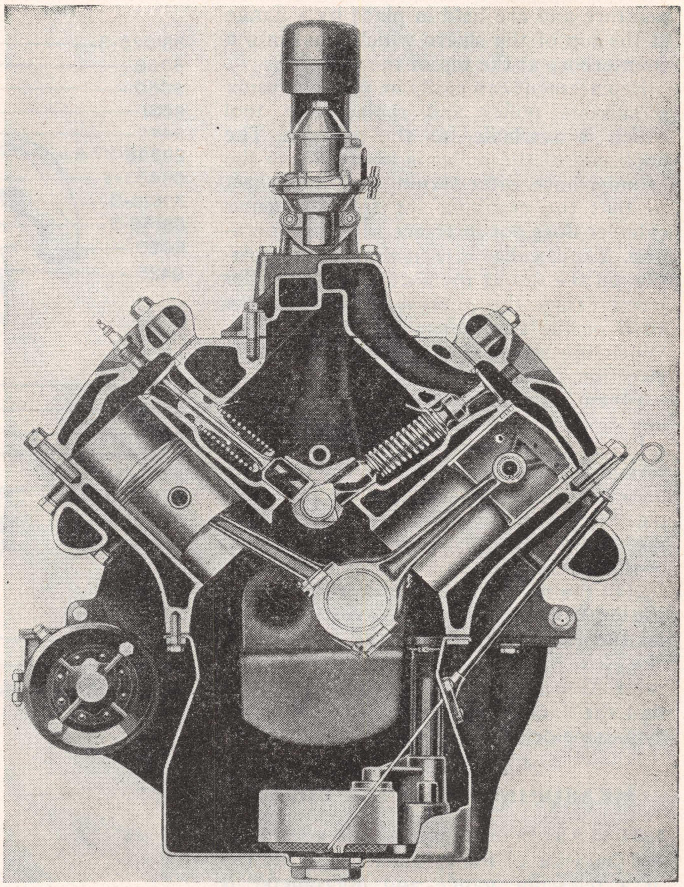
PISTONS, RENEW

1936-46 All: NOTE—A variation of 10 degrees between the temperature of the pistons and cylinder bores is sufficient to produce a difference of .0005". Therefore, both the pistons and cylinder bores should be at normal room temperature (about 70 degrees) when fitting pistons. This is particularly important because the clearances given in the PISTON & RING CLEARANCES table are minimum and pistons must not be fitted with less than specified.

Before any attempt is made to fit new pistons, cylinder bores should be carefully



1939-41 V8 ENGINE.



1936-46 V8 ENGINE.
End view.

indicated and refinished. If bores do not require refinishing, be sure to remove the ridge at the top of each bore. If refinishing is required, it is good practice to do so in alternate cylinders due to the localized temperature build-up. Cylinder bores should not be out-of-round or tapered more than .0005". For engines equipped with cylinder sleeves, see CYLINDER SLEEVES, RENEW for instructions.

Before fitting pistons, wipe the cylinder walls and pistons to remove all chips, dirt or other foreign matter. The feeler ribbon used to check piston fit should be about 12" long and ½" wide. Consult the PISTON & RING CLEARANCES table for the thickness of shim to use, as well as the recommended pounds pull on a spring scale required to withdraw the feeler ribbon past the piston.

NOTE—When fitting pistons, the dimension at the top of the skirt must be used to determine the piston size and clearance between the piston and the cylinder bore. The measurement must be made across the piston pin boss, at right angles to the pin.

The cylinder bore should be measured crosswise to the engine at a point 2" from the bottom of the bore. It is measured at this point since piston clearance must be established at the smallest diameter of the cylinder bore to prevent scoring. The difference between this dimension and the diameter of the piston measured at the point described above represents the amount of clearance for the piston. No other method of determining the clearance should be used.

To eliminate any possibility of pistons being incorrectly installed, the word "front" and an arrow are stamped on the top of each piston.

After assembling the piston to the connecting rod, check the assembly for alignment on a suitable jig.

PISTON RINGS, RENEW

1936-46 All: NOTE—To prevent the possibility of bending or breaking the second ring land—thus ruining the piston—the ridge at the top of the cylinder bore should be cut away before removing the piston and rod assemblies. If the available ridge reamer has no provision to control the depth of the cut, it is good practice to bring the piston far enough up into the cylinder to allow the reamer to rest on top of the piston. This will serve to prevent cutting down into the ring travel area.

CAUTION—Never cut down into the ring travel area more than 1/32"—or more than half the depth of the top ring.

New rings should be fitted with end gaps and groove clearances as given in the PISTON & RING CLEARANCES table. Ring grooves must be clean and free from carbon, and must show no perceptible wear.

NOTE—Ring end gaps listed in the PISTON & RING CLEARANCES table are for cylinder bores without taper. Fit rings in tapered bores with not less than the maximum dimension given. Usually, complete installation instructions are included in each ring package. Whether the original type ring is being used or some other make, the instructions should be carefully followed. This applies to clearances, position in grooves, etc.

When rings are properly fitted to the pistons, be sure to stagger the ring gaps so they are spaced equal distances around the circumference of the piston. However, see that no gaps are over the piston pins.

PISTON PINS, RENEW

1936-46 All: Although some early production aluminum pistons used a lock ring at the center of the piston pin to control the endwise movement of the pin, later production pistons—both steel and aluminum—have recesses in the piston pin bosses in which lock rings are used to control the endwise movement.

When fitting pins in aluminum pistons, the piston pin bosses should be reamed to provide a hand push fit of the pin. However, since the pressure of the hand may vary to some extent, the piston may be heated in boiling water for about a minute, after which, the pin should enter the piston easily.

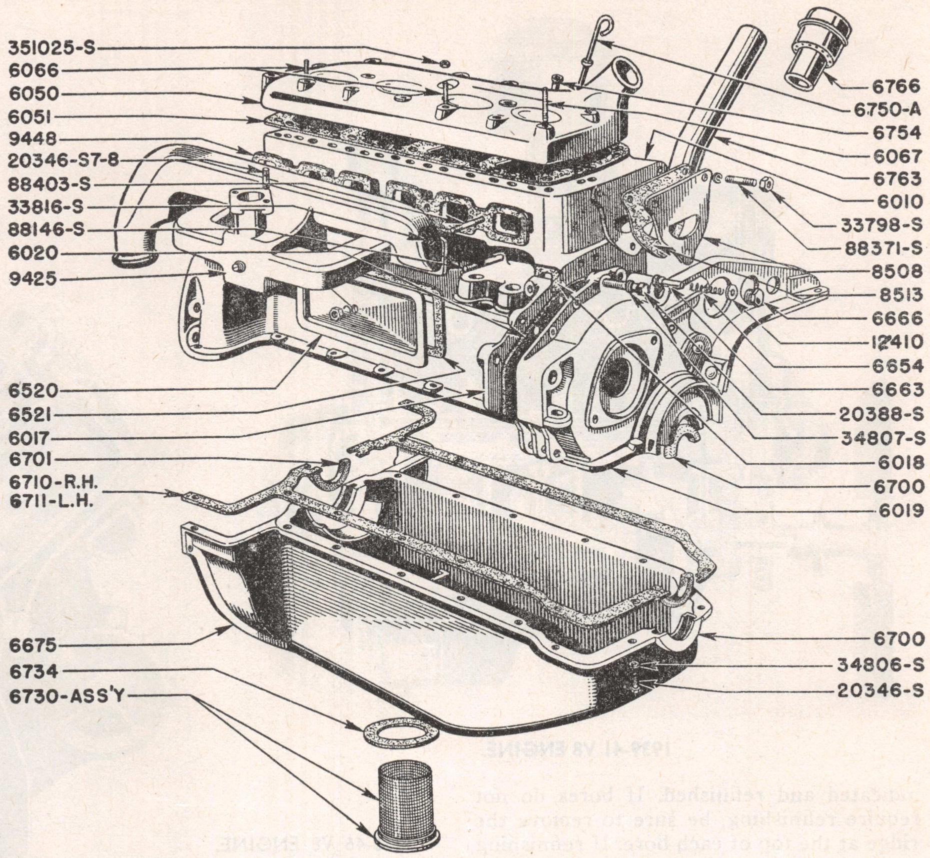
When fitting pins in steel pistons, have the piston and pin at room temperature. The correct fit of pins in this type piston should be one which will permit the pin to drop into the piston bosses slowly by its own weight but with a slight drag. This is equivalent to a clearance of .0007".

CYLINDER SLEEVES, REPLACE

1939-46: Some 90 and 100 H.P. engines, as well as the Four cylinder, are equipped with cylinder sleeves which are pressed into the cylinder bores. These sleeves are pressed in the bores at normal room temperature and are held in place by a flange at the top of the sleeve which seats into a counterbore at the top of the cylinder.

Replacement can easily be made by using a suitable puller and replacement tool which is available for the purpose. The hook end of the puller is inserted into the cylinder bore, after turning the crankshaft so that the crankpin for that particular cylinder does not interfere with the operation. A split collar is then slipped into position on the nut at the bottom of the puller screw. Turn the crankshaft so that the anvil of the hook rests on the crankpin. When the screw is turned in a clockwise direction, the sleeve can be pulled out.

When installing a new sleeve, run the nut down to the bottom of the bar—the split collar is not used in this operation. Insert the puller up through the cylinder bore, keeping the crankpin in the same position as when removing the sleeve. Slip the sleeve carefully over the screw and position it in the top of the cylinder bore. Install the top collar and turn it down until the upper flange of the sleeve rests squarely on the collar. Then turn the screw anticlockwise to draw the sleeve into the cylinder. When the sleeve is installed, be sure that the flange is flush with the top of the cylinder block.



1941-46 FOUR CYLINDER ENGINE.
Exploded view.

MEASURING CYLINDER BORES

1936-46 All: In order to measure accurately the diameter of the cylinder bores, the use of a telescope gauge and micrometer is recommended. This telescope gauge is an inexpensive item and can be used almost universally. The illustrations will clarify the following instructions: Loosen the screw on the end of the gauge handle and close the points to a size smaller than the bore to be checked, holding them while you retighten the screw. Insert the gauge in the bore at a slight angle and loosen the screw which will allow the points of the gauge to expand until stopped by the walls of the bore. As the points are controlled by spring pressure, it is necessary to retighten the screw. Owing to the angle at which the gauge was inserted into the bore, the distance between the points will be greater than the bore. In order to center the gauge in the bore, move the gauge as shown in the illustration and the screw will hold the setting. This measurement should be taken lengthwise of the block at a point 2" from the bottom of the bore. Place the gauge into the extremities of an outside micrometer to obtain the measurement of the bore.

Standard cylinder bore sizes have a tolerance of plus .001".

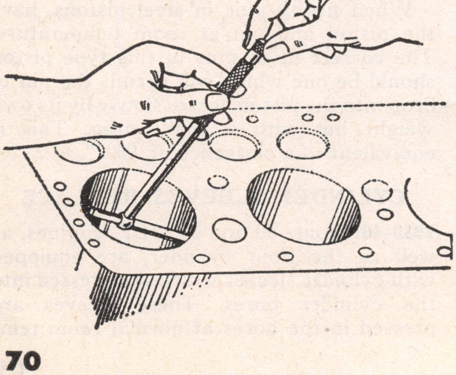
CONNECTING ROD BEARINGS, RENEW

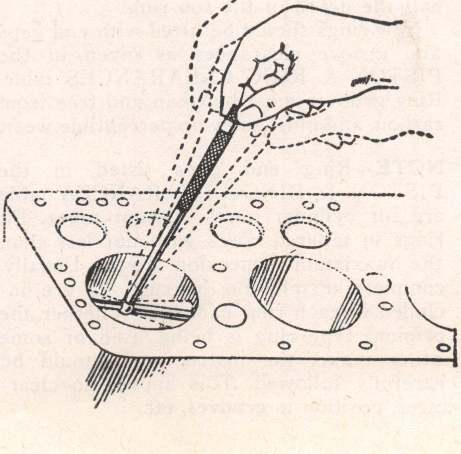
NOTE—When necessary to replace bearings, it is important that the crankpins be "miked" so as to be sure the correct size bearing is being used. This is particularly important because of the large number of reconditioned engines which have been installed in recent years.

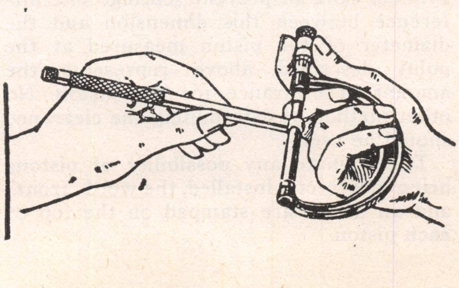
1936-46 V8's: In these engines, two connecting rods placed side by side operate on each crankpin and on one bearing assembly. These bearings are made in halves and have bearing metal applied to **both the outside and inside diameters.** The connecting rods ride on the outside diameter of the bearing, and the bearing rides on the crankpin. With this design, the bearing is free to float or turn radially.

NOTE—Oil clearance must be provided on both sides of this type bearing, and end play must exist between both rods and crank cheeks and between the rods. This bearing, unlike those of the fixed seat type which is used in the Six and Four cylinder engines, must, when paired, be truly round. The clearance between the back of the bearing and the connecting rod bore is from .0015" to .003". The theoretical maximum clearance over the crankpin is .0025".

It sometimes happens that these bearings spread or open up—in storage, for example—across the parting, which will cause tightness in the rod. To correct this condition







hold the bearing on a smooth wooden block and strike the side lightly with a soft mallet until the roundness of the bearing halves have been restored. If, during this operation, the bearing has been bent to the other extreme, it can be corrected by laying the bearing on the wooden block and striking the back lightly with a soft mallet. Be sure to check the bearings for binding when installed in the rod bores.

Connecting rods should be checked for roundness of the bearing bore as distortion may exist and the bore may be badly worn. If the rod bore is out-of-round more than .002", the rod should be discarded and a new one installed.

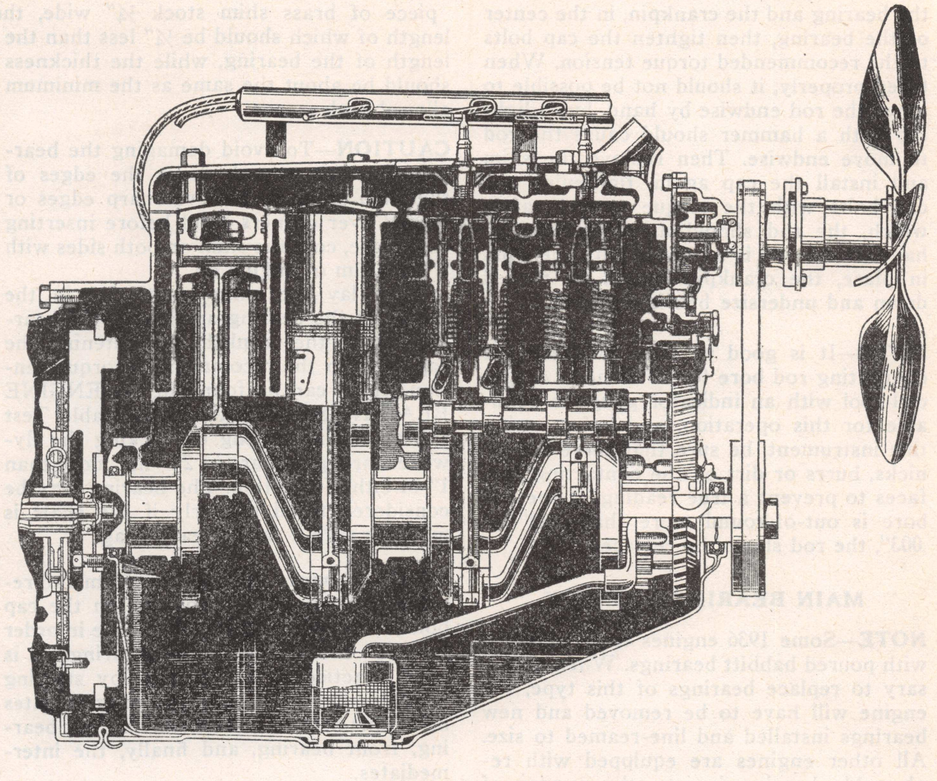
IMPORTANT—Extreme care must be used when selecting replacement rods. Because of the lightness of this rod, genuine Ford rods are made from the highest grade of alloy steel. Before using a replacement rod, carefully measure the distance between the centerline of the piston pin hole and the centerline of the rod bore, and if this distance is shorter than that of a new rod, it must not be used, as this lowers the piston in the cylinder bore and increases the volume of the combustion chamber, causing loss of power and engine roughness. Another disadvantage is the likelihood of oil ring breakage. Engines which have had a number of thousand miles of operation have a ridge in the cylinder bore at the bottom of the lower ring travel. This ridge will be of varying size, and when a short rod is used, the bottom ring will ride the ridge (may be identified by a clicking noise), or if the ridge is sufficiently high, broken oil rings may result.

Fixed Seat Bearings: This type bearing is used in both Four and Six cylinder engines. When bearings become worn, they can be replaced without removing the rod by simply taking off the bearing cap and replacing the upper and lower halves. Bearings should be replaced in sets and under no circumstances should rods or caps be filed, altered or mutilated in any way in an attempt to obtain proper bearing fit.

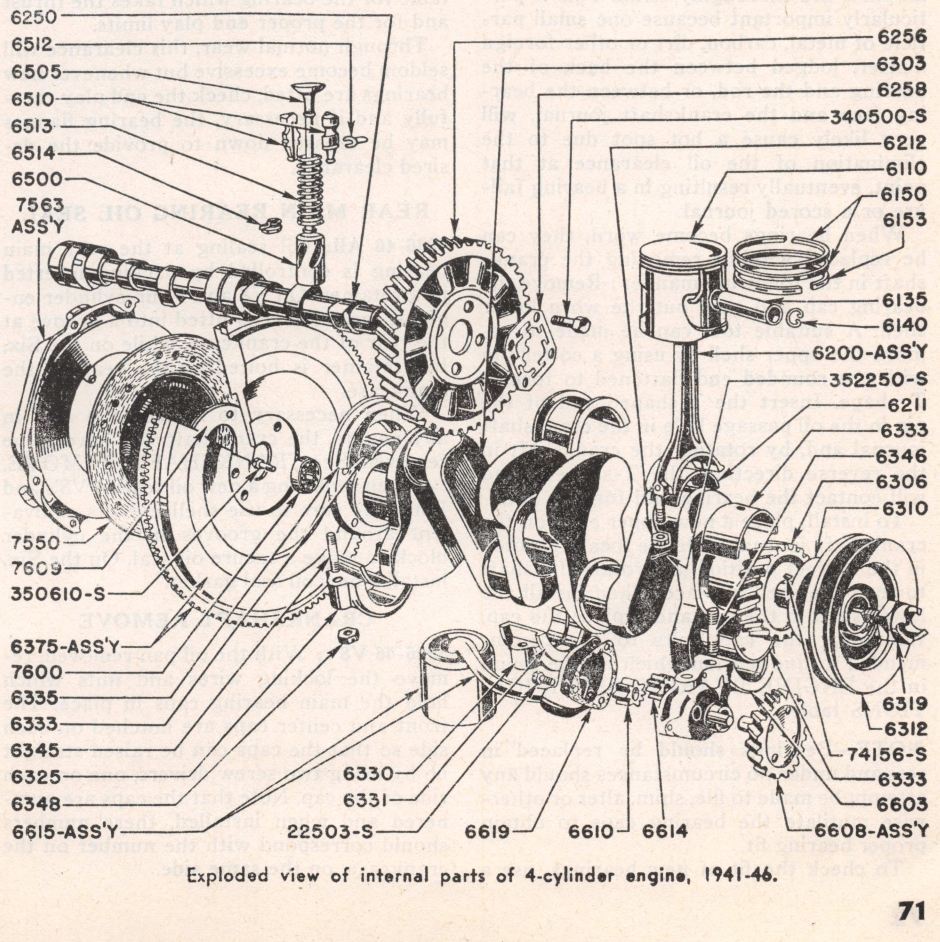
NOTE—Before replacing bearings, make sure that the crankpins are not nicked or scored. Use care also, to see that all parts are thoroughly clean. This is particularly important because one small particle of metal, carbon or other foreign matter, lodged between the back of the bearing and the rod, or between the face of the bearing and the crankpin, will very likely cause a hot spot due to the elimination of the oil clearance at that point, eventually resulting in a bearing failure or a scored crankpin.

To check the fit of new bearings, use a piece of brass shim stock ¼" wide, the length of which should be ¼" less than the length of the bearing, while the thickness should be about the same as the minimum allowable clearance.

CAUTION—To avoid damaging the bearing material, smooth down the edges of the shim stock on an oil stone so that no sharp edges remain. Install the shim between



1941-46 FOUR CYLINDER ENGINE.



Exploded view of internal parts of 4-cylinder engine, 1941-46.

the bearing and the crankpin, in the center of the bearing, then tighten the cap bolts to the recommended torque tension. When fitted properly, it should not be possible to move the rod endwise by hand, but a light tap with a hammer should cause the rod to move endwise. Then remove the shim and install the cap again, tightening the cap bolts with the torque wrench, after which, the rod should move endwise by hand. If the rod is too loose with the shim in place, the crankpin should be turned down and undersize bearings fitted.

NOTE—It is good practice to check the connecting rod bore for roundness. A special tool with an indicator gauge is available for this operation, and before using this instrument, be sure that there are no nicks, burrs or dirt on the contacting surfaces to prevent a true reading. If the rod bore is out-of-round more than .002" or .003", the rod should be replaced.

MAIN BEARINGS, RENEW

NOTE—Some 1936 engines were equipped with poured babbitt bearings. When necessary to replace bearings of this type, the engine will have to be removed and new bearings installed and line-reamed to size. All other engines are equipped with replaceable bearing inserts, the service of which is explained below.

NOTE—Before replacing bearings, make sure that the crankshaft journals are not nicked or scored. Use care also, to see that all parts are thoroughly clean. This is particularly important because one small particle of metal, carbon, dirt or other foreign matter, lodged between the back of the bearing and the rod, or between the bearing face and the crankshaft journal, will very likely cause a hot spot due to the elimination of the oil clearance at that point, eventually resulting in a bearing failure or a scored journal.

When bearings become worn, they can be replaced without removing the crankshaft in the following manner: Remove the bearing cap and take out the worn lower shell. A suitable tool can be made to remove the upper shell by using a cotter pin with the rounded end flattened to form a T shape. Insert the T-shaped end of the pin in the oil passage hole in the crankshaft journal and, by rotating the crankshaft in the reverse direction, the T-shaped head will contact the bearing and force it out.

To install, place a new upper shell on the crankshaft journal with the locating notch in the correct position and rotate the shaft to turn the shell in place. Then install the lower shell in the cap and replace the cap, tightening the cap bolts to the recommended torque tension which will be found in the ENGINE BEARING SPECIFICATIONS table.

NOTE—Bearings should be replaced in sets and under no circumstances should any attempt be made to file, shim, alter or otherwise mutilate the bearing caps to obtain proper bearing fit.

To check the fit of new bearings, use a piece of brass shim stock ¼" wide, the length of which should be ¼" less than the length of the bearing, while the thickness should be about the same as the minimum allowable clearance.

CAUTION—To avoid damaging the bearing material, smooth down the edges of the shim stock to remove sharp edges or turned over corners. And before inserting it in place, coat the shim on both sides with a light film of engine oil.

Then lay the shim lengthwise in the center of the bearing and install the bearing cap to the crankshaft, tightening the cap bolts to the recommended torque tension which can be found in the ENGINE BEARING SPECIFICATIONS table. Test the fit of the bearing by rocking the flywheel through an arc of 2"—not more than 1" in either direction. The bearing may be considered fitted properly if the shaft is movable with a fairly heavy drag.

NOTE—Remove the checking shim and replace the cap, but do not tighten the cap bolts, as this bearing must be loose in order to check the fit of the other bearings. It is good practice to fit bearings by starting at the center—or one of the intermediates on a four bearing job—then the rear bearing, front bearing, and finally, the intermediates.

CRANKSHAFT END THRUST

1936-46 All: Crankshaft end thrust is controlled by flanges on a bearing. See the ENGINE BEARING SPECIFICATIONS table for the bearing which takes the thrust and for the proper end play limits.

Through normal wear, this clearance will seldom become excessive but whenever new bearings are fitted, check the end play carefully and if necessary, the bearing flanges may be dressed down to provide the desired clearance.

REAR MAIN BEARING OIL SEAL

1936-46 All: Oil sealing at the rear main bearing is controlled by packing inserted in a retainer. On V8 and Four-cylinder engines, the retainer is fitted into a groove at the rear of the crankcase, while on the Six, the retainer is bolted to the rear of the crankcase.

When necessary to replace the seal in any engine, the crankshaft will have to be removed. See CRANKSHAFT, REMOVE.

When replacing a new oil seal on V8's and Fours, be sure to use shellac or its equivalent around the grooves in the cylinder block to make a secure oil seal. On the Six, install a new oil seal gasket.

CRANKSHAFT, REMOVE

1936-46 V8's: With the oil pan removed, remove the locking wires and nuts which hold the main bearing caps in place. The front and center caps are notched on each side so that the caps can be raised straight up by using two screw drivers, one on each side of the cap. Note that the caps are numbered and when installed, these numbers should correspond with the number on the crankcase, on the same side.

After removing the rear main bearing cap nuts and it is difficult to remove the cap, place a bar or wrench over one of the bearing cap studs. Using the tool as a fulcrum, lift up under the bearing cap drain tube. With all caps removed, the crankshaft and flywheel assembly may be lifted out.

Four Cylinder: The main bearing caps are not notched into the crankcase so there is no difficulty in lifting them off after the cap nuts have been removed.

Six Cylinder: Due to the construction of the flywheel housing on these engines, it is necessary to remove the clutch and flywheel before the crankshaft can be removed.

NOTE—When removing or installing the clutch, it is important that a clutch compressor tool be used. If the clutch is removed without the use of this tool, the cover plate assembly is apt to become distorted to the extent that the operation of the clutch would be affected.

To remove the clutch, install the pilot through the clutch disc and into the pilot bearing in the flywheel. Then place the compressor tool into position on the clutch cover and turn the handle to take up the clutch spring tension. Remove the cap screws which hold the pressure plate to the flywheel and lift off the pressure plate assembly and clutch disc. Unscrew the bolts which fasten the flywheel to the crankshaft flange and lift off the flywheel. The flywheel housing may then be unfastened from the crankcase and lifted off. After removing the main bearing caps, the crankshaft can then be lifted out.

FLYWHEEL, INSTALL

1936-46 All: When the flywheel is installed to the crankshaft, it should be checked for run-out. Tighten the flywheel cap screws but do not install the locking wire. Mount a dial indicator on the flywheel housing and rotate the flywheel slowly and note the amount of run-out. Run-out should not exceed .005" but if it does, remove the flywheel and see that no foreign matter is lodged between the crankshaft flange and the flywheel.

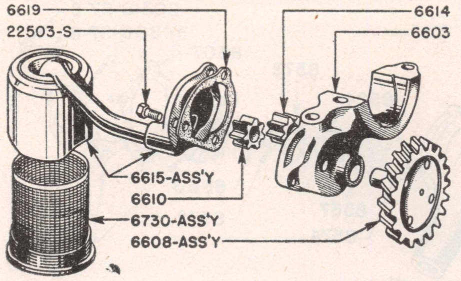
FLYWHEEL RING GEAR, RENEW

1936-46 All: A shoulder is provided on the rim of all flywheels and when installing a new ring gear, the gear should be heated sufficiently to permit it to expand enough so that it will slip over this shoulder. A gas heater is recommended as being the best way to heat the ring for its removal and installation. Since the ring gear is a shrunk fit on the flywheel, it cannot be pressed or driven off.

ENGINE OILING

OIL PAN, REMOVE

NOTE—The following procedure is specifically for 1942 V8 engines but in general can be applied to all engines, disregarding of course, any item which is not pertinent to the particular model being serviced.



Exploded view of oil pump assembly of 4-cylinder engine, 1941-46.

1936-46 All: Drain the oil from the engine and open the radiator drain plugs and drain the cooling system. Remove the engine mounting bolts and washers and loosen the lower radiator hose connections at the engine. Disconnect the oil level gauge tube at the oil pan and remove the oil filter discharge line (if equipped). Disconnect the exhaust pipe flange (both sides on V8's). Use a wooden block between the oil pan and the jack and raise the engine as far as possible. Then, after removing the large steel washer on the front rubber support, insert a wooden block, 1½" thick, between the engine mounting and the rubber support, after which, remove the jack. Raise the front end of the vehicle with a chain hoist until the front wheels are clear of the floor.

On V8's, loosen the clamp and pull off the exhaust cross pipe. Remove the cap screw which fastens the small bracket to the starter, and the screws which fasten the starter to the oil pan and take out the starter.

On all engines, disconnect the oil pan from the transmission case and unhook the brake pedal return spring. Take out the long cap screw on top—over the starter drive housing—and all the screws which fasten the pan to the crankcase, after which, lower the pan and maneuver it until it is free. It may be necessary to turn the crankshaft so the front counter-balance will not interfere with the pan. If the vehicle is equipped with a radius rod, it may be necessary to disconnect the ball cap and block the radius rod down to hold it out of the way. It may also be required to move the fan pulley forward if there isn't sufficient clearance to drop the pan.

OIL PAN, REPLACE

1936-46 All: Before replacing the pan, make sure that the gasket surfaces on both the pan and crankcase are perfectly clean and free from old gasket pieces. Be sure to soak the oil seal packings thoroughly before their installation so that an effective seal will be obtained. The flat cork gaskets should be thoroughly greased and placed on the crankcase flanges so they will stay in place when installing the pan.

NOTE—On the Sixes, it is good practice to use a couple of guide studs to aid in the pan's installation. These studs can be made by cutting off the heads of spare oil pan cap screws and sawing a slot in the head so they can be removed with a screwdriver after the pan is positioned properly. These headless screws not only prevent the gaskets from shifting but help to guide the oil pan into correct alignment with the crankcase.

CAUTION—It is important when installing the oil pan to be sure that the rear end of the pan is properly lined up with the flywheel housing. Any misalignment at this point may cause distortion of the transmission case, affecting clutch operation, as well as causing transmission gears to jump out of mesh, and also, may lead to oil leaks.

OIL PUMP, REMOVE

1936-46 All: On the V8 90 and 100 H.P. engines, remove the locking wire and cap screws which fastens the oil pump to the crankcase and pull out the pump.

On V8 60 H.P. engines, as well as the Sixes and Fours, remove the nuts from the No. 1 bearing cap (also No. 3 cap on the Six) and pull off the caps and oil pump.

OIL PUMP, OVERHAUL

NOTE—On all engines, if the oil pressure drops below normal, do not remove the oil pump or oil pan until the oil gauge is checked with another gauge known to be accurate. Check the oil level and examine the condition of the oil. If the pressure continues to drop, remove and clean the oil pan thoroughly, and disassemble, clean and inspect the pump and oil pressure regulator.

CAUTION—Before replacing the oil pump and oil pan, the oil float, screen and tube should be thoroughly cleaned, being sure that all openings in the screen are free and clean. If the screen has been crushed, it is better to replace it rather than attempt to make a repair. When assembling the pump, dip the gears in fresh engine oil as a means of priming the pump.

1936-46 V8 90 and 100 H.P.: The pump used in these engines is of the positive gear type. Oil is drawn through a screen at the bottom of the oil pan and is delivered to the pump body and thence through oil passages in the cylinder block.

Before disassembling the pump, move the drive gear at the top of the unit from side to side. If the total movement from one side to the other is not in excess of .005", the pump need not be disassembled. If the bushings are worn to the extent that the sidewise movement is in excess of .005", they should be replaced.

To disassemble the pump, drive the pin from the drive gear and press the gear from the shaft. The bushings may then be pressed out of the housing and new ones installed.

NOTE—When assembling the pump, press the gear onto the drive shaft and check to see that there is .017" clearance between the bottom of the gear and the upper end of the pump body. Before pressing on the gear, make sure that the locking pin hole is about ¼-turn away from the original hole in the shaft. Since it is impossible to press the gear back so that the holes in the gear and shaft line up, a new hole must be drilled. Use a 5/32" drill and be guided by the hole in the gear hub when drilling the shaft. Install the locking pin and secure it in place by peening it over so that it will not work loose.

V8-60, Four & Six: Pumps used in these engines are also of the gear type but the suction line and oil screen are separate from the pump proper.

The pump body is an integral part of the front main bearing cap and the oil delivery passage is directly through the body of the cap to the crankcase. The oil pump drive gear is on the front of the cap and meshes with the crankshaft timing gear. The suction line is an integral part of the oil pump cover plate and is attached to the rear side of the front main bearing cap by capscrews.

OIL PRESSURE REGULATOR

1936-46 All: The oil pressure relief valve is designed to open at about 30 pounds pressure. The oil gauge pressure as indicated on the instrument panel ordinarily shows from 15 to 30 pounds, depending upon the temperature of the oil, its viscosity, and the speed at which the engine is being operated. In view of this, oil gauge readings should only be considered merely as an indication that the oil is being circulated.

On V8 90 and 100 H.P. engines, the oil pressure regulator consists of a spring-loaded ball-ended valve which is accessible by removing the valve chamber cover (intake manifold). Oil pressure is automatically regulated when the screw cap is turned down to its seat.

NOTE—When examining the ball end of the valve for wear, do not mistake the small flat spot on the face of the valve as an indication of wear. The purpose of the flat spot is to allow a small quantity of oil to flow through the line even at low pressures.

V8 60, Six & Four: In these engines, the regulator is of the same general design as the V8 90 and 100 H.P. engines except that on the 60, it is located at the front part of the engine under the valve chamber cover (intake manifold). On the Six, its location is at the timing gear side cover plate, while on the Four, it is located at the top of the timing gear cover plate.

COOLING SYSTEM

FAN BELT, ADJUST

1936-46 All: When correctly adjusted, the fan belt will not have more than 1" total movement. The belt should be grasped by the thumb and forefinger and pulled out to take up all slack, then pushed in; the total movement should be 1 inch. To make an adjustment loosen the generator support clamp and move the generator upwards to tighten the belt.

WATER PUMP, REMOVE

1936-46 V8's: Drain cooling system. Remove lower radiator hose connections. Raise the engine so the forward mountings just clear the attaching bolts. Remove the fan belt and bolts attached to pump housing and engine bracket. The pump and engine bracket can then be removed as an assembly.

Six & Four: Drain the cooling system, disconnect the lower radiator hose, remove the fan, loosen the generator and swing it in towards the cylinder block and take off the fan belt. Remove the cap screws which fasten the pump to the engine and lift off the pump.

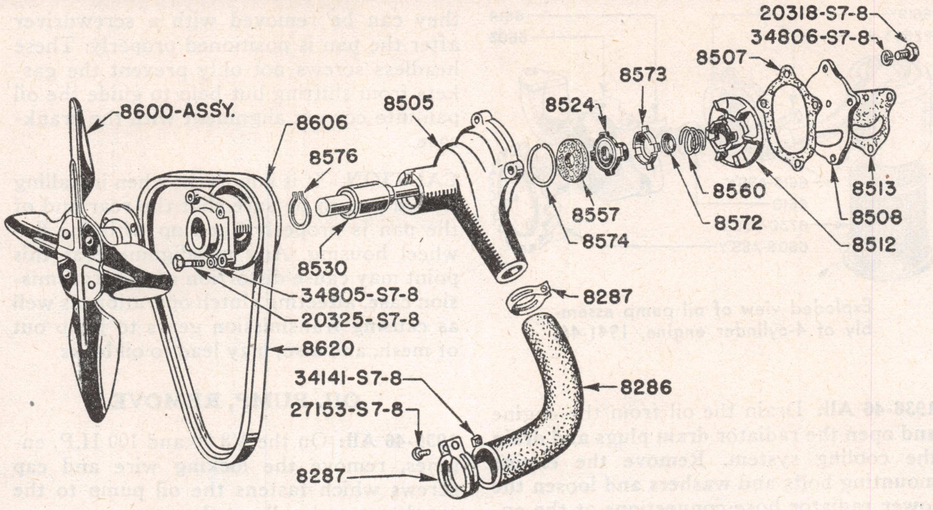
WATER PUMP, OVERHAUL

1936: Drive the pin out of the pulley hub and pump shaft and press the shaft out of the pulley, removing the shaft and impeller from the rear of the pump. Use a special driver to remove and replace the bushing. When assembling, install the packing spring on the shaft with the small end of spring next to the impeller. Then install the packing washer, packing, thrust washer and push the shaft through the bushing. Install the front thrust washer. Install the felt and felt retainer in the pulley, using a special driver. Press the pulley on the shaft and install the pin through the pulley hub and shaft.

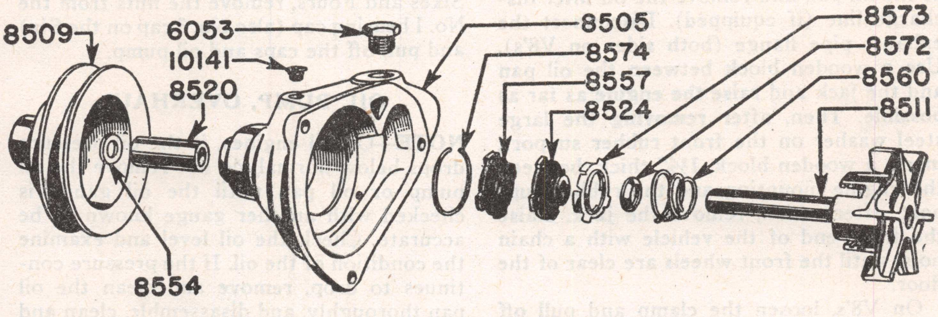
NOTE—These instructions apply to the pressure gun lubricated type of water pump. Repair parts are not available for the oil reservoir type used in part production, and if repairs are necessary this pump should be discarded and replaced with the pressure gun lubricated pump. The unit supplied for service is adaptable to either right or left hand side of the engine. These water pumps differ from the water pump used in production in that provision has been made for the installation of the lubricator fitting on either side.

These water pumps are supplied with a lubricator fitting correctly located for installation on the right hand side of the engine and a pipe plug on the opposite side.

1937-40 60 H.P.: A special spanner wrench should be used to remove and replace this water pump, which is retained in position in the block by a large nut, notched around its edge to facilitate installation and removal, and screwed into the cylinder front cover. To remove the impeller, place the pump in a special holder or clamp it in a vise with wooden blocks to prevent damage to the pump. Pull the spring retainer out to expose a few coils of the spring and wedge the spring in this position while removing the retainer which is held by the hook on the end of the spring. Allow the spring to retract and remove the impeller with the spring, pulling the spring through the hollow pump shaft. The spring may then be unhooked from the impeller. To remove the pulley, impeller shaft and bushing, mount the pump in a suitable holding fixture. When removing and replacing the impeller shaft, it is recommended that special drivers be used in order to avoid damage to the bearing. Special drivers are available for the removal and replacing of the bushing.



Exploded view of water pump of 4-cylinder engine, 1941-46.



WATER PUMP—1941-46 Six.

6503—Plug. 8505—Pump body. 8509—Pulley. 8511—Shaft and impeller. 8520—Bushing. 8524—Seal. 8554—Washer. 8557—Seal washer. 8560—Spring. 8572—Seal ring. 8573—Guide. 8574—Snap ring. 10141—Oil plug.

After the bushing has been installed, it should be reamed.

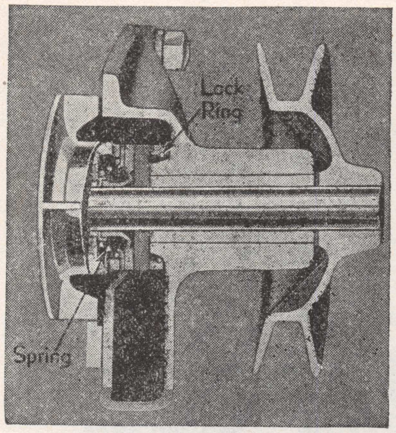
When reassembling the pump, attach the spring to the impeller and use a suitable spring hook to pull the spring into place, through the shaft. Avoid stretching the spring more than necessary to install the spring retainer on the hook of the spring.

NOTE—This pump can be used interchangeably on the right or left hand side of the cylinder assembly.

1937-46, V8 90 & 100 H.P.: Right and left pumps are not interchangeable. With the water pump removed from the engine, see Water Pump. Remove, press shaft out of pulley, removing impeller and shaft from the rear of the pump. Note the relative position of the water pump thrust washer, seal, spring and spring guide, so they can be assembled in the same order. Press the bushing out of the housing and press a new bushing in place with a special tool or a properly fitting driver that will not damage the new bushing or the pump body. Assemble the spring next to the impeller, then the spring guide, ring, seal, thrust washer and seal lock ring, on the impeller shaft. Insert the shaft from the rear of the pump, push it through the bushing and front thrust washer, then press the pulley on the shaft. Avoid damage to the impeller by supporting the impeller end of the shaft properly while pressing on the pulley.

1941-46 Six: The impeller shaft is pressed into the fan pulley and special tools should be used to remove both the fan pulley and the porous water pump shaft bushing if the pump has to be overhauled. The arrangement of the parts is clearly shown in the exploded view of the "six" water pump. There is an oil reservoir in the pump body which feeds oil through the porous bushing to the water pump shaft. It is very important that no grease be used on this shaft when it is reassembled otherwise it may cut off the supply of oil to the shaft. In assembling, do not forget to put the washer (8554) over the shaft before the fan pulley is pressed in place. Note also that the small end of the spring (8560) should be toward the pump impeller. The oil reservoir should be filled with light engine oil, through the hole closed by the plug (10141) after the pump is reassembled.

1940-46, Four: To disassemble this unit, first take out the four cap screws which hold the fan in place and remove it. Next take out the cap screw (20318) which holds the cover plate (8508) and its gasket on the pump housing. Press off the fan pulley in an arbor press. A special fixture which will hold the pulley by the belt groove should be used for this operation. Use a piece of stock ½" x 2" to push the shaft out. Next



WATER PUMP: 85 HP, 1937-38.

remove the housing snap ring (**8576**) and press off the impeller (**8512**), using the same ½" driver as for the pulley. Remove the seal snap ring (**8574**). Then all the seal parts may be removed.

NOTE—Ordinarily it is not advisable to reassemble an impeller and pulley on the old bearing (**8530**). When they are pressed off some metal is invariably removed from the bearing shaft as well as from the holes in the impeller and pulley. The bore of these must be carefully checked before they are reassembled to make sure that they will be a tight press fit on the new bearing shaft. If there is the slightest question do not attempt to use them.

ENGINE WATER THERMOSTATS

1936-46 All: Four types of thermostats have been used in V8 engines and a fifth type in the Six. All of the thermostats are located in the water outlet hose or outlet connection on the cylinder head except on the Six where a special unit is inserted in the cylinder head. All the thermostats are designed to open at about 145 deg. Fahr., and be fully open at 180 deg. They are operated in three ways; with a bi-metal coiled thermostatic element; by an expanding chemical or by a bellows type of expansion unit. The first type, bi-metallic, is provided in two forms; one for hose mounting and one for head outlet mounting. The latter mounting is used on all the other types also. When thermostats are installed, be sure that the hose-mounted type is not clamped so tight that it sticks. If it doesn't work after installation, make sure that it has not been installed upside down.

Head outlet type thermostats used since 1937 must be held down tight by forcing the hose down on them. If they are loose they may rock enough to bypass water and thus not function properly. The coil may strike the side of the water outlet and that too will affect its functioning. Dirt or pieces of hose rubber imbedded in the butterfly valve will also upset the thermostat, either holding it open or shut.

1941-46 All: A change was made in this series of bi-metallic thermostats that causes them to lock open once they are subjected to excessive temperatures. When a thermostat has been subjected to high temperatures, the bi-metal element distorts and takes a permanent set. This ordinarily results in a change of the opening temperature with the result that it will not open the valve at normal temperatures and overheating results. To avoid this possibility, a change was made in these thermostats to protect the engine. A stop pin has been provided so that after the thermostat has been subjected to temperatures above 324 degrees, the valve will not close. This prevents the engine from overheating due to a damaged thermostat. This only happens when the water in the cooling system is allowed to become lower than the thermostat. Damaged thermostats should be discarded and replaced.

1941-46 Six: A bypass type of thermostat is provided on the six cylinder engines. When the thermostat valve is closed, water passes through the holes around the bellows and down the water bypass passage to the water pump. No water goes to the radiator via the outlet pipe. The water pump delivers water into the distributing manifold. When the thermostat valve is wide open, the passages are closed so that no water is bypassed and all the water must circulate through the outlet pipe to the radiator.

CHECKING THERMOSTAT RANGE

1936-46 All: The easiest way to check the range of a thermostat is to heat a pail of water to boiling, or fill a pail with steaming hot water. Use an accurate thermometer and a stick to stir the water. When the temperature reaches about 190 degrees on the thermometer, immerse the thermostat to be tested. It should immediately start to open and stay wide open as long as the temperature is above 180 degrees Fahr. Allow the water to cool but keep stirring. The valve should start to close as the temperature drops below 180 deg. Next, observe the temperature at which the valve closes. This should be about 145 deg. After the valve closes, it can be double checked for its opening temperature by either heating the pail over a fire or adding hot water and gradually raising the temperature. Always stir the water constantly to be sure that the temperature is uniform, especially at the critical temperature points. When the water reaches 145 degrees on the way up, watch carefully to see if the valve starts to open.

WATER DISTRIBUTING TUBE

1941-46 Six: These engines are provided with a water distributing tube located in the water jacket of the cylinder block. Whenever the water pump is removed, the tube should be pulled out and cleaned thoroughly.

FUEL SYSTEM

NOTE—For service information on Carburetors, Automatic Chokes, Governors, Fuel Pumps, Air Cleaners and Gasoline Gauges, see the **Table of Contents on** page 1.

MANIFOLD HEAT CONTROL

1941-46 Six: On these engines, the exhaust manifold is equipped with an automatic heat control valve to regulate the amount of heat by-passed around the heat riser to provide a quick engine warm-up.

A valve in the intake manifold by-passes the exhaust gases around the heat riser but as soon as the engine is warmed up, the counterweight on the outside of the manifold overcomes the action of the bi-metal thermostat spring and opens the butterfly valve so that the exhaust gases pass out without heating the intake.

This valve should be checked to see that it works freely. The position of the weight indicates the position of the valve. When the manifold is cold, the weight should be in the raised position.

ELECTRIC SYSTEM

NOTE—For service information on Distributors, Magnetos, Generators, Generator Regulators, Starting Motors and Starter Switches, see the Table of Contents on page 1.

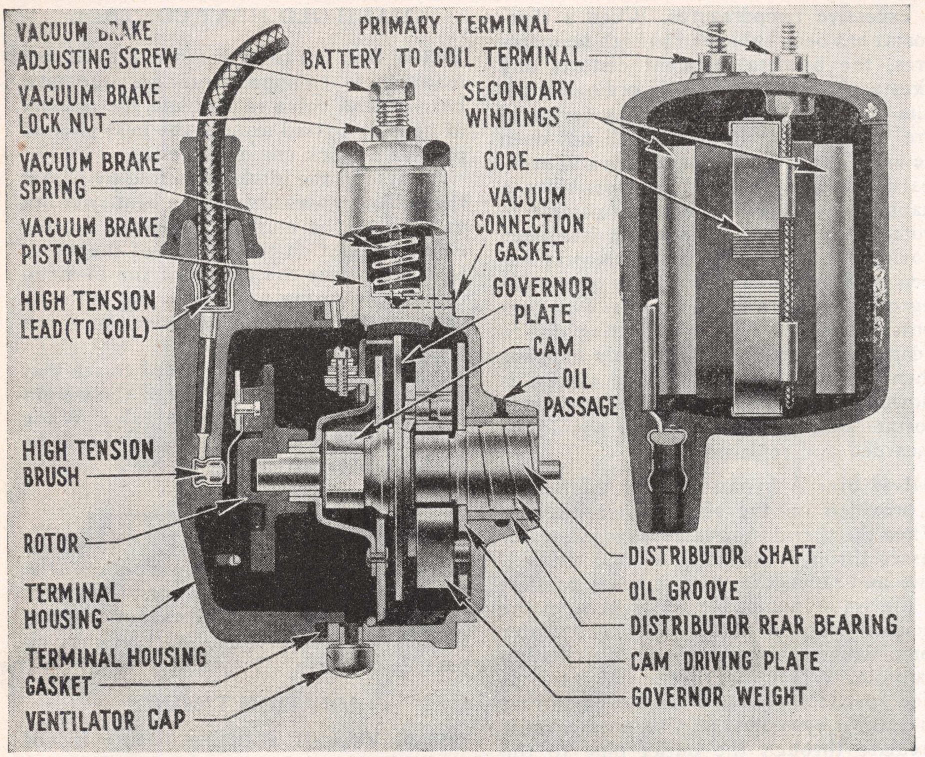
IGNITION TIMING

1936-38 V8's: If a timing fixture is not available, crank the engine until No. 1 piston is at TDC of its compression stroke. In this position, pistons Nos. 2 and 3 will be exactly the same distance from the top of the cylinder block. Loosen the breaker plate adjusting screw and move it to the bottom of its travel. Turn on the ignition switch. Move the breaker plate adjusting screw up slowly until a spark occurs at No. 1 spark plug. Tighten the screw and be sure that the final movement of the screw was upward. If the final movement is not upward the setting will be inaccurate.

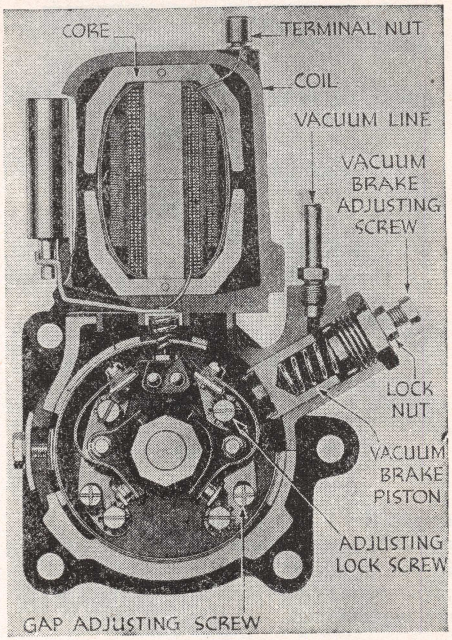
Note the position of the graduation on the adjusting screw plate with regard to the line on the distributor body. Now move the screw upward an additional graduation. The spark will then occur 4 degrees before TDC.

A change in timing can be made to compensate for the various grades of gasoline available by means of the distributor vacuum brake on the side of the distributor. The adjusting screw should be turned counterclockwise until the engine pings under load. It should then be turned clockwise just enough to eliminate the ping. Do not tighten the screw more than necessary or the timing will be retarded for normal running.

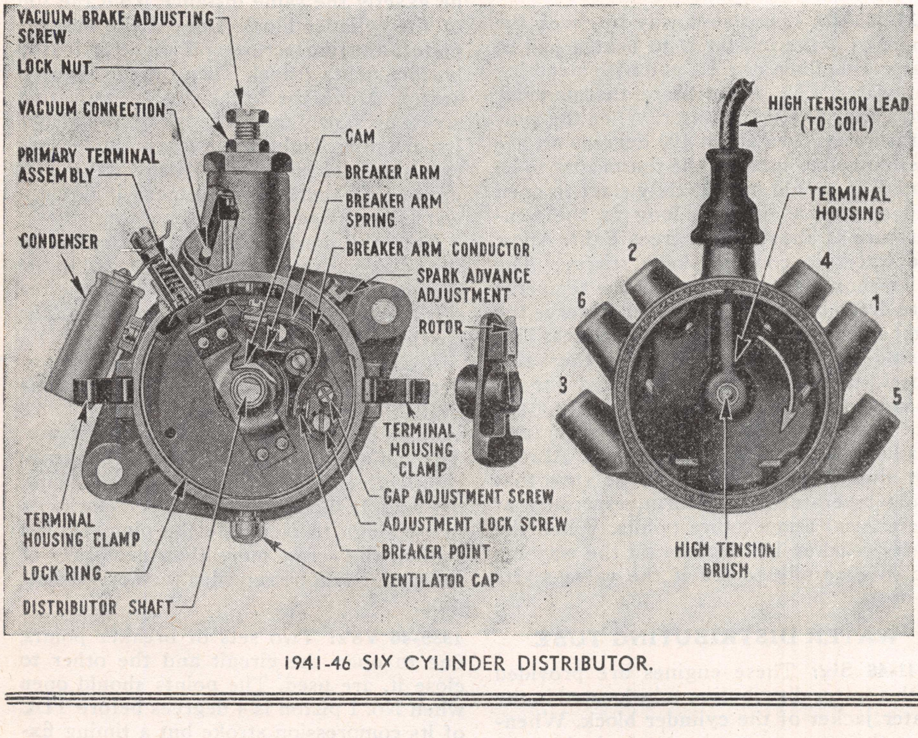
1939-46 V8's: Two sets of breaker points, one to open the circuit and the other to close it, are used. The points should open when No. 1 piston is 4 degrees before TDC of its compression stroke but a timing fixture is necessary to set the distributor. As the breaker points wear, the timing will change slightly, but if the distributor is not disturbed, setting the breaker points at their correct spacing will automatically correct the timing. If an adjustment of the distributor is necessary, loosen the clamp screw on the calibrated timing plate at distributor. With No. 1 piston in its firing position move timing plate upward until the


VACUUM BRAKE ADJUSTING SCREW
VACUUM BRAKE LOCK NUT
VACUUM BRAKE SPRING
VACUUM BRAKE PISTON
HIGH TENSION LEAD (TO COIL)
HIGH TENSION BRUSH
ROTOR
TERMINAL HOUSING
TERMINAL HOUSING GASKET
VENTILATOR CAP
PRIMARY TERMINAL
BATTERY TO COIL TERMINAL
SECONDARY WINDINGS
CORE
VACUUM CONNECTION GASKET
GOVERNOR PLATE
CAM
OIL PASSAGE
DISTRIBUTOR SHAFT
OIL GROOVE
DISTRIBUTOR REAR BEARING
CAM DRIVING PLATE
GOVERNOR WEIGHT

1942-46 V8 DISTRIBUTOR AND COIL. Sectional view.


CORE
TERMINAL NUT
COIL
VACUUM LINE
VACUUM BRAKE ADJUSTING SCREW
LOCK NUT
VACUUM BRAKE PISTON
ADJUSTING LOCK SCREW
GAP ADJUSTING SCREW

1937-41 V8 DISTRIBUTOR.


VACUUM BRAKE ADJUSTING SCREW
LOCK NUT
VACUUM CONNECTION
PRIMARY TERMINAL ASSEMBLY
CONDENSER
TERMINAL HOUSING CLAMP
LOCK RING
DISTRIBUTOR SHAFT
CAM
BREAKER ARM
BREAKER ARM SPRING
BREAKER ARM CONDUCTOR
SPARK ADVANCE ADJUSTMENT
ROTOR
TERMINAL HOUSING CLAMP
GAP ADJUSTMENT SCREW
ADJUSTMENT LOCK SCREW
BREAKER POINT
VENTILATOR CAP
HIGH TENSION LEAD (TO COIL)
TERMINAL HOUSING
HIGH TENSION BRUSH
2
4
6
1
3
5

1941-46 SIX CYLINDER DISTRIBUTOR.

points open. Then move timing plate up one more graduation and tighten the screws.

A vacuum brake is fitted which provides a means of adjusting the timing for various grades of gasoline without disturbing the timing for part throttle operation. To adjust the vacuum brake, loosen the lock nut and back off the adjusting screw until the engine pings under load. Then tighten the screws just enough to remove the ping. If the screw is too tight it will retard the spark for normal running.

1941-46 Six & Four: On the Four, the points should break when the piston is at TDC of its compression stroke, while on the Six, the points should break 2 degrees before TDC. The Six is provided with a vacuum brake which provides a means of adjusting the timing for various grades of gasoline without disturbing the timing for part throttle operation. Adjustment is made in the same manner as described for the V8 engines.

For correct timing, the distributor should be removed and adjusted on a special fixture. If the spark is to be retarded, loosen the adjusting screw and move the screw up in its slot. If an advance is desired, move the screw down. When the setting is satisfactory, tighten the screw.

GMC GASOLINE ENGINES

Year	Engine Model	Number Cylinders and Valve Arrangement	Bore and Stroke	Displacement Cubic Inches	Compression Ratio	Taxable H. P.	Brake H. P. at R. P. M.	Maximum Torque at R. P. M. Pounds Feet	Oil Capacity Quarts
1936	213	6-L	3 5/16x4 1/8	213.30	6.00	26.30	84@3500	152@1200	6
	239	6-I	3 5/16x4 5/8	238.90	5.10	26.30	81@3000	170@1000	7
	257	6-I	3 7/16x4 5/8	257.50	5.00	28.33	87.5@2800	190@800	7
	286	6-I	3 5/8x4 5/8	286.40	4.90	31.53	90@2600	205@1000	7
	331	6-I	3 3/4x5	331.40	4.74	33.75	94@2500	230@800	12
	400	6-I	4 1/8x5	400.90	4.75	40.90	110@2300	296@800	12
	450	6-I	4 3/8x5	450.90	4.73	45.90	150@2500	380@800	12
1937	230	6-L	3 7/16x4 1/8	229.70	6.10	28.40	86@3500	172@1200	6
	239	6-I	3 5/16x4 5/8	238.90	5.10	26.30	81@3000	175@800	7
	257	6-I	3 7/16x4 5/8	257.50	5.00	28.33	87.5@2800	190@800	7
	286	6-I	3 5/8x4 5/8	286.40	4.90	31.53	90@2600	205@1000	7
	331	6-I	3 3/4x5	331.40	4.74	33.75	94@2500	230@800	12
	400	6-I	4 1/8x5	400.90	4.75	40.90	110@2300	296@800	12
1938	223	6-L	3 7/16x4	222.70	6.20	28.40	81@3400	-----	6
	230	6-L	3 7/16x4 1/8	229.70	6.10	28.40	86@3500	172@1200	6
	239	6-I	3 5/16x4 5/8	238.90	5.10	26.30	81@3000	175@800	7
	257	6-I	3 7/16x4 5/8	257.50	5.00	28.33	87.5@2800	190@800	7
	286	6-I	3 5/8x4 5/8	286.40	4.90	31.53	90@2600	205@1000	7
	331	6-I	3 3/4x5	331.40	4.74	33.75	94@2500	230@800	12
	400	6-I	4 1/8x5	400.90	4.75	40.90	110@2300	296@800	12
1939	228	6-I	3 9/16x3 13/16	228.01	6.15	30.45	80@3000	178@1000	8
	230	6-I	3 7/16x4 1/8	229.70	6.10	28.40	86@3500	172@1200	6
	308	6-I	3 13/16x4 1/2	308.23	6.00	33.89	110@2800	239@800	9
	361	6-I	4 1/8x4 1/2	360.83	6.00	40.84	122@2800	265@800	11
	426	6-I	4 1/4x5	425.58	6.00	43.34	145@2700	322@1000	11
	451	6-I	4 3/8x5	450.90	6.00	45.90	146@2400	350@1000	11
1940	228	6-I	3 9/16x3 13/16	228.01	6.15	30.45	80@3000	178@1000	8
	248	6-I	3 23/32x3 13/16	248.50	6.15	33.19	88@3000	195@1000	8
	278	6-I	3 5/8x4 1/2	278.66	6.00	31.54	100@2900	213@1000	9
	308	6-I	3 13/16x4 1/2	308.23	6.00	33.89	110@2800	239@800	9
	361	6-I	4 1/8x4 1/2	360.83	6.00	40.84	122@2800	265@800	11
	426	6-I	4 1/4x5	425.58	6.00	43.34	145@2700	322@1000	11
	451	6-I	4 3/8x5	450.90	6.00	45.90	146@2400	350@1000	11
1941–46	228①	6-I	3 9/16x3 13/16	228.01	6.75	30.45	61@2800④	-----	8
	228②	6-I	3 9/16x3 13/16	228.01	6.75	30.45	76@3000④	178@1000	8
	236	6-I	3 5/8x3 13/16	236.10	6.75	31.53	87@3000④	-----	8
	248	6-I	3 23/32x3 13/16	248.50	6.75	33.19	89.5@3000④	195@1000	8
	256	6-I	3 25/32x3 13/16	256.86	6.75	34.30	91@3000	-----	8
	270	6-I	3 25/32x4	269.52	6.75	34.35	94@2800④	216@1000	10 1/2
	278	6-I	3 5/8x4 1/2	278.66	6.00	31.54	85.5@2800④	213@1000	9
	308	6-I	3 13/16x4 1/2	308.23	6.00	34.89	92.5@2600④	239@800	9
	361	6-I	4 1/8x4 1/2	360.83	6.00	40.80	105@2500④	265@800	11
	426	6-I	4 1/4x5	425.58	6.00	43.30	126@2400④	322@1000	11
	451	6-I	4 3/8x5	450.99	6.00	45.90	146@2400	350@1000	11
	477	6-I	4 1/2x5	477.13	6.00	48.60	136.5@2400④	365@1000	11

Engine Number Location—Plate on left side of engine.

Chassis Number Location—Plate on instrument panel or dash; also on right frame side rail above front spring.

① **Economy engine.**
② **Standard engine.**
④ **Certified net horsepower.**

TUNE UP CHART

Year	Engine Model	Firing Order	Spark Plug Gap	Breaker Gap	Cam Angle, Degrees	Timing Mark Location	Spark Timing, Degrees	Tappet Clearance For Running, Hot Int.	Tappet Clearance For Running, Hot Exh.	Tappet Clearance For Timing, Intake	Battery Terminal Grounded
1936	213	153624	.030-.033	.018-.022	35	Vib. Damper	2BTDC	.008	.010	.008	④
	239	142635	.023-.028	.018-.022	35	Flywheel	15BTDC	.013⑤	.013⑤	.012	④
	257	142635	.023-.028	.018-.024	35	Flywheel	15BTDC	.013⑤	.013⑤	.012	④
	286	142635	.023-.028	.018-.022	35	Flywheel	2BTDC	.013⑤	.013⑤	.012	④
	331	142635	.035	.018-.022	35	Flywheel	17BTDC	.013⑤	.013⑤	.012	④
	400	142635	.035	.018-.022	35	Flywheel	17BTDC	.012	.012	.012	Positive
	450	142635	.035	.018-.022	35	Flywheel	17BTDC	.012	.012	.012	Positive
1937	230	153624	.030	.018-.024	35	Flywheel	5BTDC	.008	.011	.008	Positive
	239	142635	.023-.028	.018-.024	35	Flywheel	15BTDC	.013⑤	.013⑤	.012	④
	257	142635	.023-.028	.018-.024	35	Flywheel	15BTDC	.013⑤	.013⑤	.012	④
	286	142635	.023-.028	.018-.024	35	Flywheel	15BTDC	.013⑤	.013⑤	.012	④
	331	142635	.035	.018-.022	37	Flywheel	15BTDC	.013⑤	.013⑤	.012	④
	400	142635	.035	.018-.022	35	Flywheel	17BTDC	.012	.012	.012	Positive
1938	223	153624	.030	.018-.024	35	Flywheel	5BTDC	.012⑤	.012⑤	.011	Positive
	230	153624	.030	.018-.024	35	Flywheel	5BTDC	.008	.011	.008	Positive
	239	142635	.023-.028	.018-.024	35	Flywheel	15BTDC	.013⑤	.013⑤	.012	④
	257	142635	.023-.028	.018-.024	35	Flywheel	15BTDC	.013⑤	.013⑤	.012	④
	286	142635	.023-.028	.018-.024	35	Flywheel	15BTDC	.013⑤	.013⑤	.012	④
	331	142635	.035	.018-.022	37	Flywheel	15BTDC	.013⑤	.013⑤	.012	④
	400	142635	.035	.018-.022	37	Flywheel	15BTDC	.012	.012	.012	Positive
1939-40	228	153624	.023-.028	.018-.024	35③	Flywheel	②	.006	.013	.008	Positive
	230	153624	.030	.018-.024	35	Flywheel	5BTDC	.008	.011	.008	Positive
	248	153624	.023-.028	.018-.024	35③	Flywheel	②	.006	.013	.008	Positive
	278	142635	.023-.028	.018-.024	35	Flywheel	TDC	.012	.012	.014	Positive
	308	142635	.023-.028	.018-.024	35	Flywheel	TDC	.012	.012	.014	Positive
	361	142635	.023-.028	.018-.024	35	Flywheel	TDC	.012	.012	.014	Positive
	426	142635	.023-.028	.018-.024	35	Flywheel	TDC	.012	.012	.014	Positive
	451	142635	.023-.028	.018-.024	35	Flywheel	TDC	.012	.012	.014	Positive
1941-46	228	153624	.023-.028	.018-.024	35	Flywheel	3BTDC	.012①	.012①	.014①	Positive
	236	153624	.023-.028	.018-.024	35	Flywheel	3BTDC	.012①	.012①	.014①	Positive
	248	153624	.023-.028	.018-.024	35	Flywheel	3BTDC	.012①	.012①	.014①	Positive
	256	153624	.023-.028	.018-.024	35	Flywheel	3BTDC	.012①	.012①	.014①	Positive
	270	153624	.023-.028	.018-.024	35	Flywheel	5BTDC	.012①	.012①	.014①	Positive
	278	142635	.023-.028	.018-.024	35	Flywheel	TDC	.012	.012	.014	Positive
	308	142635	.023-.028	.018-.024	35	Flywheel	TDC	.012	.012	.014	Positive
	361	142635	.023-.028	.018-.024	35	Flywheel	TDC	.012	.012	.014	Positive
	426	142635	.023-.028	.018-.024	35	Flywheel	TDC	.012	.012	.014	Positive
	451	142635	.023-.028	.018-.024	35	Flywheel	TDC	.012	.012	.014	Positive
	477	142635	.023-.028	.018-.024	35	Flywheel	TDC	.012	.012	.014	Positive

① Clearance listed is for second series. For first series, intake .006″, exhaust .013″. See text under "Camshaft and Bearings" for engine serial number break. For timing, set intake at .008″. ② For vehicle models 300, 310, 350, 360 TDC; all others 5 BTDC. ③ For distributor number 1110062, 33. ④ With 100 watt generator, negative; with 200 watt generator, positive. ⑤ Plus or minus .001″.

VALVE SYSTEM

Year	Engine Model	Stem Clearance		Tappet Guide Clearance	Tappet Clearance				Valve Spring Pressure Test		Valve Seat Angle, Degrees
		Intake	Exhaust		Running, Hot		Timing		Free Length, Inches	Pounds at Inches, Length	
					Intake	Exhaust	Intake	Exhaust			
1936	213	.001-.003	.002-.004	.0008	.008	.010	.008	.010	2⁹⁄₁₆	116@1¹⁵⁄₁₆	④
	239	.0015-.0035	.0035-.0055	.0005-.0025	.012-.014	.012-.014	.012	.012	O 2⁷⁄₁₆	O 60-68@1¹⁹⁄₃₂	45
									I 1⁵⁹⁄₆₄	I 31-38@1⁵⁄₁₆	
	257	.0015-.0035	.0035-.0055	.0005-.0025	.012-.014	.012-.014	.012	.012	O 2⁷⁄₁₆	O 60-68@1¹⁹⁄₃₂	45
									I 1⁵⁹⁄₆₄	I 31-38@1⁵⁄₁₆	
	286	.0015-.0035	.0035-.0055	.0005-.0025	.012-.014	.012-.014	.012	.012	O 2⁷⁄₁₆	O 60-68@1¹⁹⁄₃₂	45
									I 1⁵⁹⁄₆₄	I 31-38@1⁵⁄₁₆	
	331	.0015-.0035	.0035-.0055	.0005-.0025	.012-.014	.012-.014	.012	.012	O 2⁷⁄₁₆	O 60-68@1¹⁹⁄₃₂	45
									I 1⁵⁹⁄₆₄	I 31-38@1⁵⁄₁₆	
	400	.0015-.0035	.0035-.0055	.0005-.0025	.012-.014	.012-.014	.012	.012	O 2⁷⁄₁₆	O 60-68@1¹⁹⁄₃₂	30
									I 1⁵⁹⁄₆₄	I 31-38@1⁵⁄₁₆	
	450	.0015-.0035	.0035-.0055	.0005-.0025	.012-.014	.012-.014	.012	.012	O 2⁷⁄₁₆	O 60-68@1¹⁹⁄₃₂	30
									I 1⁵⁹⁄₆₄	I 31-38@1⁵⁄₁₆	
1937	230	.001-.003	.0025-.0045	.0003-.0007	.008	.011	.008	.011	2⅝	95½@1¹⁵⁄₁₆	④
	239	.0015-.0035	.0035-.0055	.0005-.0025	.012-.014	.012-.014	.012	.012	O 2⁷⁄₁₆	O 60-68@1¹⁹⁄₃₂	45
									I 1⁵⁹⁄₆₄	I 31-38@1⁵⁄₁₆	
	257	.0015-.0035	.0035-.0055	.0005-.0025	.012-.014	.012-.014	.012	.012	O 2⁷⁄₁₆	O 60-68@1¹⁹⁄₃₂	45
									I 1⁵⁹⁄₆₄	I 31-38@1⁵⁄₁₆	
	286	.0015-.0035	.0035-.0055	.0005-.0025	.012-.014	.012-.014	.012	.012	O 2⁷⁄₁₆	O 60-68@1¹⁹⁄₃₂	45
									I 1⁵⁹⁄₆₄	I 31-38@1⁵⁄₁₆	
	331	.0015-.0035	.0035-.0055	.0005-.0025	.012-.014	.012-.014	.012	.012	O 2⁷⁄₁₆	O 60-68@1¹⁹⁄₃₂	45
									I 1⁵⁹⁄₆₄	I 31-38@1⁵⁄₁₆	
	400	.0015-.0035	.0035-.0055	.0005-.0025	.012-.014	.012-.014	.012	.012	O 2⁷⁄₁₆	O 60-68@1¹⁹⁄₃₂	30
									I 1⁵⁹⁄₆₄	I 31-38@1⁵⁄₁₆	
1938	223	②	②	.0005-.0025	.011-.013	.011-.013	.011	.011	2⁵⁄₁₆	96@1⁸⁹⁄₆₄	④
	230	.001-.003	.0025-.0045	.0003-.0007	.008	.011	.008	.011	2⅝	95½@1¹⁵⁄₁₆	④
	239	.0015-.0035	.0035-.0055	.0005-.0025	.012-.014	.012-.014	.012	.012	O 2⁷⁄₁₆	O 60-68@1¹⁹⁄₃₂	45
									I 1⁵⁹⁄₆₄	I 31-38@1⁵⁄₁₆	
	257	.0015-.0035	.0035-.0055	.0005-.0025	.012-.014	.012-.014	.012	.012	O 2⁷⁄₁₆	O 60-68@1¹⁹⁄₃₂	45
									I 1⁵⁹⁄₆₄	I 31-38@1⁵⁄₁₆	
	286	.0015-.0035	.0035-.0055	.0005-.0025	.012-.014	.012-.014	.012	.012	O 2⁷⁄₁₆	O 60-68@1¹⁹⁄₃₂	45
									I 1⁵⁹⁄₆₄	I 31-38@1⁵⁄₁₆	
	331	.0015-.0035	.0035-.0055	.0005-.0025	.012-.014	.012-.014	.012	.012	O 2⁷⁄₁₆	O 60-68@1¹⁹⁄₃₂	45
									I 1⁵⁹⁄₆₄	I 31-38@1⁵⁄₁₆	
	400	.0015-.0035	.0035-.0055	.0005-.0025	.012-.014	.012-.014	.012	.012	O 2⁷⁄₁₆	O 60-68@1¹⁹⁄₃₂	30
									I 1⁵⁹⁄₆₄	I 31-38@1⁵⁄₁₆	
1939-40	228	.001-.003	.002-.004	.0005-.002	.006	.013	.008	.015	2⁷⁄₃₂	121-133@1.505	30
	230	.001-.003	.0025-.0045	.0003-.0007	.008	.011	.008	.011	2⅝	95½@1¹⁵⁄₁₆	④
	248	.001-.003	.002-.004	.0005-.002	.006	.013	.008	.015	2⁷⁄₃₂	121-133@1.505	30
	278	.0015-.003	.0025-.004	.0025-.005	.012	.012	.014	.014	2⅜	96-104@③	45
	308	.0015-.003	.0025-.004	.0025-.005	.012	.012	.014	.014	2⅜	96-104@③	45
	361	.0015-.003	.0025-.004	.0025-.005	.012	.012	.014	.014	2⅜	96-104@③	④
	426	.0015-.003	.0025-.004	.0025-.005	.012	.012	.014	.014	2⅜	96-104@③	④
	451	.0015-.003	.0025-.004	.0025-.005	.012	.012	.014	.014	2⅜	96-104@③	④
1941-46	228	.001-.003	.002-.004	.0005-.0025	.012①	.012①	.014①	.014①	2⅛	122-134@1.505	30
	236	.001-.003	.002-.004	.0005-.0025	.012①	.012①	.014①	.014①	2⅛	122-134@1.505	30
	248	.001-.003	.002-.004	.0005-.0025	.012①	.012①	.014①	.014①	2⅛	122-134@1.505	30
	256	.001-.003	.002-.004	.0005-.0025	.012①	.012①	.014①	.014①	2⅛	122-134@1.505	30
	270	.001-.003	.002-.004	.0005-.0025	.012①	.012①	.014①	.014①	2⅛	122-134@1.505	30
	278	.0015-.003	.0025-.004	.0025-.005	.012	.012	.014	.014	2⅜	117-125@1⁴¹⁄₆₄	45
	308	.0015-.003	.0025-.004	.0025-.005	.012	.012	.014	.014	2⅜	117-125@1⁴¹⁄₆₄	45
	361	.0015-.003	.0025-.004	.0025-.005	.012	.012	.014	.014	2⅜	117-125@1⁴¹⁄₆₄	④
	426	.0015-.003	.0025-.004	.0025-.005	.012	.012	.014	.014	2⅜	117-125@1⁴¹⁄₆₄	④

VALVE SYSTEM

Year	Engine Model	Stem Clearance		Tappet Guide Clearance	Tappet Clearance				Valve Spring Pressure Test		Valve Seat Angle, Degrees
					Running Hot		Timing				
		Intake	Exhaust		Intake	Exhaust	Intake	Exhaust	Free Length, Inches	Pounds at Inches, Length	
1941–46	451	.0015–.003	.0025–.004	.0025–.004	.012	.012	.014	.014	2⅜	117–125@1 41/64	④
	477	.0015–.003	.0025–.004	.0025–.005	.012	.012	.014	.014	2⅜	117–125@1 41/64	④

O—Outer spring. I—Inner spring. ① Clearance listed is for second series. For first series, intake .006″, exhaust .013″. For timing, intake .008″, exhaust .015″.

See text under "Camshaft and Bearings" for engine number break. ② Free fit to .0006″ at bottom.

③ With valve open.

④ Intake 30: exhaust 45.

PISTON AND RING CLEARANCES

Year	Engine Model	Piston Skirt, Inches		Fitting Pistons with Shim and Spring Scale		Ring End Gap, Inch ①		Ring and Groove, Inch	
		Top	Bottom	Shim Thickness	Pounds Pull on Scale	Com-pression	Oil	Com-pression	Oil
1936	213	.0015	.0015	.002	4 to 11	.007–.012	.007–.015	.0015–.003	.001–.0025
	239	.004	.003	.003	4 to 6	.011–.016	.011–.016	.0015–.003	.0015–.0035
	257	.004	.003	.003	4 to 6	.011–.016	.011–.016	.0015–.003	.0015–.0035
	286	.00425	.00325	.003	4 to 6	.011–.016	.011–.016	.0015–.003	.0015–.0035
	331	.005	.003	.003	4 to 6	.012–.017	.012–.017	.0015–.003	.0025–.0035
	400	.0065	.004	.003	4 to 6	.012–.017	.012–.017	.0015–.003	.0025–.0035
	450	.0065	.004	.003	4 to 6	.012–.017	.012–.017	.0015–.003	.0025–.0035
1937	230	.0013–.0018	.0013–.0018	.002	4 to 11	.009–.0014	.009–.014	.002–.0035	.0025
	239	.004	.003	.003	4 to 6	.011–.016	.011–.016	.0015–.003	.0015–.0035
	257	.004	.003	.003	4 to 6	.011–.016	.011–.016	.0015–.003	.0015–.0035
	286	.00425	.00325	.003	4 to 6	.011–.016	.011–.016	.0015–.003	.0115–.0035
	331	.005	.003	.003	4 to 6	.012–.017	.012–.017	.0015–.003	.0025–.0035
	400	.0065	.004	.003	4 to 6	.012–.017	.012–.017	.0015–.003	.0025–.0035
1938	223	.002	.002	.002	10 to 25	.007–.017	.007–.017	.0015–.003	.001–.0025
	230	.0013–.0018	.0013–.0018	.002	4 to 11	.009–.014	.009–.014	.002–.0025	.0025
	239	.004	.003	.003	4 to 6	.011–.016	.011–.016	.0015–.003	.0015–.0035
	257	.004	.003	.003	4 to 6	.011–.016	.011–.016	.0015–.003	.0015–.0035
	286	.00425	.00325	.003	4 to 6	.011–.016	.011–.016	.0015–.003	.0015–.0035
	331	.005	.003	.003	4 to 6	.012–.017	.012–.017	.0015–.003	.0025–.0035
	400	.004	.003	.003	4 to 6	.012–.017	.012–.017	.0015–.003	.0025–.0035
1939–40	228	.004	.003	.003	4 to 6	.010–.015	.010–.015	.001–.003	.0015–.0035
	230	.0013–.0018	.0013–.0018	.002	4 to 11	.009–.014	.009–.014	.002–.0035	.0025
	248	.004	.003	.003	4 to 6	.010–.015	.010–.015	.001–.003	.0015–.0035
	278	.004	.003	.003	4 to 6	.010–.015	.010–.015	.0015–.0035	.0015–.003
	308	.004	.003	.003	4 to 6	.010–.015	.010–.015	.001–.003	.0015–.003
	361	.004	.003	.003	4 to 6	.011–.016	.011–.016	.001–.003	.0015–.003
	426	.0042	.0032	.003	4 to 6	.012–.017	.012–.017	.001–.003	.0015–.003
	451	.0042	.0032	.003	4 to 6	.018–.023	.015–.020	.0015–.0035	.0015–.003
1941–46	228	.004	.003	.003	4 to 6	.009–.014	.009–.014	.0015–.0025	.002–.003
	236	.004	.003	.003	4 to 6	.009–.014	.009–.014	.0015–.0025	.002–.003
	248	.004	.003	.003	4 to 6	.009–.014	.009–.014	.0015–.0025	.002–.003
	256	.004	.003	.003	4 to 6	.009–.014	.009–.014	.0015–.0025	.002–.003
	270	.004	.003	.003	4 to 6	.009–.014	.009–.014	.0015–.0025	.002–.003

PISTON AND RING CLEARANCES

Year	Engine Model	Piston Skirt, Inches		Fitting Pistons with Shim and Spring Scale		Ring End Gap, Inch ①		Ring and Groove, Inch	
		Top	Bottom	Shim Thickness	Pounds Pull on Scale	Compression	Oil	Compression	Oil
1941–46	278	.004	.003	.003	4 to 6	.009–.014	.010–.015	.0015–.0035	.0015–.003
	308	.004	.003	.003	4 to 6	.010–.015	.010–.015	.001–.003	.0015–.003
	361	.004	.003	.003	4 to 6	.011–.016	.011–.016	.001–.003	.0015–.003
	426	.0042	.0032	.003	4 to 6	.012–.017	.012–.017	.001–.003	.0015–.003
	451	.0042	.0032	.003	4 to 6	.018–.023	.015–.020	.0015–.0035	.0015–.003
	477	.0044	.0034	.003	4 to 6	.013–.018	.013–.018	.0015–.0035	.0015–.003

① Clearances are for cylinder bores without taper. Fit rings in tapered bores with not less than the maximum figures given in the table.

ENGINE BEARING SPECIFICATIONS

Year	Engine Model	Camshaft		Connecting Rod			Mains				
		Journal Diameter	Clearance	Journal Diameter	Clearance	Bearing Bolt Tension Lb. Ft.	Journal Diameter	Clearance	Bearing Bolt Tension Lb. Ft.	Thrust on No.	End-play
1936	213	⑩	.002–.004	1.998–1.999	.001–.003	50–60	⑨	.001–.003	80–90	⑦	.004–.008
	239	③	.0005–.0025	2.123–2.124	.0015–.002	80–90	2.373–2.374	.0015–.002	90–100	3	.003–.007
	257	③	.0005–.0025	2.123–2.124	.0015–.002	80–90	2.373–2.374	.0015–.002	90–100	3	.003–.007
	286	③	.0005–.0025	2.123–2.124	.0015–.002	80–90	2.373–2.374	.0015–.002	90–100	3	.003–.007
	331	③	.002–.0025	2.372–2.373	.0025–.003	90–100	2.495–2.505	.0015–.002	90–100	3	.003–.007
	400	③	.002–.0025	2.624–2.625	.0025–.003	90–100	2.7075–2.7085	.0015–.002	90–100	3	.003–.007
	450	③	.002–.0025	2.624–2.625	.0025–.003	90–100	2.7075–2.7085	.0015–.002	90–100	3	.003–.007
1937	230	⑧	.002–.004	2.123–2.124	.0005–.002	50–60	⑥	.001–.003	80–90	⑦	.004–.008
	239	③	.0005–.0025	2.123–2.124	.0015–.002	80–90	2.373–2.374	.0015–.002	90–100	3	.003–.007
	257	③	.0005–.0025	2.123–2.124	.0015–.002	80–90	2.373–2.374	.0015–.002	90–100	3	.003–.007
	286	③	.0005–.0025	2.123–2.124	.0015–.002	80–90	2.373–2.374	.0015–.002	90–100	3	.003–.007
	331	③	.002–.0025	2.372–2.373	.0025–.003	90–100	2.495–2.505	.0015–.002	90–100	3	.003–.007
	400	③	.002–.0025	2.624–2.625	.0025–.003	90–100	2.7075–2.7085	.0015–.002	90–100	3	.003–.007
1938	223	④	.0015–.0025	2.000	.0005–.0015	50–60	⑤	.001–.003	80–90	3	.003–.008
	230	⑧	.002–.004	2.123–2.124	.0005–.002	50–60	⑥	.001–.003	80–90	⑦	.004–.008
	239	③	.0005–.0025	2.123–2.124	.0015–.002	80–90	2.373–2.374	.0015–.002	90–100	3	.003–.007
	257	③	.0005–.0025	2.123–2.124	.0015–.002	80–90	2.373–2.374	.0015–.002	90–100	3	.003–.007
	286	③	.0005–.0025	2.123–2.124	.0015–.002	80–90	2.373–2.374	.0015–.002	90–100	3	.003–.007
	331	③	.002–.0025	2.372–2.373	.0025–.003	90–100	2.495–2.505	.0015–.002	90–100	3	.003–.007
	400	③	.002–.0025	2.624–2.625	.0025–.003	90–100	2.7075–2.7085	.0015–.002	90–100	3	.003–.007
1939–40	228	②	.0015–.0035	2.311–2.312	.0011–.0021	40–50	①	.0013–.0023	70–80	3	.003–.008
	230	⑧	.002–.004	2.123–2.124	.0005–.002	50–60	⑥	.001–.003	80–90	⑦	.004–.008
	248	②	.0015–.0035	2.311–2.312	.0011–.0021	40–50	①	.0013–.0023	70–80	3	.003–.008
	278	2.125	.002–.0035	2.374–2.375	.0015–.0025	65–75	2.749–2.750	.0015–.0025	75–85	4	.004 .008
	308	2.125	.002–.0035	2.374–2.375	.0015–.0025	65–75	2.749–2.750	.0015–.0025	75–85	4	.004–.008
	361	2.125	.002–.0035	2.624–2.625	.0015–.0025	90–100	2.999–3.000	.0015–.0025	90–100	4	.003–.007
	426	2.125	.002–.0035	2.624–2.625	.0015–.0025	90–100	2.999–3.000	.0015–.0025	90–100	4	.003–.007
	451	2.125	.002–.0035	2.624–2.625	.0015–.0025	90–100	2.999–3.000	.0015–.0025	90–100	4	.003–.007

ENGINE BEARING SPECIFICATIONS

Year	Engine Model	Camshaft Journal Diameter	Camshaft Clearance	Connecting Rod Journal Diameter	Connecting Rod Clearance	Connecting Rod Bearing Bolt Tension Lb. Ft.	Mains Journal Diameter	Mains Clearance	Mains Bearing Bolt Tension Lb. Ft.	Thrust on No.	End-play
1941–46	228	②	.0015–.0035	2.311–2.312	.0006–.0026	40–50	①	.001–.0033	70–80	3	.003–.008
	236	②	.0015–.0035	2.311–2.312	.0006–.0026	40–50	①	.001–.0033	70–80	3	.003–.008
	248	②	.0015–.0035	2.311–2.312	.0006–.0026	40–50	①	.001–.0033	70–80	3	.003–.008
	256	②	.0015–.0035	2.311–2.312	.0006–.0026	40–50	①	.001–.0033	70–80	3	.003–.008
	270	②	.0015–.0035	2.311–2.312	.0015–.0035	40–50	①	.001–.0033	70–80	3	.003–.008
	278	2.125	.002–.0035	2.374–2.375	.001–.004	65–75	2.749–2.750	.001–.003	75–85	4	.003–.008
	308	2.125	.002–.0035	2.374–2.375	.001–.004	65–75	2.749–2.750	.001–.003	75–85	4	.003–.008
	361	2.125	.002–.0035	2.624–2.625	.001–.003	90–100	2.999–3.000	.001–.003	90–100	4	.003–.008
	426	2.125	.002–.0035	2.624–2.625	.001–.003	90–100	2.999–3.000	.001–.003	90–100	4	.004–.008
	451	2.125	.002–.0035	2.624–2.625	.002–.004	90–100	2.999–3.000	.001–.003	90–100	4	.004–.008
	477	2.125	.002–.0035	2.624–2.625	.002–.004	90–100	2.999–3.000	.001–.003	90–100	4	.004–.008

① No. 1—2.6835″–2.6845″. No. 2—2.7145″–2.7155″. No. 3—2.7455″–2.7465″. No. 4—2.7765″–2.7775″.

② No. 1—2.0282″–2.0292″. No. 2—1.9657″–1.9667″. No. 3—1.9032″–1.9042″. No. 4—1.8407″–1.8417″.

③ Ream bearings to the following diameter: No. 1—2.058″–2.059″. No. 2—2.0265″–2.0285″. No. 3—1.9355″–1.9375″. No. 4—1.7805″–1.7825″.

④ Ream bearings to following diameters: No. 1—1.9950″–1.9955″. No. 2—1.9637″–1.9642″. No. 3—1.9325″–1.9330″. No. 4—1.9012″–1.9017″.

⑤ No. 1—2.3725″–2.3735″. No. 2—2.4037″–2.4047″. No. 3—2.4662″–2.4672″. No. 4—2.4975″–2.4985″.

⑥ No. 1—2.478″–2.479″. No. 2—2.5405″–2.5415″. No. 3—2.6655″–2.6665″. No. 4—2.6855″–2.6865″.

⑦ Bronze thrust washers at front of shaft.

⑧ No. 1—1.9970″–1.9975″. No. 2—1.9345″–1.9350″. N 3—1.8720″–1.8725″. No. 4—1.8095″–1.8100.″

⑨ No. 1—2.478″–2.479″. No. 2—2.5405″–2.5415″. No. 3—2.6655″–2.6665″. No. 4—2.728″–2.729″.

⑩ No. 1—1.9970″–1.9975″. No. 2—1.9345″–1.9350″. No. 3—1.8720″–1.8725″. No. 4—1.8095″–1.8100″.

ENGINE

CYLINDER HEAD

1936-46 All: Tighten cylinder head bolts in the order shown, drawing down evenly, and repeating the operation until all are normally tight. After the engine has been run sufficiently long to bring it to operating temperature, a final tightening should be made. When using a torque indicating wrench, the final tightening should be within the limits given under the illustrations.

ROCKER ARMS & PUSH RODS

228, 236, 248, 256, 270, 278, 308, 361, 426, 451, 477: Rocker arm bushings are pressed in the arms with oil holes in bushings in line with oil holes in arms. When bushings become worn, replace rocker arm and bushing as a unit.

NOTE—During 1941 production of engines 228, 236, 248, 256 and 270, a new, specially treated rocker shaft was used in conjunction with rocker arms without bushings.

CAUTION—When disassembling rocker shaft assembly, place all parts on the bench in their proper relationship to assure correct assembly. To prevent the possibility of bending or twisting push rods, they should always be removed before taking off the cylinder head, and replaced after the head is installed.

239, 257, 286: Rocker arm bushings are pressed in the arms with oil holes in bushings in line with oil holes in arms. After replacing bushings, they should be reamed to provide a clearance of from .001″ to .002″. When the reaming operation is completed, make sure that the ends of the bushings are flush with the rocker arm hubs.

NOTE—When disassembling rocker shaft assembly, place all parts on the bench in their proper relationship to assure correct assembly.

331, 400, 450: Rocker arm bushings are pressed in arms with oil holes in bushings in line with oil holes in arms. After replacing bushings, they should be reamed to provide a clearance of from .0005″ to .0015″.

NOTE—Push rod guides are pressed into the cylinder head and swaged at both ends. Before installing push rods, dip the ends of the rods in crankcase sealing compound. After guides are swaged at both ends, brush a small amount of the sealing compound over the ends to prevent oil leakage.

VALVE SEAT INSERTS

213, 223, 228, 230: Not used.

236, 239, 248, 256, 257, 270, 278, 286, 308, 361, 426, 451, 477: Since these inserts are too hard to reface by the ordinary grinding methods, a high-speed grinding stone or a special lapping tool should be used to perform this operation. When using this equipment, be sure valve guides are clean and that the valve guide pilot is a snug fit in order to assure a concentric finish. Finished seats should be checked with a dial indicator and run-out should not exceed .0005″.

To remove an insert, use a drill which is smaller in diameter than the insert width and drill two holes at opposite sides, but not all the way through. Cut through the undrilled portion of the insert with a sharp chisel and remove the two pieces.

To install an insert, pack in "dry ice" for at least fifteen minutes to allow the metal to contract, and heat the exhaust valve port area gradually, to permit this material to expand. Then use a suitable driver to install the insert into the cylinder head, using extreme care to see that it is not cocked or misaligned. When installed, finish the seats with the grinding or lapping equipment already mentioned.

331, 400, 450: These inserts are screwed into the cylinder head casting and staked in place at four points. As special equipment is necessary to install these inserts, it is recommended that the cylinder head be replaced when seats are damaged beyond refacing.

To reface these seats, the same special grinding stone or lapping tool is required as already mentioned above.

VALVE STEM GUIDES

213: New guides should be installed so that the top of the guide is 15/16″ from the top of the block. After installation, new guides should be reamed to provide a clearance within the limits given in the VALVE SYSTEM table.

223: As these guides are tapered with the upper end slightly larger than the lower end, a suitable taper reamer should be used to fit the valve stems in the guides. The guides taper .001" to an inch, and when valves are installed, they should just fall through the guides by their own weight. At the bottom end of the guide, the maximum clearance should be from a free fit to .0006".

228, 236, 248, 256, 270: New guides should be installed and reamed to provide a clearance within the limits given in the VALVE SYSTEM table. When correctly installed, the dimension from the top of the guide to the counterbore for the spring seat should be 61/64".

230: New guides should be installed and reamed to provide a clearance within the limits given in the VALVE SYSTEM table. When correctly installed, the upper end of the guide should be ⅝" from the top of the cylinder block.

239, 257, 286: New guides should be installed and reamed to provide a clearance within the limits given in the VALVE SYSTEM table. Guides are removed by driving them up through the top of the head, and installed by pushing them in until the shoulder bottoms against the head boss.

278, 308, 361, 426, 451, 477: New guides should be pressed in place and reamed to provide a clearance within the limits given in the VALVE SYSTEM table. When correctly installed, the shoulder on the guide should be flush with the edge of the cylinder head recess.

331, 400, 450: New guides should be installed and reamed to provide a clearance within the limits given in the VALVE SYSTEM table.

NOTE—Install one guide at a time and measure the position of one which has not been removed to determine the position of the guide being installed.

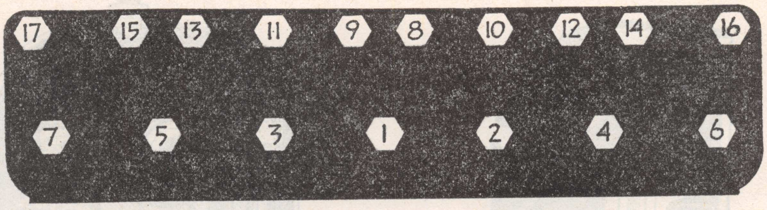
VALVE TAPPETS & GUIDES

213, 223: Valve tappets are assembled directly to guide holes cast in the cylinder block and can easily be removed without removing the oil pan or camshaft. Simply take off the cylinder head, remove valves and springs and lift out the tappets.

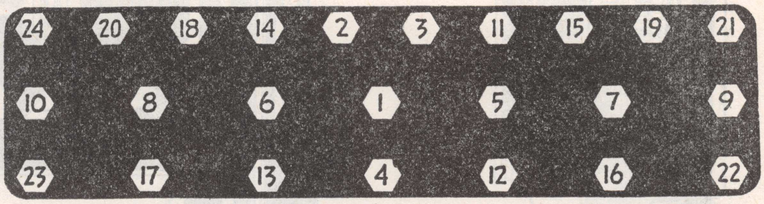
Tappets should be a free fit in the guide hole without side play. If the fit is too loose, a .005" oversize tappet is available and should be installed in the following manner:

Remove cylinder head and oil pan. Take out valve, valve spring and valve guide. Use a clean rag to cover the camshaft to protect it from iron filings.

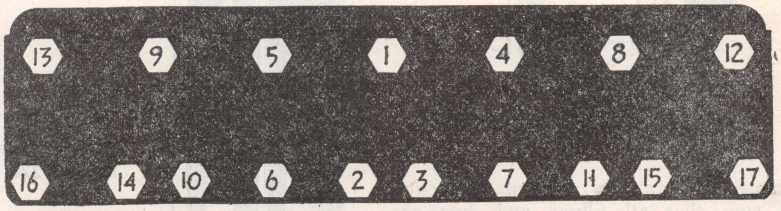
NOTE—To avoid removing camshaft, use a reamer with a removable head and when using this tool, take off the head, insert the pilot shaft through the valve guide hole and install the reamer head on the shaft through the valve cover opening. After the reaming operation is completed, carefully wipe out all chips and remove the rag from



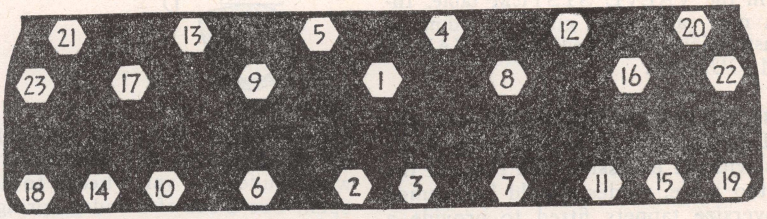
Cylinder Head Tightening Sequence on Engines 239, 257, 286, 331, 400, 450



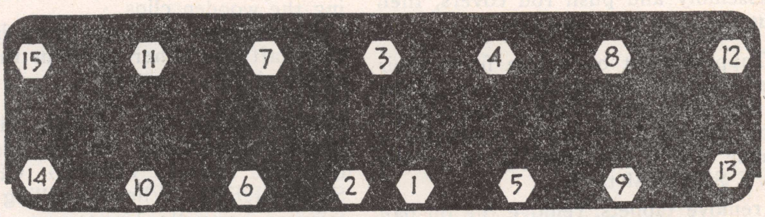
Cylinder Head Tightening Sequence on Engines 213, 230



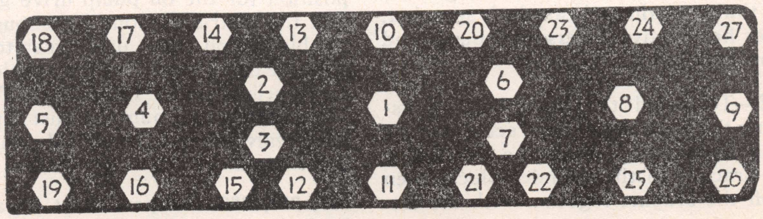
Tighten Head Bolts as Shown to 65-75 Lbs. Ft. on Engines 278, 308



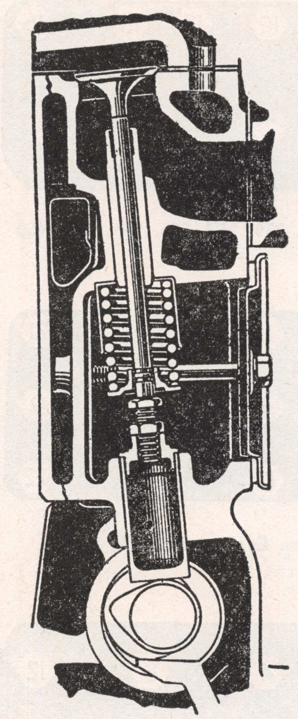
Tighten Head Bolts as Shown to 65-75 Lbs. Ft. on Engines 361, 426, 451, 477



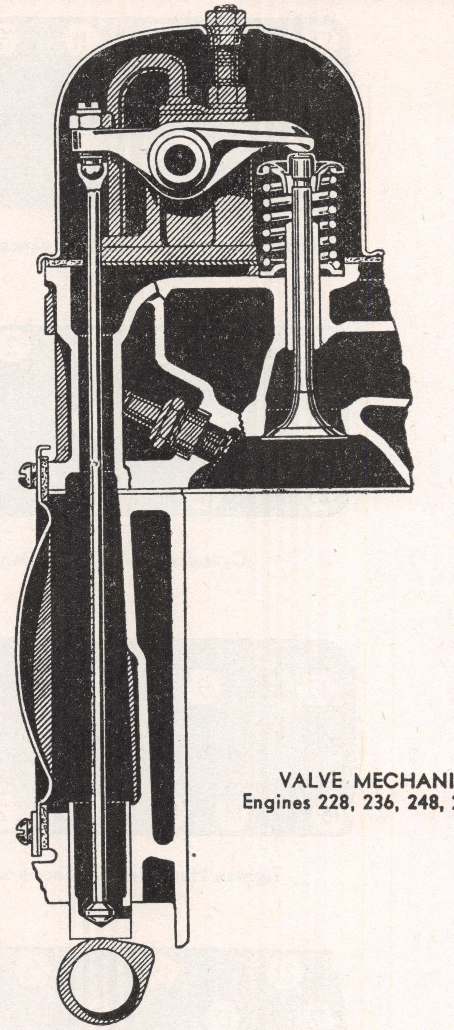
Tighten Head Bolts as Shown to 60-70 Lbs. Ft. on Engines 228, 236, 248, 256, 270



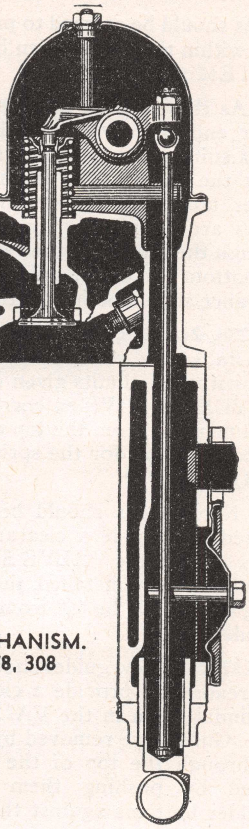
Cylinder Head Tightening Sequence on Engine 223



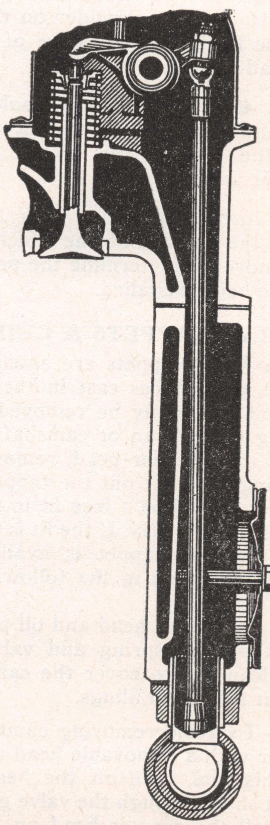
VALVE MECHANISM. Engine 223



VALVE MECHANISM.
Engines 228, 236, 248, 256, 270



VALVE MECHANISM.
Engines 278, 308



VALVE MECHANISM.
Engines 361, 426, 451, 477

the camshaft. Make a careful inspection to be sure that all filings and dust are removed.

Install the oversize lifter and check to see that the clearance is within the limits given in the VALVE SYSTEM table. Install a new valve stem guide according to the instructions described under VALVE STEM GUIDES.

228, 236, 248, 256, 270, 278, 308, 361, 426, 451, 477: Tappets must be a free fit in their guides without excessive side play. If the fit is too loose, guides should be reamed and oversize tappets fitted to provide a clearance within the limits given in the VALVE SYSTEM table.

To remove tappets, take off the rocker arm assembly and push rod covers, then lift out the push rods and tappets.

230: Tappets must be a free fit in their guides without excessive side play. If the fit is too loose, guides should be reamed and oversize tappets fitted to provide a clearance within the limits given in the VALVE SYSTEM table.

To remove tappets, remove the oil pan and block up the front end of the engine in order to take off the timing chain cover. Then remove in the following sequence: vibration damper and fan belt, timing chain cover, timing chain and camshaft sprocket, cylinder head, valve covers, fuel pump and ignition distributor.

NOTE—To avoid the possibility of assembling the distributor incorrectly, remove the cap screw which holds the distributor clamp bracket to the cylinder block, then take off the bracket together with the distributor.

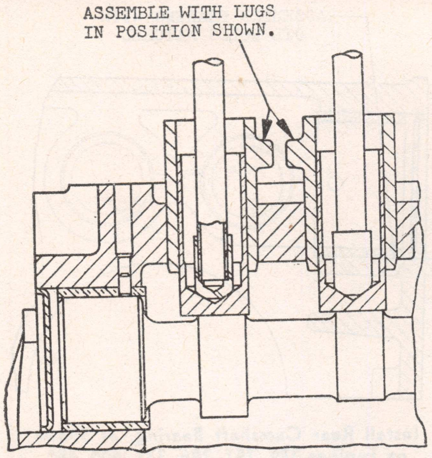
Remove the oil pump assembly. Raise the valve springs and slip small pieces of wood under the valve heads to hold them open. Use a set of wooden spring clips to hold the tappets in the raised position in order to clear the cams on the camshaft. Then pull out the camshaft, and remove any or all lifters from below, after removing the wooden clips.

After fitting the new lifter, install the camshaft and other parts in the reverse order of their removal.

NOTE—Install the timing chain and sprocket according to the instructions described under TIMING CHAIN & SPROCKETS. When installing the distributor, bring No. 1 piston up on its compression stroke and set the distributor on the number one cam. Slide the distributor into position to determine the approximate position for the oil pump drive gear, then pull the distributor out far enough to assemble the oil pump drive gear to the distributor drive shaft. Set the ignition timing as described under IGNITION TIMING.

Install the fuel pump, adjust tappets, replace valve covers, install oil pan and cylinder head.

239, 257, 286: Tappets must be a free fit in their guides without excessive side play.



VALVE LIFTER GUIDES.
Engines 239, 257, 286

If the fit is too loose, guides should be removed and new guides pressed into the case.

CAUTION—When installed, be sure the lugs on each pair of guides are toward each other.

331, 400, 450: The valve lifter and guide assemblies are equipped with compression springs retained by spring caps. The assemblies are secured in sets of two by a clamp.

NOTE—The roller pins are a pressed fit in the tappets, and after assembly, the roller should have about .002" side clearance to permit free movement.

VALVE TIMING

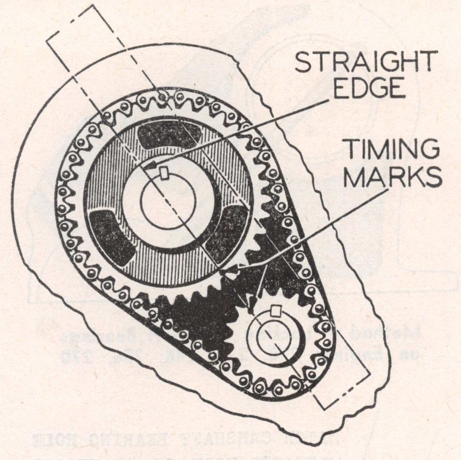
NOTE—On all engines, check the timing with the engine at normal room temperature, and with the intake valve lash set to the clearance for timing as given in the VALVE SYSTEM table.

213, 223, 230: Crank the engine until No. 1 intake valve starts to open. At this point, the ignition mark on the vibration damper, or on the flywheel for 223 and 230, should be in line with the pointer. If not, see TIMING CHAIN & SPROCKETS for correct setting.

1939-40—228, 248: Crank the engine until No. 1 intake valve is closed and the "UDC" mark on the flywheel is in line with the pointer on the flywheel housing. Slip a .002" feeler ribbon between the rocker arm and the valve cap and continue turning the engine until all lash is eliminated. If the timing is correct, the pointer on the flywheel housing should be in line with the triangle mark on the flywheel. If not, see TIMING GEARS for correct setting.

1941-46—228, 236, 248, 256, 270: Follow instructions already described for 228, 1940 except that the pointer on the flywheel housing should be ⅛" away from the steel ball and toward the "UDC" mark. If not, see TIMING GEARS for correct setting.

239, 257, 286: Intake opens 4 degrees before TDC and exhaust closes 27½ degrees after TDC. When the timing is correct, the marks on the timing gears should be meshed.



TIMING MARKS
Engines 213, 223, 230

278, 308, 361, 426, 451, 477: Crank the engine until No. 1 intake valve starts to open. At this point, the "UDC" mark on the flywheel should be visible at the inspection hole in the flywheel housing. If not, see TIMING GEARS for correct setting.

331, 400, 450: For 1937, 400 engine and all 331, intake opens 17 degrees, 54 minutes after TDC, and exhaust closes 20 degrees, 4 minutes after TDC. For 1936 and 1938, 400 and 450 engines, intake opens 8 degrees before TDC, and exhaust closes 20 degrees after TDC.

When the timing is correct, the timing marks on the gears should be meshed.

TIMING CHAIN & SPROCKETS

213, 223, 230: To install the chain, turn the sprockets so that the timing marks are in a direct line through the centers of both shafts.

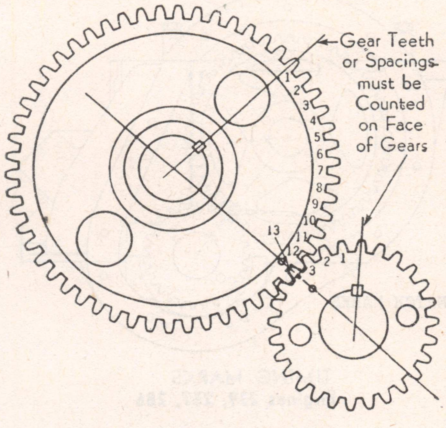
NOTE—After installing the chain, lay a straight edge across the face of the sprockets to be sure the marks are aligned.

TIMING GEARS & COVER

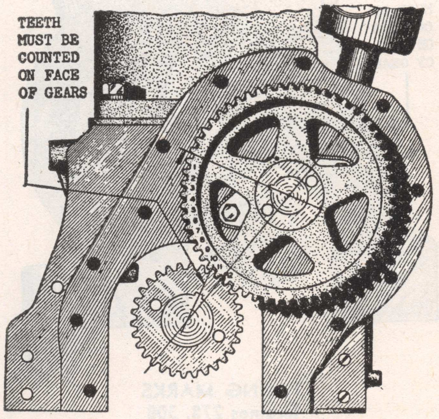
228, 236, 248, 256, 270: Timing gear backlash should be from .003" to .004". Before removing gears, make sure the timing marks are legible. When the valves are correctly timed, the marks on the gears should be meshed. However, if regular production gears are not in use, gears should be installed as shown in the illustration.

NOTE—The timing gear cover cannot be removed without first taking off the oil pan, and then removing the two bolts near the front main bearing cap. Whenever the gear cover is removed, it is good practice to replace the oil seal in the cover. When installing the seal, use care to see that it is fully seated, otherwise premature wear will result, with a consequent loss of lubricant.

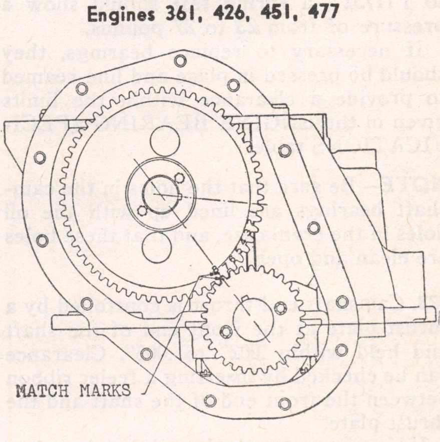
239, 257, 278, 286, 308, 331, 400, 426, 450, 451, 477: On all engines except 1941-46 series, timing gear backlash should be from .0005" to .0015". On 1941-46 engines, gear lash should be from .0015" to .0035".



TIMING MARKS.
Engines 228, 236, 248, 256, 270



TIMING MARKS
Engines 361, 426, 451, 477



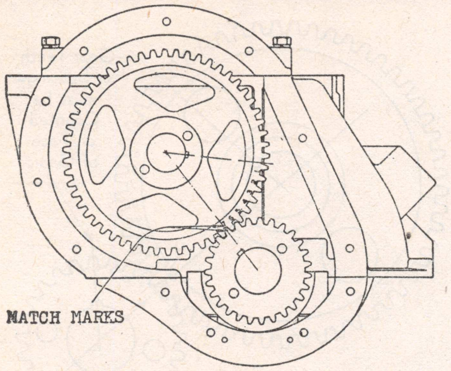
TIMING MARKS
Engines 331, 400, 450

Always use suitable puller and pusher equipment when removing or replacing gears. The relationship between the pistons and valves is correct when the marks on the gears are meshed.

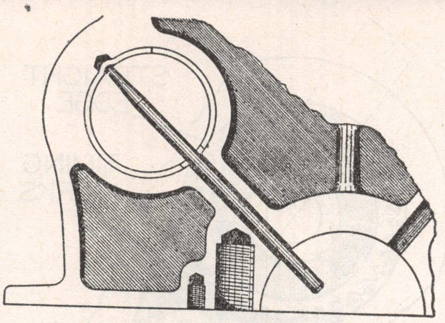
CAUTION—Before removing gears make sure the timing marks are legible, and if regular production gears are not in use, install the gears as shown in the illustrations.

CAMSHAFT & BEARINGS

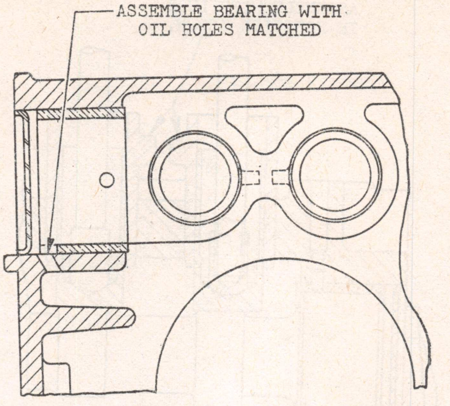
213, 230: Camshaft end thrust is controlled by a spring-loaded steel plunger in the front end of the shaft. The free length of this spring is 1 21/32", and when compressed



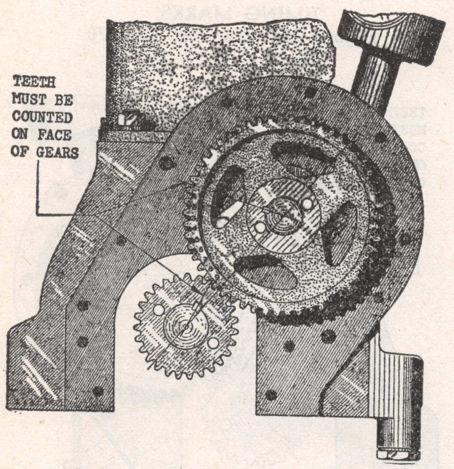
TIMING MARKS
Engines 239, 257, 286



Method of Locking Camshaft Bearings on Engines 228, 236, 248, 256, 270



Install Rear Camshaft Bearing, as Shown on Engines 239, 257, 286, 331, 400, 450



TIMING MARKS
Engines 278, 308

to 1 11/32", a spring test should show a pressure of from 23 to 27 pounds.

If necessary to replace bearings, they should be pressed in place and line-reamed to provide a clearance within the limits given in the ENGINE BEARING SPECIFICATIONS table.

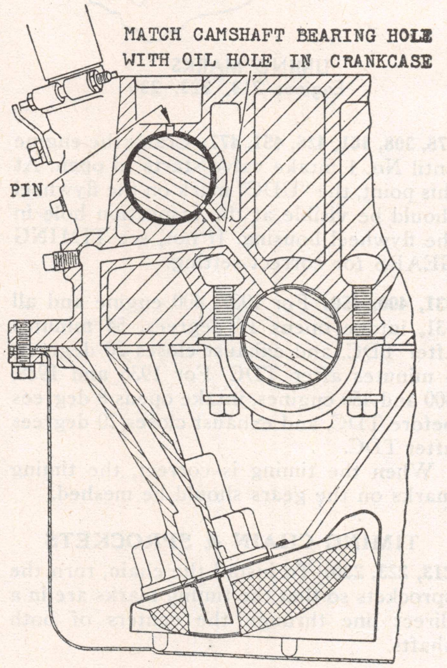
NOTE—Be sure that the holes in the camshaft bearings are lined up with the oil holes in the crankcase, and that these holes are clean and open.

223. Camshaft end thrust is controlled by a thrust plate at the front end of the shaft and held within .002" to .005". Clearance can be checked by inserting a feeler ribbon between the front end of the shaft and the thrust plate.

If necessary to replace bearings, they should be pressed in place and line-reamed to provide a clearance within the limits given in the ENGINE BEARING SPECIFICATIONS table.

NOTE—Be sure the oil holes in the bearings are in line with the oil holes in the crankcase, and that these holes are clean and open.

1939-40, 228, 248: Camshaft end play should be from .003" to .006" and is controlled by a thrust plate at the front end of the shaft. This clearance can be checked by inserting a feeler ribbon between the front end of the shaft and the thrust plate.



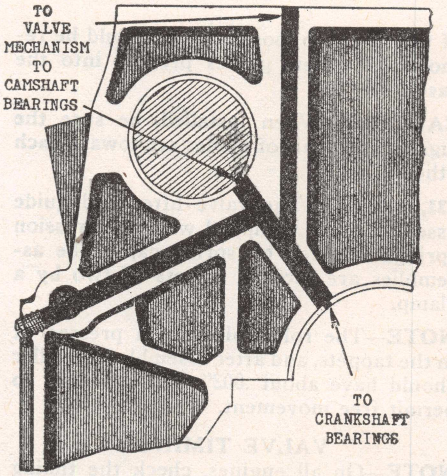
Install Camshaft Bearings as Shown on Engines 239, 257, 286, 331, 400, 450

If necessary to replace bearings, drive out the expansion plug at the rear of the rear bearing and use suitable equipment to remove and replace the bearings.

CAUTION—Be sure the oil holes in the bearings are lined up with the oil holes in the crankcase. It is important that the rear bearing be installed with the cut-out toward the rear of the block, otherwise the oil flow to the bearing will be restricted. Before reaming the bearings, insert a 9/32" round-nosed punch through the oil passage from the main to the camshaft bearings and stake each bearing in place as shown in the illustration.

1941-46, 228, 236, 248, 256, 270: Service instructions are the same as described for 1940-228 engine and the same precautions should be carefully observed. However, pay particular attention to the following note.

NOTE—Effective with engine numbers listed below, a new camshaft (part number 2136000—stamped on shaft) is used and effects valve timing arrangement and valve tappet clearances. However, this change does not effect timing gears or timing gear markings, nor does it change the method of checking valve timing. In the VALVE SYSTEM table, engines produced prior to the following engine serial numbers are referred to as "First Type", while engines effective with these numbers are designated as "Second Type".



Oil Holes in Main and Camshaft Bearings Must Line Up as Shown on Engines 278, 308, 361, 426, 451, 477

Engine 228............	No. 228-87569
Engine 236............	No. 236-001
Engine 248............	No. 248-17848
Engine 256............	No. 256-02769
Engine 270............	No. 270-11344

CAUTION—When replacing the camshaft, compare the part number stamped on the old and new shafts to be sure the right one is being used.

239, 257, 286, 331, 400, 450: Camshaft end play should be from .002" to .006" and is controlled by a thrust plate at the front end of the shaft. Check the clearance by inserting a feeler ribbon between the shaft and thrust plate.

If necessary to replace bearings, they should be pressed in place and line-reamed to provide a clearance within the limits given in the ENGINE BEARING SPECIFICATIONS table. However, to assure proper camshaft fit, the reaming operation should be performed **after** the cylinder block is bolted to the crankcase.

NOTE—The bearings are held in place with dowel pins. When bearings are installed, the oil holes in the bearings must be lined up with oil holes in the crankcase. The rear bearing must be installed with the cut-out to the rear and toward the inside, otherwise the oil flow to the bearing will be restricted. The drilled hole in the front bearing journal must be clean, as oil is directed to the thrust plate through this hole.

278, 308, 361, 426, 451, 477: Camshaft end play should be from .003" to .006" and is controlled by a thrust plate at the front end of the shaft. Check the clearance by inserting a feeler ribbon between the shaft and thrust plate.

If necessary to replace bearings, they should be pressed in place and line-reamed to provide a clearance within the limits given in the ENGINE BEARING SPECIFICATIONS table. However, to assure proper camshaft fit, the reaming operation should be performed **after** the cylinder block is bolted to the crankcase.

NOTE—The drilled hole in the front bearing journal supplies a small amount of oil to the thrust plate and timing gears. Be sure that this hole, as well as the oil holes in the camshaft gear, are clean and open. Be sure also, that the holes in the camshaft bearings are lined up with the holes in the crankcase.

PISTONS & RODS, REMOVE

1936-46: On all engines except 331, the pistons and rods are removed from the top of the cylinder block. Although regular production rods are marked with the cylinder number in which they are installed, replacement rods are not; therefore, unmarked rods should be suitably identified with punch-marks, as removed.

NOTE—On 331 engines, the pistons and rods are removed from below, at the camshaft side of the engine, after first removing the oil line assembly and the vibration damper—which is mounted between No. 1 and 2 crank throws. In order to remove No. 6 piston and rod, it is necessary to rotate the crankshaft as the piston is withdrawn.

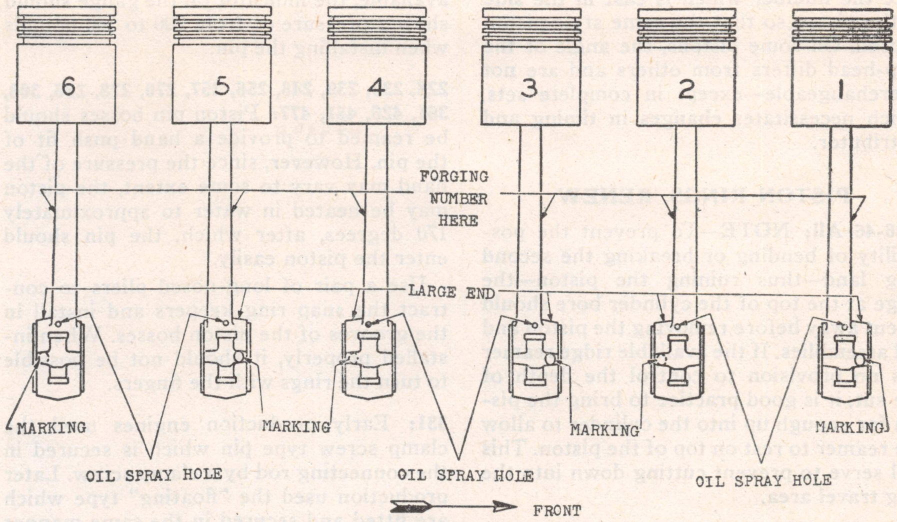
PISTON & ROD, ASSEMBLE

213, 228, 230, 236, 248, 256, 270: When correctly assembled, the oil spray hole in the upper half of the connecting rod must be on the camshaft side of the engine with the T-slot side of the piston opposite to the camshaft side.

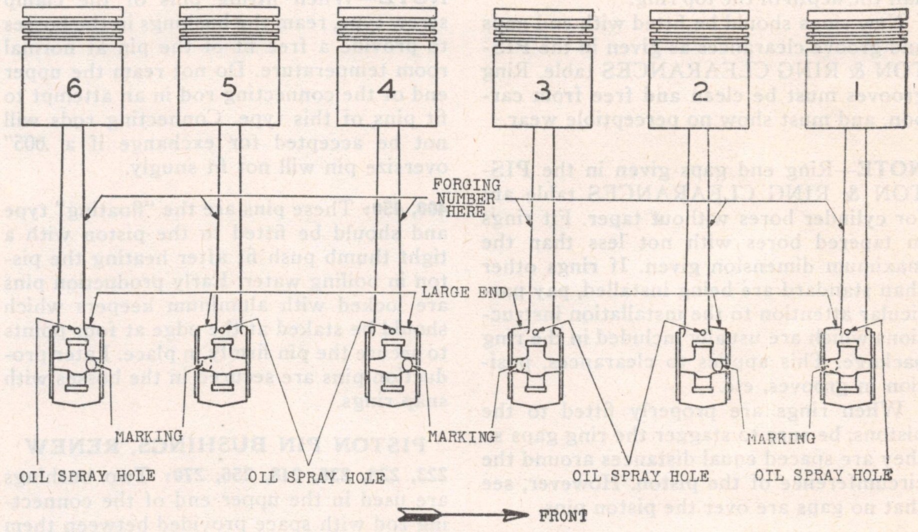
223: Assembly of the piston and rod on this engine presents no problem since the piston is the same on both sides.

239, 257, 286: When installed, the slot in the piston skirt must face away from the camshaft and rods should be assembled as shown in the illustrations.

278, 308, 361, 426, 451, 477: Assemble the piston with the T-slot side of the piston on the camshaft side and the oil spurt hole in the rod must be in line with the step-head side of the piston—opposite the camshaft.



Install Connecting Rods as Shown. Engines 239, 257



Install Connecting Rods as Shown. Engine 286

331, 400, 450: When installed, the vertical slot in the piston skirt must face away from the camshaft with the oil spurt hole facing the camshaft.

PISTONS, RENEW

1936-46 All: NOTE—A variation of 10 degrees between the temperature of the pistons and cylinder bores is sufficient to produce a difference of .0005". Therefore, both the pistons and cylinder bores should be at normal room temperature (about 70 degrees) when fitting pistons. This is particularly important because the clearances given in the PISTON & RING CLEARANCES table are minimum and pistons must not be fitted with less than specified.

Before any attempt is made to fit new pistons, cylinder bores should be carefully indicated and refinished. If bores do not require refinishing, be sure to remove the ridge at the top of each bore. If refinishing is required, it is good practice to do so in alternate cylinders due to the localized temperature build-up. Cylinder bores should not be out-of-round or tapered more than .0005".

Before fitting pistons, wipe the cylinder walls and pistons to remove all chips, dirt or other foreign matter. The feeler ribbon used to check piston fit should be about 12" long and ½" wide. Consult the PISTON & RING CLEARANCES table for the thickness of shim to use, as well as the recommended pounds pull on a spring scale required to withdraw the feeler ribbon past the piston.

Insert the piston in the bore upside down and in its running position (see PISTON & ROD, ASSEMBLE). Place the feeler ribbon between the cylinder wall and the thrust side of the piston (opposite slotted side) in a position at right angles to the piston pin hole.

After assembling the piston to the connecting rod, check the assembly for alignment on a suitable jig.

NOTE—On 1941-46 engines 228, 236, 248, 256, 270, when pistons are to be replaced,

note the number which is cast in the side of the piston so that the same style piston is used. On some pistons, the angle of the step-head differs from others and are not interchangeable—except in complete sets, which necessitates changes in timing and distributor.

PISTON RINGS, RENEW

1936-46 All: NOTE—To prevent the possibility of bending or breaking the second ring land—thus ruining the piston—the ridge at the top of the cylinder bore should be cut away before removing the piston and rod assemblies. If the available ridge reamer has no provision to control the depth of the cut, it is good practice to bring the piston far enough up into the cylinder to allow the reamer to rest on top of the piston. This will serve to prevent cutting down into the ring travel area.

CAUTION—Never cut down into the ring travel area more than 1/32"—or more than half the depth of the top ring.

New rings should be fitted with end gaps and groove clearances as given in the PISTON & RING CLEARANCES table. Ring grooves must be clean and free from carbon, and must show no perceptible wear.

NOTE—Ring end gaps given in the PISTON & RING CLEARANCES table are for cylinder bores without taper. Fit rings in tapered bores with not less than the maximum dimension given. If rings other than standard are being installed, pay particular attention to the installation instructions which are usually included in the ring package. This applies to clearances, position in grooves, etc.

When rings are properly fitted to the pistons, be sure to stagger the ring gaps so they are spaced equal distances around the circumference of the piston. However, see that no gaps are over the piston pins.

PISTON PINS, RENEW

213, 230: Pins are a press fit in both bosses but the boss on the lock screw side is reamed approximately .0003" smaller than the opposite boss.

To remove the pin, heat the piston in boiling water for about one minute. Then remove the lock screw and press the pin out toward the plain boss side.

To install, again heat the piston, then dip the pin in hot engine oil and start the pin through the plain boss and connecting rod, making sure that the lock screw hole in the pin and boss are in line. Press the pin all the way through.

NOTE—If heavy pressure is required to push the pin in the lock screw boss, very likely the piston has cooled slightly, in which case, remove the rod and again heat the piston.

223: When fitting pins, coat the inside of both bosses with graphite grease, then press the pin into the piston, entering the slotted end first into the lock boss. It is recommended that a special removing and replacing fixture be used for this work, and if available, the indicator on the gauge should show a pressure of from 200 to 300 pounds when installing the pin.

228, 236, 239, 248, 256, 257, 270, 278, 286, 308, 361, 426, 451, 477: Piston pin bosses should be reamed to provide a hand push fit of the pin. However, since the pressure of the hand may vary to some extent, the piston may be heated in water to approximately 170 degrees, after which, the pin should enter the piston easily.

Use a pair of long-nosed pliers to contract the snap ring keepers and install in the grooves of the piston bosses. When installed properly, it should not be possible to turn the rings with the fingers.

331: Early production engines used the clamp screw type pin which is secured in the connecting rod by a clamp screw. Later production used the "floating" type which are fitted and secured in the same manner as described for 228 engines.

NOTE—When fitting pins of the clamp screw type, ream the bushings in the bosses to provide a free fit of the pin at normal room temperature. Do not ream the upper end of the connecting rod in an attempt to fit pins of this type. Connecting rods will not be accepted for exchange if a .005" oversize pin will not fit snugly.

400, 450: These pins are the "floating" type and should be fitted to the piston with a tight thumb push fit after heating the piston in boiling water. Early production pins are locked with aluminum keepers which should be staked at the edge at four points to secure the pin firmly in place. Later production pins are secured in the bosses with snap rings.

PISTON PIN BUSHINGS, RENEW

223, 228, 236, 248, 256, 270: Two bushings are used in the upper end of the connecting rod with space provided between them for lubrication. New bushings should be pressed in place, then reamed to provide a hand push fit of the pin at normal room temperature.

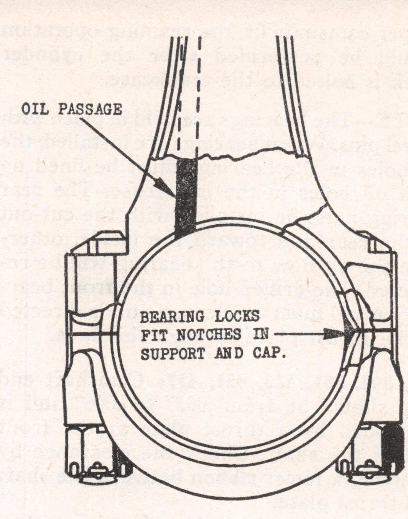
213, 230, 239, 257, 278, 286, 308, 361, 400, 426, 450, 451, 477: New bushings should be pressed in place and reamed to provide a hand push fit of the pin at normal room temperature. When installed, be sure the oil hole in the bushing lines up with the hole in the connecting rod.

NOTE—On 213 engine, the bushing is the split type and when installed, it should be bonded to the rod with a burnishing tool before reaming.

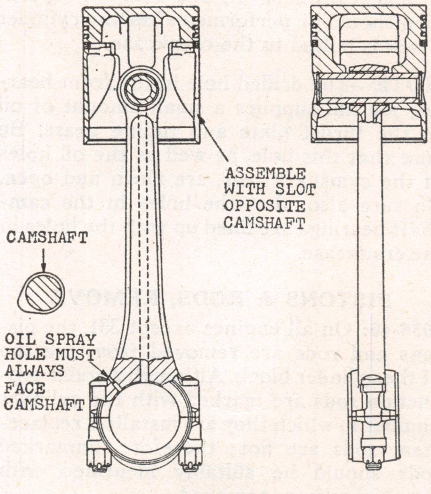
331: See PISTON PINS, RENEW.

CONNECTING ROD BEARINGS, RENEW

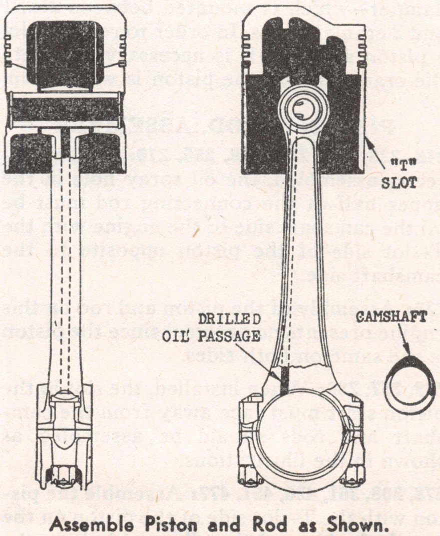
1936-46 Except 239, 257, 286, 331: When bearings become worn, they can be replaced without removing the rod by simply taking off the bearing cap and replacing the upper and lower halves. Bearings should be replaced in sets and under no circumstances should rods or caps be filed,



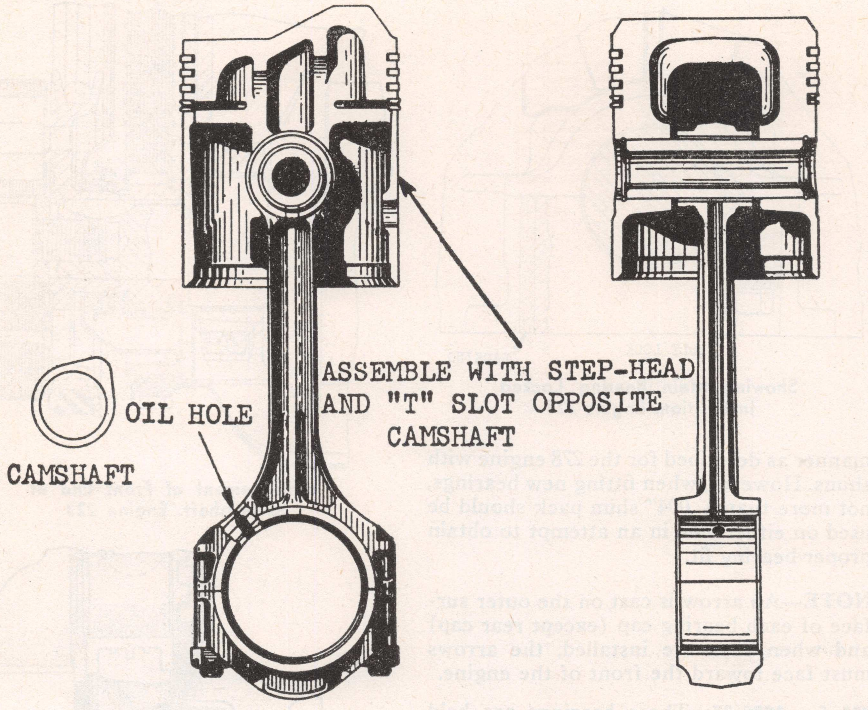
CONNECTING ROD CAP ASSEMBLY.
Engines Using Precision Insert Bearings


ASSEMBLE WITH SLOT OPPOSITE CAMSHAFT
CAMSHAFT
OIL SPRAY HOLE MUST ALWAYS FACE CAMSHAFT

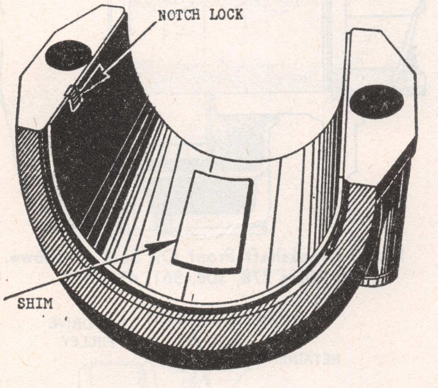
Assemble Piston and Rod as Shown
Engines 239, 257, 286, 331, 400, 450



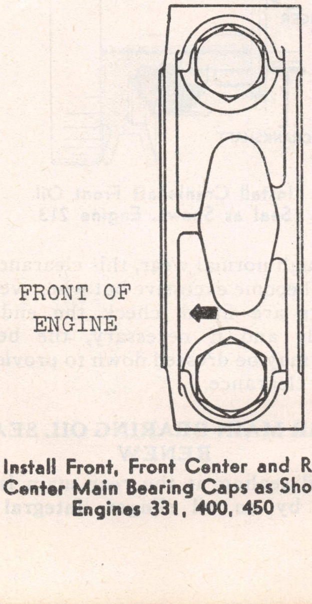
Assemble Piston and Rod as Shown.
Engines 278, 308, 361 426, 451, 477



Assemble Piston and Rod as Shown. Engines 213, 228, 230, 236, 248, 256, 270



Method of Checking Bearing Fit of Precison Insert Type



Install Front, Front Center and Rear Center Main Bearing Caps as Shown. Engines 331, 400, 450

altered or mutilated in any way in an attempt to obtain proper bearing fit.

NOTE—Before replacing bearings, make sure that the crankpins are not nicked or scored. Use care also, to see that all parts are thoroughly clean. This is particularly important because one small particle of metal, carbon or other foreign matter, lodged between the back of the bearing and the rod, or between the face of the bearing and the crankpin, will very likely cause a hot spot due to the elimination of the oil clearance at that point, eventually resulting in a bearing failure or a scored crankpin.

CAUTION—Some of these engines employ shims between the bearing cap and rod **only** on the side opposite the bearing lock notch. When shims are used, never use more than a .006" shim pack to obtain proper bearing fit. On engines which do not use shims, do not attempt to obtain proper bearing fit by their use.

On engines with shims, two sizes of shims are used: the .002" shim can be identified by a small hole near the rod bolt hole, while the .003" shim has no hole. Clearance can be reduced for example, by substituting a .002" shim for a .003" shim. Use any combination of these shims to obtain proper clearance.

To check the fit of new bearings, use a piece of brass shim stock ¼" wide, the length of which should be ¼" less than the length of the bearing, while the thickness should be about the same as the minimum allowable clearance.

CAUTION—To avoid damaging the bearing material, smooth down the edges of the shim stock on an oil stone so that no sharp edges remain. Install the shim between the bearing and the crankpin, in the center of the bearing, then tighten the cap bolts to the recommended torque tension. When fitted properly, it should not be possible to move the rod endwise by hand, but a light tap with a hammer should cause the rod to move endwise. Then remove the shim and install the cap again, tightening the cap bolts with the torque wrench, after which, the rod should move endwise by hand. If the rod is too loose with the checking shim in place and all rod shims removed (when used), the crankpin should be turned down and undersize bearings fitted.

NOTE—It is good practice to check the connecting rod bore for roundness. A special tool with an indicator gauge is available for this operation, and before using this instrument, be sure that there are no nicks, burrs or dirt on the contacting surfaces to prevent a true reading. If the rod bore is out-of-round more than .002" or .003", the rod should be replaced.

239, 257, 286, 331: These bearings are the spun type and are not replaceable. If bearings require adjustment, remove the same thickness of shims from each side until a metal-to-metal contact is established with the crankpin. The bearing may then be scraped to provide maximum bearing surface and sufficient shims installed on both sides to provide a clearance within the limits given in the ENGINE BEARING SPECIFICATIONS table.

CAUTION—See the illustrations for the proper assembly of rods in the cylinder bores on 239, 257 and 286 engines. And do not attempt to insert rods into the bores with the bearing caps bolted in place.

MAIN BEARINGS, RENEW

NOTE—Before replacing bearings, make sure that the crankshaft journals are not nicked or scored. Use care also, to see that all parts are thoroughly clean. This is particularly important because one small particle of metal, carbon, dirt of other foreign matter, lodged between the back of the bearing and the cap, or between the bearing face and the crankshaft journal, will very likely cause a hot spot due to the elimination of the oil clearance at that point, eventually resulting in a bearing failure of a scored journal.

213, 223, 228, 230, 236, 248, 256, 270, 278, 308, 361, 426, 451, 477: When bearings become worn, they can be replaced without removing the crankshaft in the following manner: Remove the bearing cap and take out the worn lower shell. A suitable tool can be made to remove the upper shell by using a cotter pin with the rounded end flattened to form a T shape. Insert the T-shaped end of the pin in the oil passage hole in the crankshaft journal and, by rotating the crankshaft in the reverse direction, the T-shaped head will contact the bearing and force it out.

To install, place a new upper shell on the crankshaft journal with the locating notch in the correct position and rotate the shaft to turn the shell in place. Then install the lower shell in the cap and replace the cap, tightening the cap bolts to the recommended torque tension which will be found in the ENGINE BEARING SPECIFICATIONS table.

NOTE—Bearings should be replaced in sets and under no circumstances should any attempt be made to file, alter or otherwise mutilate the bearing caps to obtain proper bearing fit. However, early production 228 and 248 engines employed shims between the bearing cap and support **only** on the side opposite the bearing lock notch; later production on these engines do not use shims. Similarly, early production 278, 308, 361, 426 and 451 engines used shims between the cap and support on **both** sides, which have been eliminated entirely on later production of these engines. In either case, whether shims are used on one side or both sides, the shim pack should not exceed .006" on any one side, nor should these shims project between the edges of the bearings as this will cause the bearings to buckle when bolts are tightened.

CAUTION—Never attempt to fit bearings by using shims on both sides if the bearing is designed for the use of shims on one side only; nor should shims be eliminated from one side if the bearing is designed for the use of shims on both sides. If the bearing design requires no shims, do not attempt to obtain a bearing fit by their use.

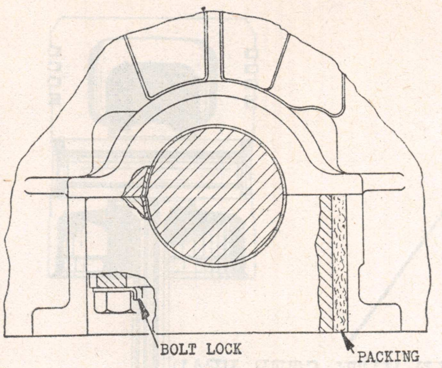
When fitting bearings on engines using shims, two sizes are available: the .002" shim can be identified by a small hole near the bolt hole, while the .003" shim has no hole. Bearing clearance can be reduced, for example, by removing a .003" shim and putting in a .002" shim.

To check the fit of new bearings, use a piece of brass shim stock ¼" wide, the length of which should be ¼" less than the length of the bearing, while the thickness should be about the same as the minimum allowable clearance.

CAUTION—To avoid damaging the bearing material, smooth down the edges of the shim stock to remove sharp edges or turned over corners. And before inserting it in place, coat the shim on both sides with a light film of engine oil.

Then lay the shim lengthwise in the center of the bearing and install the bearing cap to the crankshaft, tightening the cap bolts to the recommended torque tension which can be found in the ENGINE BEARING SPECIFICATIONS table. Test the fit of the bearing by rocking the flywheel through an arc of 2"—not more than 1" in either direction. The bearing may be considered fitted properly if the shaft is movable with a fairly heavy drag.

NOTE—Remove the checking shim and replace the cap, but do not tighten the cap bolts, as this bearing must be loose in order to check the fit of the other bearings. It is good practice to fit bearings by starting at the center—or one of the intermediates on a four bearing job—then the rear bearing, front bearing, and finally, the intermediates.



Showing Main Bearing Locked in Position. Engine 223

239, 257, 286: These bearings are the replaceable type and are serviced in the same manner as described for the 278 engine with shims. However, when fitting new bearings, not more than a .004" shim pack should be used on either side in an attempt to obtain proper bearing fit.

NOTE—An arrow is cast on the outer surface of each bearing cap (except rear cap) and when caps are installed, the arrows must face toward the front of the engine.

331 for 1936-37: These bearings are held in supports and caps by dowel pins, and when new bearings are fitted, they should be line reamed to fit the crankshaft.

When adjusting these bearings, remove the same thickness of shims from each side until a metal-to-metal contact is established with the crankshaft journal. If the bearing material is scored, rough, or shows only partial contact, bearing may be scraped to obtain maximum contact. (If babbitt is cracked or worn excessively, replace the bearings.) Then install the same thickness of shims on each side to provide a clearance within the limits given in the ENGINE BEARING SPECIFICATIONS table.

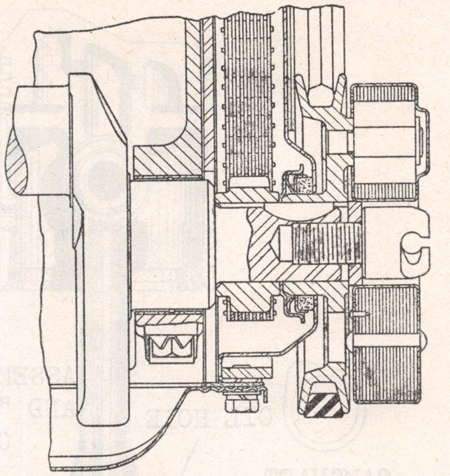
331 for 1938: These bearings are the replaceable type with shims provided for adjustment on both sides. Bearings are serviced in the same manner as described for 278 engine with shims. However, if bearings are to be fitted with the crankshaft in place, loosen all the bearing caps and install one pair at a time.

400, 450: These bearings are serviced in the same manner as described for 278 engine with shims. Under no circumstances should more than a .006" shim pack be used on either side, nor should these shims project between the edges of the bearings as they will cause the bearings to buckle when bolts are tightened.

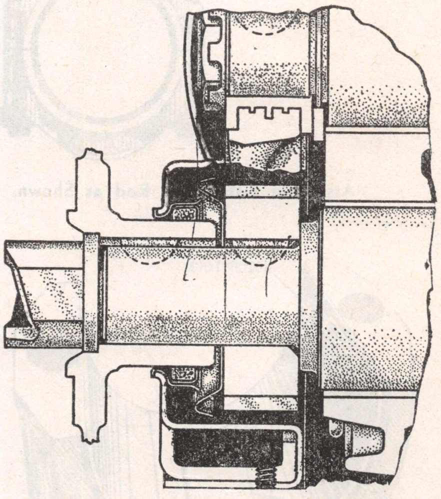
NOTE—An arrow is cast on the outer surface of each bearing cap (except rear) and when installed, these arrows must face toward the front of the engine.

CRANKSHAFT END THRUST

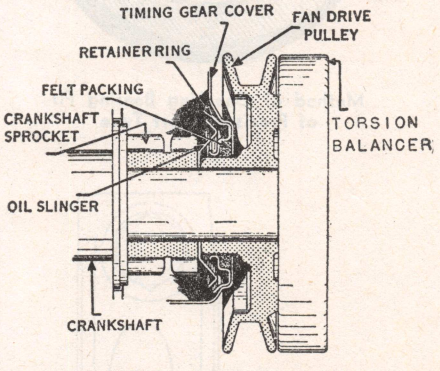
1936-46: Crankshaft end thrust is controlled by flanges on a bearing (see the ENGINE BEARING SPECIFICATIONS table for the bearing which takes the thrust and for the proper end play limits).



Arrangement of Front End of Crankshaft. Engine 223



Install Crankshaft Front Oil Seal as Shown. Engines 278, 308, 361, 451, 477

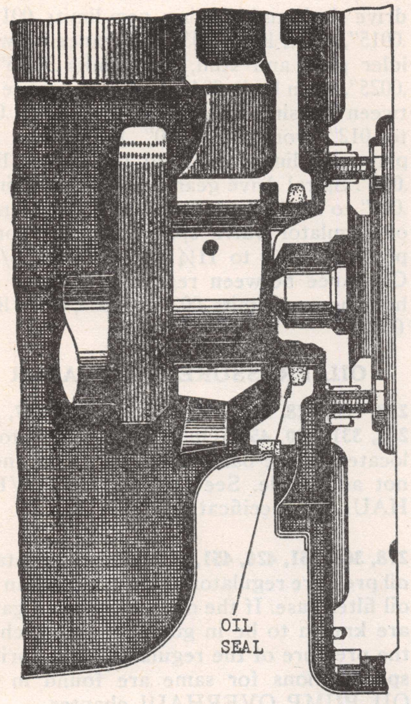


Install Crankshaft Front Oil Seal as Shown. Engine 213

Through normal wear, this clearance will seldom become excessive but whenever new bearings are fitted, check the end play carefully and if necessary, the bearing flanges may be dressed down to provide the desired clearance.

REAR MAIN BEARING OIL SEAL, RENEW

213: Oil sealing at the rear main is controlled by an oil slinger, integral with



Install Rear Main Bearing Oil Seal as Shown. Engines 228, 236, 248, 256, 270

crankshaft, running in a groove having a cored hole leading into the oil sump. In addition, a cork gasket is used at the vertical joint between the bearing cap and crankcase.

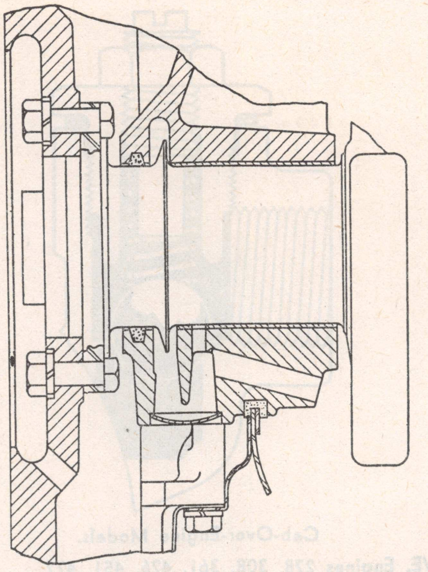
223: This engine uses the slinger type oil seal and surplus oil is returned to the oil pan through an oil passage and tube.

228, 230, 236, 239, 248, 256, 257, 270, 286, 331, 400, 450: The rear main bearing support is provided with packing which forms an oil seal at the outer end of the shaft. In addition, an oil slinger, integral with crankshaft, deflects the major portion of the oil into the groove of the bearing cap and support.

NOTE—If it is necessary to replace the packing in the upper half of the rear main bearing, the crankshaft must be removed from the engine and the packing installed in the same manner as described below for the lower half of the bearing.

To install, insert the packing in the groove of the bearing cap and use a smooth, rounded tool to work the packing from each end towards the center of the cap, to force, and shape the packing in the groove. Then cut off the overlapping ends of the packing flush with the surface of the cap.

NOTE—Make sure that the packing is not pulled out of the groove when cutting off the ends. A special seal compressor, or a round block of wood of the same diameter as the crankshaft flange may be used to hold the packing firmly in position.



Install Rear Main Bearing Oil Seal as Shown. Engines 239, 257, 286, 331, 400, 450

On 239, 257, 286, 331, 400 and 450 engines, a cork seal fits into the groove on the outer surface of the cap, providing a seal between the crankcase and the oil pan. Whenever the oil pan is removed, a new seal should be installed.

278, 308, 361, 426, 451, 477: The oil seal is contained in a retainer and consists of a leather ring held in close contact with the outer face of the flywheel flange by a spring. This spring-loaded leather seal, with the aid of the oil slinger at the rear bearing, prevents leakage of oil at the rear of the crankshaft.

Whenever the engine is removed, it is good practice to replace the oil seal, regardless of its condition of wear. The seal and its retainer is readily removed after taking off the flywheel.

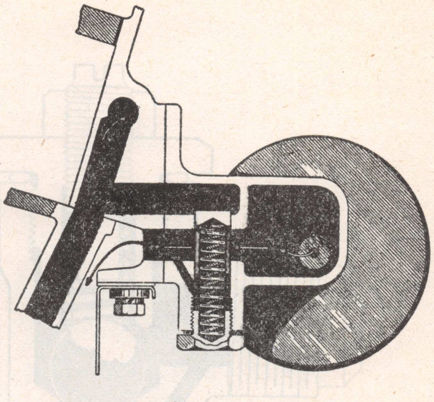
NOTE—When pressing the seal into its retainer, make sure that it seats firmly all around; and when installing, use care to see that the crankshaft flange does not damage the seal.

ENGINE OILING

OIL PUMP

NOTE—On all engines, if the oil pressure drops below normal, do not remove the oil pump or oil pan until the oil gauge is checked with another gauge known to be accurate. Check the oil level and examine the condition of the oil. If the pressure continues to drop, remove and clean the oil pan thoroughly, and disassemble, clean and inspect the pump and oil pressure regulator.

CAUTION—Before replacing the oil pump and oil pan, the oil float, screen and tube should be thoroughly cleaned, being sure that all openings in the screen are free and clean. If the screen has been crushed, it is better to replace it rather than attempt to make a repair. When assembling the pump, dip the gears in fresh engine oil as a means of priming the pump.



OIL PRESSURE REGULATOR IN FILTER. Engines 278, 308, 361, 426, 451, 477

213, 230: Normal oil pressure, 30 to 35 pounds. Backlash between gears, new limits .004", worn limit .012". Between gears and housing, new limits .0025" to .0085", worn limit .012". End clearance between gears and cover, new limits .0005" to .0015", worn limit .004". Clearance between the regulator plunger and housing, new limits .003" to .005", worn limit .008". Free length of regulator valve spring, 3¼"; spring pressure 9⅛" to 9⅜" at 1 29/32".

The pump is attached to the engine on the manifold side and can be removed without disturbing the drive mechanism. Disassemble and clean the pump thoroughly, then make an inspection according to the specifications described above.

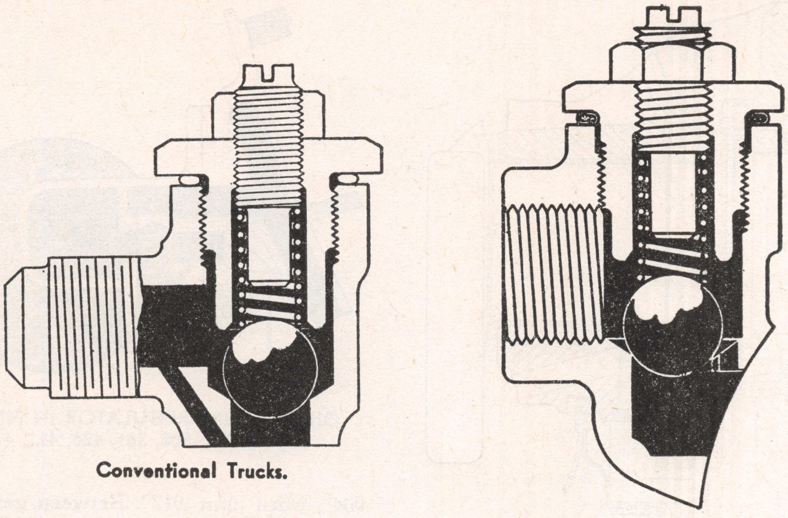
NOTE—Clearance between the gears and cover may be checked by placing a steel scale across the face of the housing, and a feeler ribbon between the steel scale and gears. If clearance is excessive, it may be reduced by grinding the lower face of the housing, using an abrasive compound evenly distributed on a perfectly flat surface.

223: Normal oil pressure, 35 to 45 pounds. Shaft bearing clearance .0005" to .002" Clearance between cover and shaft .002" to .006". Idler gear bearing clearance .0005" to .002". Drive gear backlash .003" to .004" Backlash between drive and idler gears .006" to .008". Clearance between drive and idler gears .002" to .006". Relief valve ball clearance .0145" to .0165".

To remove or replace the pump, crank the engine to bring No. 1 piston to the top of its compression stroke and note the position of the distributor rotor, which should be in the firing position for No. 1 cylinder. Disconnect the oil pump from the engine and lift out.

To install, check the distributor to see that the rotor is in the No. 1 firing position and the piston up on the compression stroke. Place the pump in position and mesh the oil pump gear with the camshaft gear.

NOTE—Set the ignition timing according to instructions described under IGNITION TIMING. End clearance between the cover and shaft may be reduced in the same manner as described for 213 engine.



Conventional Trucks.

Cab-Over-Engine Models.

CRANKCASE VENTILATOR CHECK VALVE. Engines 278, 308, 361, 426, 451, 477

228, 236, 248, 256, 270: Normal oil pressure, 35 to 40 pounds at 1,000 RPM. Gear backlash, .003" to .006".

The following clearances are specifications when installing new parts: Between drive shaft and housing .0005" to .003". Between drive gear and shaft .0005" to .002". Between idler gear and shaft .001" to .0025". Between gear and housing—(radial) .002" to .005". Between cover and housing .0015" to .0045". Between relief valve and housing .003" to .006". Free length of the regulator valve spring 23/32"; spring pressure, 10½ to 11½ pounds at 1 25/32".

To remove the pump, loosen the pump housing set screw (at the upper end of housing) and disconnect the main oil line at the crankcase. Then take out the pump and main oil line together, after which, disconnect the oil line from the pump.

NOTE—End clearance between the cover and gears can be reduced in the same manner as described for 213 engine.

To install the pump, connect the main oil line to the pump, then attach the main oil line to the crankcase. The pointed end of the set screw sets into the countersunk hole in the upper end of the pump housing.

CAUTION—Do not tighten the set screw excessively as the distributor shaft may bind as a result. Be sure to tighten the set screw lock nut.

239, 257, 286: Normal oil pressure, 30 pounds. Gear backlash .007" to .010". Gear end play .0005" to .004". The following clearances are specifications when installing new parts: Between drive shaft and housing .001" to .0025". Between idler gear and stud .0005" to .0025". Between housing and gears (radial) .001" to .008". Between regulator plunger and housing .002" to .006". Free length of regulator valve spring 3 5/16"; spring pressure 10½ to 11¼ pounds at 1 25/32".

NOTE—End clearance between the cover and gears can be reduced in the same manner as described for 213 engine.

To remove the pump, take off the oil pan, loosen the pump support bolts and remove the pump. Install the pump in the reverse manner, but when tightening the support bolts, turn the pump shaft with the fingers to be sure it does not bind in either the pump housing or the crankcase.

NOTE—A special aligning bushing is available for use when installing the pump, and when using this tool, remove the ignition distributor and place the tool guide in the distributor shaft bore. Then install the pump as explained above.

278, 308, 361, 426, 451, 477: Normal oil pressure, 35 to 40 pounds at 1,000 RPM. Gear backlash .003" to .005". The following clearances are specifications when fitting new parts: Between drive shaft and housing bushing .0005" to .002". Between idler gear and shaft .0005" to .0025". Between gear and housing (radial) .002" to .005". Between cover and gear .001" to .002". Between relief valve and housing .002" to .0035". Free length of regulator valve spring 2⅜"; spring pressure, 19 to 20 pounds at 1 11/16".

NOTE—End clearance between the cover and gear can be reduced in the same manner as described for 213 engine.

To install the pump, crank the engine to bring No. 1 piston to the top of the compression stroke, which is when the "UDC" mark on the flywheel is in line with the indicator on the flywheel housing. Be sure the octane selector is set at "O," and if the distributor has been removed, turn the rotor so that it is in the No. 1 firing position.

Locate the pump shaft so that the keyway is on the same side of the distributor shaft tang as the distributor rotor—rotor being in No. 1 firing position. Hold the pump in position with one hand and turn the rotor in either direction until the distributor shaft tang meshes with the slot in the oil pump drive gear.

331, 400, 450: Normal oil pressure, 42 to 45 pounds. Gear backlash, new limits .007" to .010", worn limit .015". Clearance between drive shaft and housing, new limits .001" to .0015", worn limit .003". Clearance between idler gear and stud, new limits .0005" to .0025", worn limit .004". Radial clearance between housing and gears, new limits .006" to .012", worn limit .020". Pump gear end play, new limits .0005" to .004", worn limit .008". Spiral drive gear end play, new limits .001" to .002", worn limit .006". Free length of regulator valve spring 3 5/16"; spring pressure, 10½ to 11¼ pounds at 1 25/32". Clearance between regulator plunger and housing, new limits .002" to .006", worn limit .008".

OIL PRESSURE REGULATOR

213, 223, 228, 230, 236, 239, 248, 256, 257, 270, 286, 331, 400, 450: Oil pressure regulator is located in the base of the oil pump and is not adjustable. See OIL PUMP, OVERHAUL for specifications.

278, 308, 361, 426, 451, 477: A non-adjustable oil pressure regulator valve is located in the oil filter base. If the oil pump and oil gauge are known to be in good condition, check the pressure of the regulator valve spring; specifications for same are found in the OIL PUMP, OVERHAUL chapter.

OIL TEMPERATURE REGULATOR

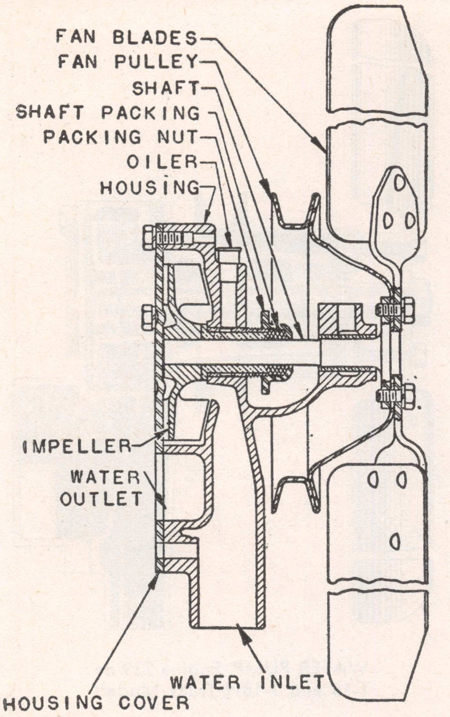
400, 450: (Not used on other engines.) Oil temperature regulator consists of a radiator type core enclosed in a housing, connected with both the cooling and oiling systems. Oil and water flows through passages at right angles to each other and are separated by thin copper walls. As the oil passes through the regulator, the water temperature raises or lowers the oil temperature, maintaining proper oil temperature under all operating conditions.

NOTE—If the oil filter is allowed to remain in a dirty condition, sludge and foreign matter will clog up the oil passage in the regulator core. If the oil filter is cleaned at regular intervals, the temperature regulator may be cleaned at 10,000 mile intervals.

To clean the regulator, remove it from the engine, take off the covers and withdraw the core. Use a small grease gun with pipe fittings brazed to the end to blow out the passages. Immerse the core in a good grade of benzol or coal tar naphtha for at least five minutes. Connect the grease gun to the oil inlet and pump for several minutes to remove the dissolved sludge. Then blow out the water and oil passages in both directions, applying from 50 to 75 pounds air pressure. However, do not connect the air hose to the fitting, but hold it a short distance away. Assemble the unit and install on the engine.

CRANKCASE VENTILATOR

NOTE—The interval at which the ventilator and air cleaner should be cleaned can only be determined by the type of service to which the vehicle is subjected. Vehicles operating in dusty or sandy areas require more frequent service than vehicles operating under more favorable conditions.



WATER PUMP. Engine 213

IMPORTANT—For vehicles operating in dust storm areas, cleaner should be cleaned immediately after such storms occur.

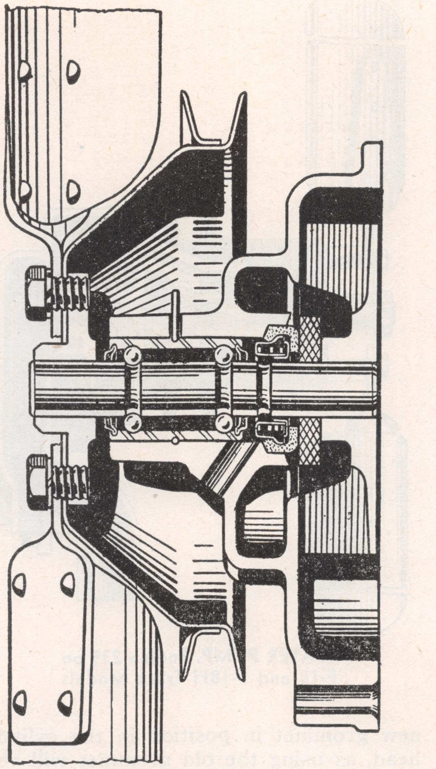
213, 223, 228, 230, 236, 248, 256, 270: The crankcase ventilator breather is fitted with an oil-wetted air cleaner which should be removed and washed at least every 1,000 miles. After the cleaner element is washed, blow it dry with compressed air, then dip it in SAE 50 engine oil. The outlet tube should be cleaned every 2,000 miles.

239, 257, 286, 331, 400, 450: Inspect the assembly at least every 2,000 miles, and if a sludge formation is evident around the outlet of the tube or in the oil filter housing, remove the entire assembly, disassemble, and clean it thoroughly in gasoline.

Allow the assembly to soak in the gasoline for about 30 minutes, then blow it out with compressed air, and at the same time, tap the tube lightly to dislodge any solid particles of sludge.

278, 308, 361, 426, 451, 477: The crankcase ventilating system used on these engines is equipped with either an oil-wetted type air cleaner or an oil bath cleaner. In addition, a ball check valve is incorporated in the cleaner, the purpose of which is to restrict the flow of ventilating air through the engine. This valve consists of housing, ball check, spring, retainer, adjusting screw and lock nut.

The breather which is fitted with the oil-wetted type air cleaner is serviced in the same manner as described for 213 engines. The oil bath type cleaner is serviced in exactly the same manner but before installing the cleaner element, wipe out the oil reservoir thoroughly with a clean cloth and fill it to the "Oil Level" with SAE 50 engine oil.



WATER PUMP. Engine 223

NOTE—The ventilator valve should be removed, disassembled and cleaned frequently, particularly in dusty areas. To adjust the valve, turn the adjusting screw all the way in until it contacts the ball, then back off two full turns.

CAUTION—Before assembling the filter, make sure the by-pass hole is clean and open.

OIL FILTER

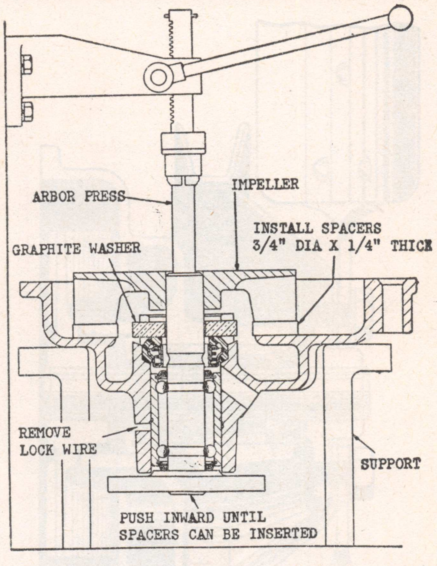
213, 223, 230: Not used as standard equipment.

1936-46 All (except 213, 223, 230): No definite mileage period can be recommended for oil filter element changes because these periods are definitely related to oil changing periods, the type and quality of oil used, and the severity of and type of operation.

In consideration of these factors, frequent inspections of oil should be made to determine the advisable intervals between oil changes and oil filter element changes. In some types of service, where operating conditions are severe, laboratory tests of oil drained from the engine, conducted by the oil supplier or another suitable laboratory, may be of great help in determining the advisable intervals between oil changes and filter element changes to suit a particular type of operation.

To remove the filter element, first take out the plug from the base of the filter and allow the oil to drain. Then remove the cover and pull out the element.

NOTE—At frequent intervals, it is good practice to drain the filter to get rid of any solid matter or water which may have settled in the filter sump. Whenever this is done, be sure to add an extra quart of oil to the crankcase to compensate for the oil drained. Of course, this applies also when changing the element.



When Removing Water Pump Shaft, Insert Spacers as Shown. Engine 223

Filters used on 239, 257, 286, 331, 400 and 450 engines are equipped with a ball check type by-pass valve which allows oil to by-pass around the filter when the oil is cold or thick, or when the filter is clogged.

COOLING SYSTEM

WATER PUMP, OVERHAUL

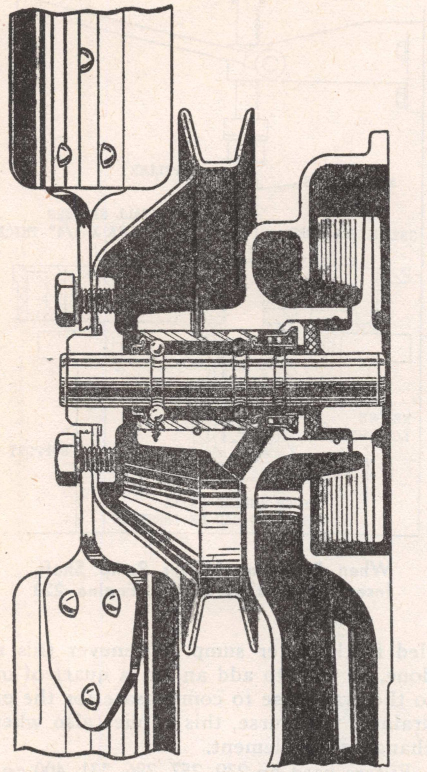
213: If packing only is required, remove pump from engine and take off fan. Disconnect pump cover and press off impeller. Install new packing, coating the bearing surface of both packing and shaft with engine oil. Tighten packing nut a normal amount, then rotate shaft and retighten nut. Run engine until hot to allow packing to seat properly, then make a final tightening of the nut.

NOTE—Either bushing may be replaced without disturbing the other. When bushings are pressed in place, they should be burnished to provide a clearance of from .0005" to .0022" between the shaft and bushings.

Press impeller on shaft until shaft is slightly more than flush with impeller hub. Replace pump cover and check shaft end play, which should be from .008" to .014". If not within these limits, remove cover and change position of impeller on shaft. Attach fan to pump and install assembly on engine.

223, 230: Take off pump cover, fan and pulley. Remove bearing lock ring.

NOTE—On 223 engine, push fan blade flange to rear until inner side is against pump housing. This will provide sufficient clearance between impeller blades and housing to insert four ¼" spacers—which



WATER PUMP. Engine 230

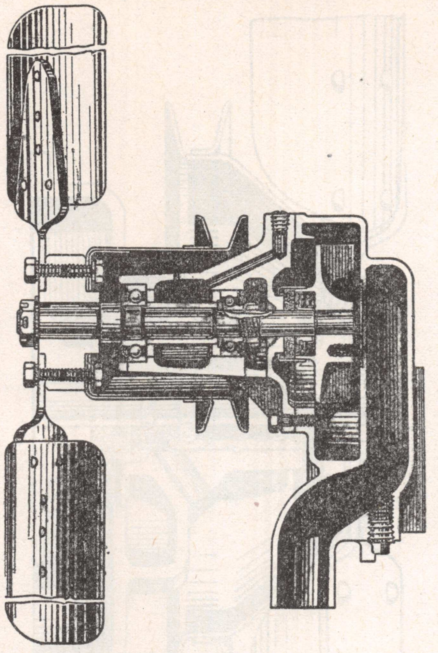
should be evenly spaced. These spacers are used to prevent damaging the graphite washer which acts as a seal.

Support forward end of body in an arbor press and press the shaft and bearing assembly through the impeller and housing.

NOTE—Since the pump shaft bearing is of the shielded type, packed with sufficient lubricant at the time of manufacture to last the life of the bearing, it should never be immersed in cleaning fluid, because this fluid will dissolve the lubricant, thereby quickly ruining the bearing when used in this condition. To clean the shaft and bearing, merely moisten a cloth with cleaning fluid and wipe away any foreign matter or surplus lubricant which may be present. However, when a new shaft and bearing assembly is installed, it is good practice to use a new pulley and hub because, frequently, the hub is damaged when removed from the original shaft.

To assemble, press fan pulley flange on shaft until hub or flange is flush with end of shaft. Press shaft into housing until bearing lock ring snaps in place in bearing race groove. Install packing parts in reverse order of removal. Support the flange end of the shaft on the flat bed of the arbor press and press impeller on shaft until the impeller is 1/32" below the surface of pump housing. Check this dimension by laying a straight-edge across the face of the housing and take a measurement from the impeller vanes on the hub to the straight-edge.

Complete the assembly by installing the cover, fan and pulley. However, before connecting the pump to the engine, install a new grommet in position in the cylinder head, as using the old grommet will very likely cause a leak to develop at this point.



WATER PUMP. Engine 239 on F-18 and F-18H Truck Models

228, 236, 248, 256, 270: Disassemble: Remove fan and pulley and pump cover. Use a suitable puller to remove hub from shaft. Pull off bearing retainer cap. Support front end of pump in an arbor press and push the shaft and bearing assembly out of the impeller and housing.

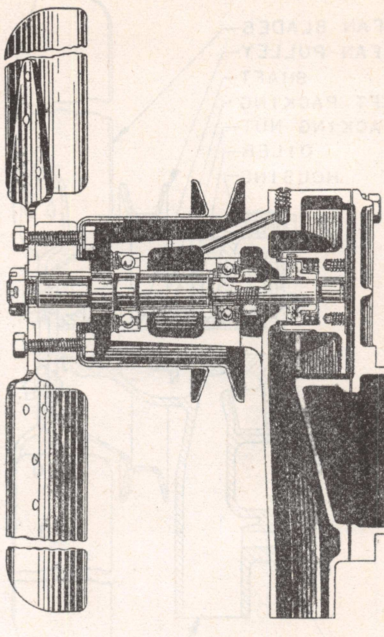
NOTE—Since the pump shaft bearing is of the shielded type, packed with sufficient lubricant at the time of manufacture to last the life of the bearing, it should never be immersed in cleaning fluid, because this fluid will dissolve the lubricant, thereby quickly ruining the bearing when used in this condition. To clean the shaft and bearing, merely moisten a cloth with cleaning fluid and wipe away any foreign matter or surplus lubricant which may be present. Whenever a new shaft and bearing assembly is installed, it is good practice to use a new pulley and hub because, frequently, the hub is damaged when removed from the original shaft.

The face of the housing, against which the graphite washer turns, should be smooth and free from scores. If required, take a light cut on the pump housing boss to smooth it up. Clean the housing and see that the drain hole between the seal and bearing is open.

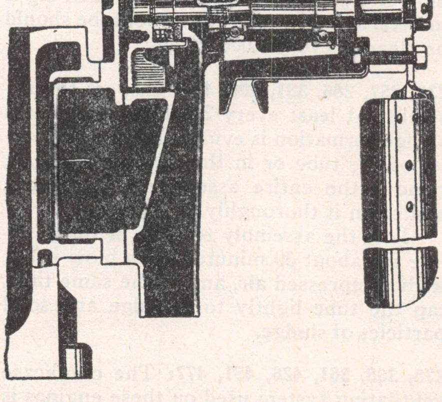
Assemble: Press shaft and bearing assembly into housing until the outer bearing race bottoms.

CAUTION—To prevent damaging the housing and bearing, support the housing under the shaft boss and apply pressure on the outer race of the bearing.

Press the bearing retainer into the pump housing. Install a new seal in the impeller and insert the graphite washer.



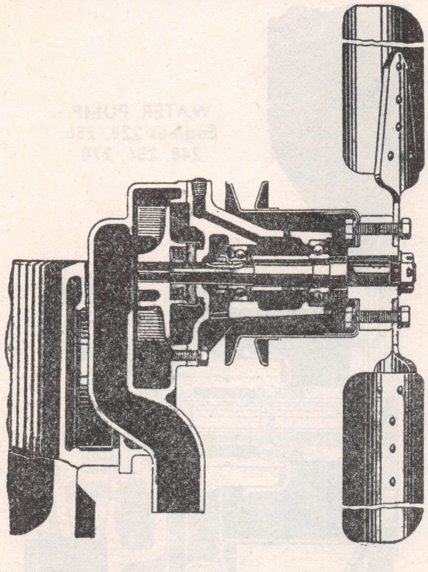
WATER PUMP. Engine 239 on T-18 and T-18H Truck Models



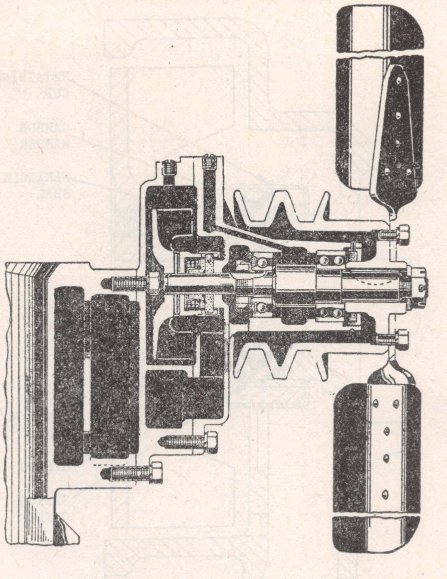
WATER PUMP. Engines 257 on Truck Model T-23 and Engine 286 on Truck Model T-33

NOTE—Assemble the seal so that the side with the identification mark is next to the washer, and apply a light film of water pump grease to the outer face of the graphite washer.

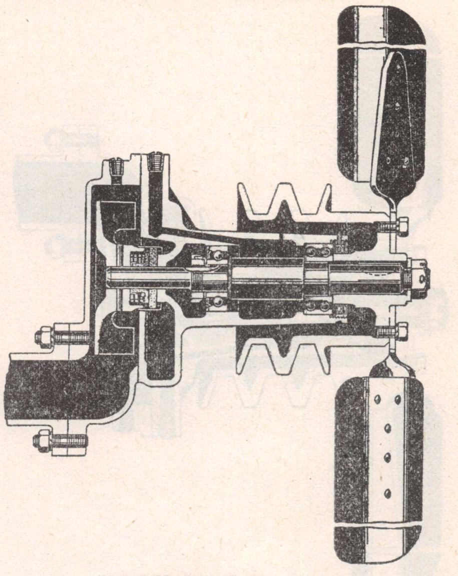
Lay the impeller on the flat surface of the arbor press and push the shaft and housing into the impeller, pressing on the shaft. When this is done, turn the assembly over on the press and push the impeller



WATER PUMP. Engine 257 on Truck Model F-23 and Engine 286 on Truck Model F-33



WATER PUMP. Engines 331, 400, 450 on Truck Models T-46 T-61 T-61H



WATER PUMP. Engine 331 on Truck Model F-46

into the housing until from .010" to .035" clearance is obtained between the inner edge of the impeller blades and the surface of the housing. Press the pulley on the shaft until its outer end is 4 9/32" from the impeller end of the housing, with the water pump cover and gasket removed. When installed, the pulley runout must not exceed .015".

239, 257, 278, 286, 308, 331, 361, 400, 426, 450, 451, 477: Pull the fan hub and pulley from the shaft. Take off the pump cover. Use a puller to remove impeller. Release outer bearing snap ring and press shaft and bearings out of the housing. Remove the seal and carbon washer from the impeller.

NOTE—Clean the bearings thoroughly and check for wear and roughness. Clean all traces of rubber or carbon from the shaft. The shaft may be smoothed out by taking a light grinding cut, but if it is scored or pitted excessively, install a new one.

Assemble: Lubricate bearings and install on shaft in original position, being sure the spacer is in place between the bearings. See that the vent hole in the body is open, then press shaft and bearings into the body from the front until the front bearing is seated on the shoulder of the body, after which, install a new snap ring. Lubricate the seal clamp ring with hard grease and assemble seal parts to the impeller in the following order: Seal spring, flexible seal with brass clamp ring and seal guide, carbon washer, and seal retaining snap ring. Assemble impeller and seal over end of shaft, pressing on impeller until the hub is flush with end of shaft.

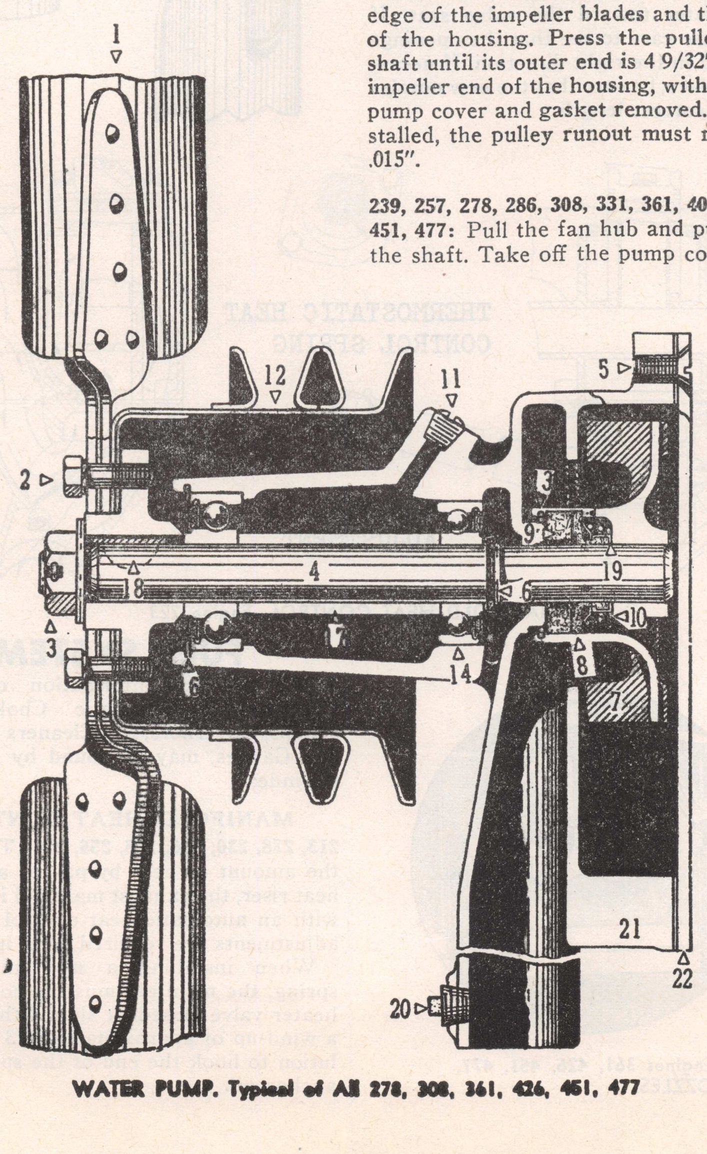
NOTE—Install the grease fitting in the pump body temporarily and apply water pump grease under light pressure until grease overflows.

CAUTION—To prevent ruining the seals, it is important that grease be not applied under heavy pressure.

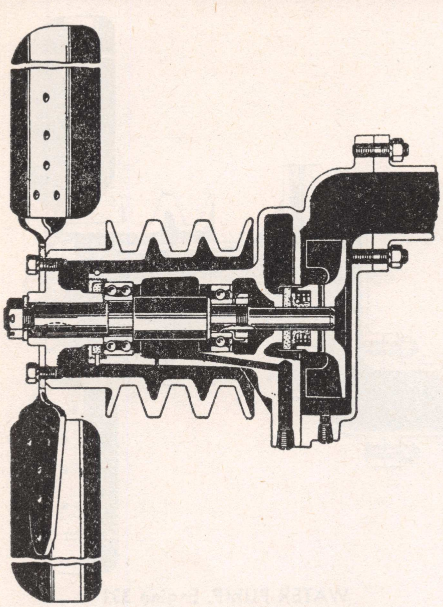
Press shaft into the fan hub, with flat end of hub toward front. Complete the assembly by replacing the hub retaining washer and nut, and the pump cover.

ENGINE WATER THERMOSTAT

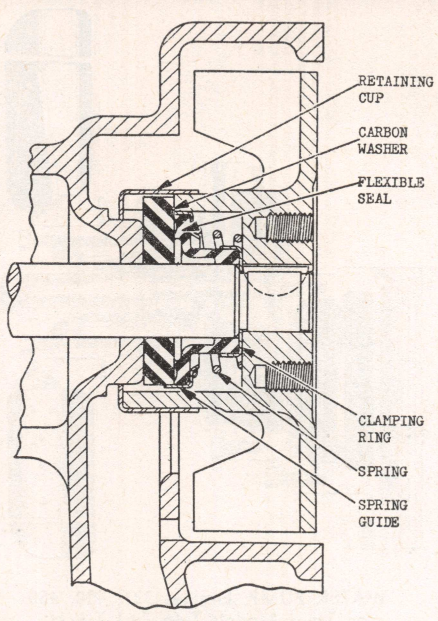
1936-46 All: If the thermostat is not functioning properly, remove the assembly from the water outlet and see if the bellows and valve are in good condition. If they are, test its operation by completely submerging it in water, heating the water gradually



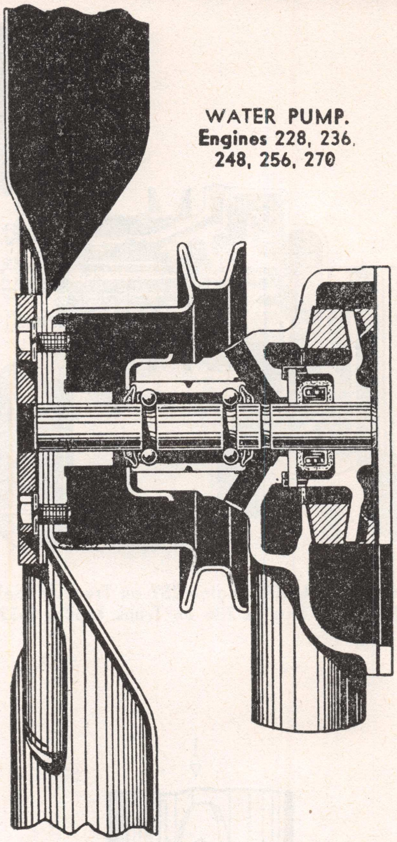
WATER PUMP. Typical of All 278, 308, 361, 426, 451, 477



WATER PUMP. Engines 400, 450 on Truck Models F-61, F-61H



Install Water Pump Seal Parts as Shown. Engines 331, 400, 450



WATER PUMP. Engines 228, 236, 248, 256, 270

until it reaches the opening temperature of the thermostat, and then in water at fully closed temperature.

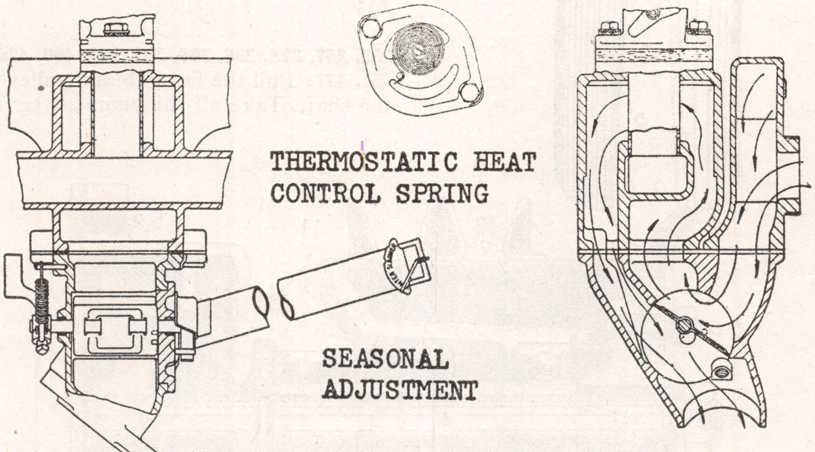
NOTE—When taking temperature readings, agitate the water thoroughly. And if the thermostat fails to function properly, it should be replaced rather than attempt to make a repair. However, before installing the new unit, it should be tested as directed above.

On all engines except 278, 308, 361, 426, 451 and 477, the thermostat should start to open at approximately 145 degrees, and be fully open at about 170 degrees. On 278, 308, 361, 426, 451 and 477 engines, the opening temperature is approximately 150 degrees, and should be fully open at about 173 degrees.

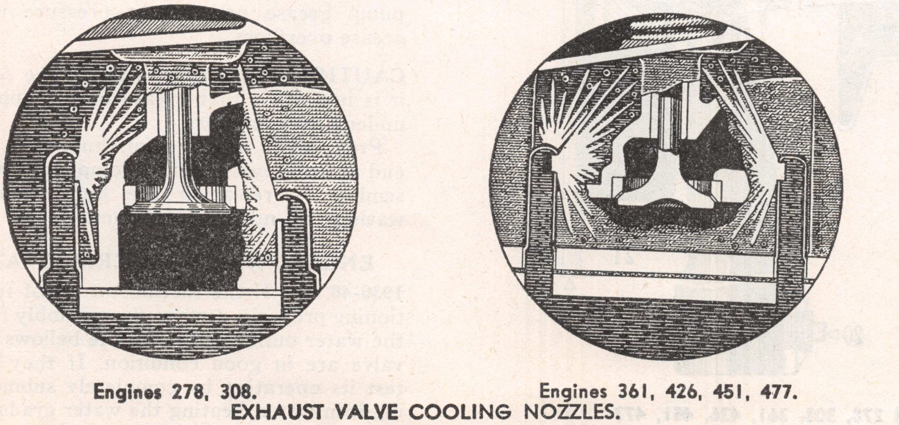
EXHAUST VALVE COOLING NOZZLES

213, 223, 230, 239, 257, 286, 331, 400, 450: Not used.

228 236, 248, 256, 270, 278, 308, 361, 426, 451, 477: Copper nozzles are installed in the cylinder head in such a manner that the opening near the upper end directs the flow of water toward the valve seat. If removed, use care to see that the openings are pointed in the right direction. If necessary to replace, be sure that the new nozzles are of the correct length.



MANIFOLD HEAT CONTROL. Engine 223



Engines 278, 308.

Engines 361, 426, 451, 477.

EXHAUST VALVE COOLING NOZZLES.

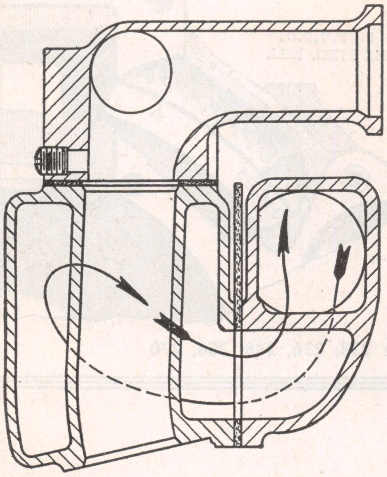
FUEL SYSTEM

NOTE—Service information concerning Carburetors, Automatic Chokes, Fuel Pumps, Governors, Air Cleaners and Gasoline Gauges, may be found by consulting the index.

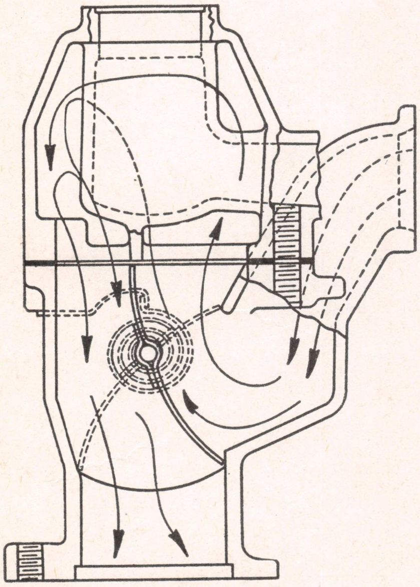
MANIFOLD HEAT CONTROL

213, 228, 230, 236, 248, 256, 270: To regulate the amount of heat by-passed around the heat riser, the exhaust manifold is equipped with an automatic heat control valve. No adjustments are required after installation.

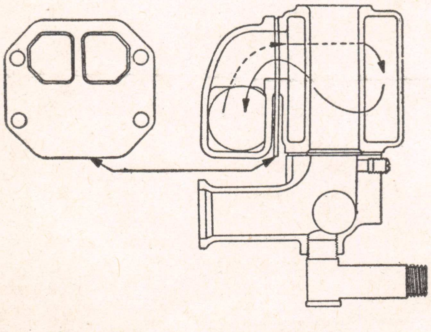
When installing a new thermostatic spring, the manifold must be cold and the heater valve closed. It should then require a wind-up of approximately 1/3 of a revolution to hook the end of the spring on its anchor pin.



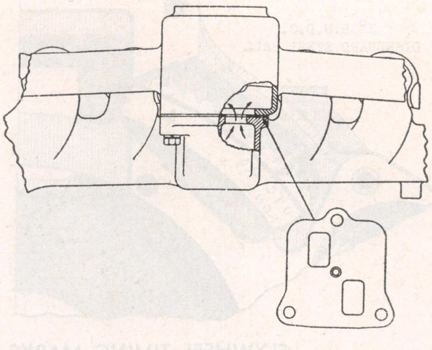
Showing Manifold Heat Control Gasket in Position. Engines 239, 257, 286, 400, 450 on F Model Trucks



MANIFOLD HEAT CONTROL. Engines 278 and 308 for 1939-40



Showing Position of Manifold Heat Control Baffle Plate During Cold Weather Operation. Engines 278, 308, 361, 426, 451, 477 on "AF" and "AY" Truck Models



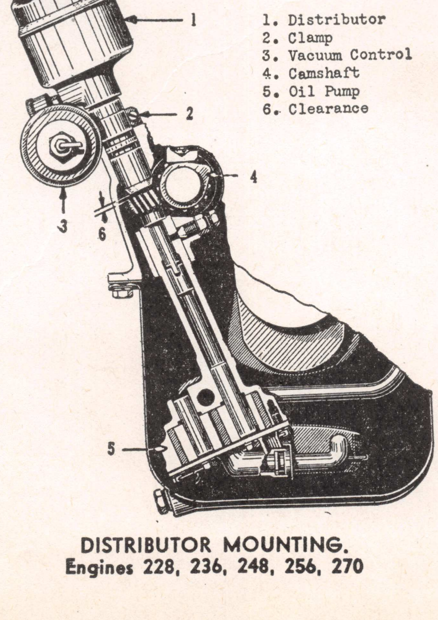
Showing Position of Manifold Heat Control Baffle Plate for Cold Weather Operation. Engines 278 and 308 on "AC" Truck Models

223: The operation of this valve is the same as described for 213 engine except that the thermostatic spring is cooled by a blast of air directed against it by a tube which draws air from behind the fan. The valve, which is located at the end of this tube, controls the air thrown against the thermostat, and can be set for seasonal requirements.

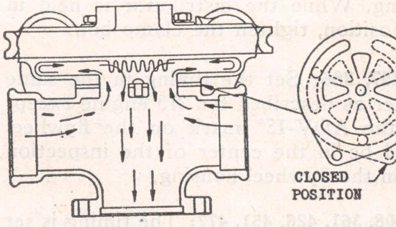
NOTE—Whenever the heat tube is removed, make sure the thermostat spring is in its proper place before replacing the tube.

239, 257, 286, 331, 400, 450: The operation of this valve is the same as described for 213 engine except on cab-over-engine models. On these latter vehicles, the flow of exhaust gas through the heat chamber is controlled by the position of the special gasket used at that point.

NOTE—In general, the gasket may be left in the position as shown in the illustration, but when operating continuously at extremely high atmospheric temperatures, it may be advisable to loosen the manifold and reverse this gasket so as to render the vaporizer inoperative.



DISTRIBUTOR MOUNTING. Engines 228, 236, 248, 256, 270



Showing Position of Manifold Heat Control Baffle During Cold Weather Operation. Engines 361, 426, 451, 477 on "AC" Truck Models

278, 308, 361, 426, 451, 477: See the illustrations for the correct positions for seasonal settings of the several manifold heat controls.

ELECTRIC SYSTEM

NOTE—Service information concerning Generators, Generator Regulators, Starters, Starter Controls, Distributors and Vacuum Controls, and Magnetos may be found by consulting the index.

IGNITION TIMING

213, 223, 230, 331, 400, 450: With the breaker gap set to the clearance given in the TUNE UP CHART, crank the engine to bring No. 1 piston up on its compression stroke and stop when the "IGN" mark on the flywheel (vibration damper on 213) is in line with the indicator.

Locate No. 1 spark plug wire on the distributor cap, place the cap in position on the distributor and mark the housing opposite No. 1 terminal so that its relative position will be known when the cap is removed.

With the octane selector set midway between advance and retard, loosen the distributor body clamp and rotate the distributor until the points close. Then rotate the distributor in the opposite direction until the points just begin to open. Tighten the clamp bolt.

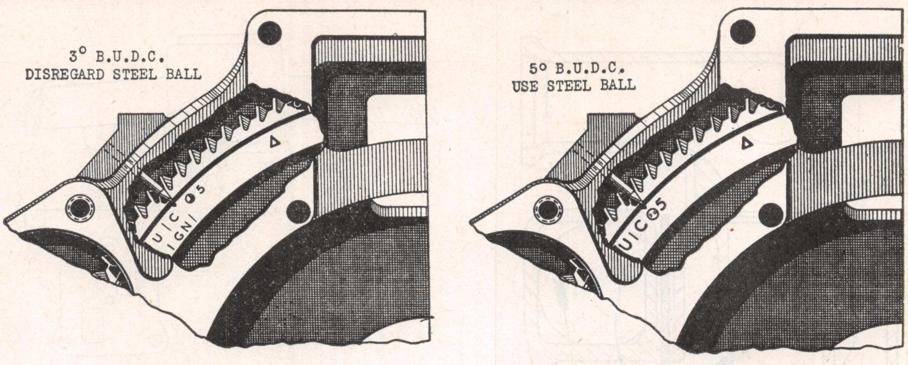
NOTE—For best results, use a Neon timing light or a conventional test lamp to check the timing. Advance or retard the octane selector to compensate for the grade of fuel being used. For best performance and fuel economy, this setting should be one which will provide smooth engine performance with a slight "ping" on wide-open throttle at comparatively low vehicle speed.

228, 236, 248, 256, 270: The ignition timing is set in the same manner as described for 213 engine except that the ignition mark is ahead of the steel ball on the flywheel. However, see the TUNE UP CHART for engines using 5 degree timing, and on these engines, use the steel ball for timing.

NOTE—After setting the timing, but before tightening the distributor clamp bolt, remove the distributor cap and press down on the rotor, and, at the same time, raise the housing 1/32". This will equalize the clearance at the top and bottom of the housing. While the distributor is held in this position, tighten the clamp bolt.

239, 257, 286: Set the timing in the same manner as described for 213 engine except that the ADV-15° mark on the flywheel should be in the center of the inspection hole in the flywheel housing.

278, 308, 361, 426, 451, 477: The timing is set in the same manner as described for 213 engines except that the line between the UDC and IGN marks on the flywheel should be in line with the pointer on the flywheel housing.



FLYWHEEL TIMING MARKS. Engines 228, 236, 248, 256, 270

HERCULES GASOLINE ENGINES

Year	Engine Model	Number Cylinders and Valve Arrangement	Bore and Stroke	Displacement Cubic Inches	Compression Ratio	Taxable H. P.	Brake H. P. at R. P. M.	Maximum Torque at R. P. M. Pounds Feet	Oil Capacity Quarts ①
1936-46	HXB	6-L	5x6	707	5.75	60.00	148@2000	502@900	20
1936-46	HXC	6-L	5¼x6	779	5.69	66.15	164@2000	550@1000	20
1936-46	HXD	6-L	5½x6	855	5.73	72.60	180@2000	630@900	20
1936-46	HXE	6-L	5¾x6	935	5.50	79.35	198@2000	695@900	20
1936-46	IX	4-L	2½x4	78.5	5.20	10.00	28@3200	55@2000	2½
1936-46	IXA-3	4-L	3x4	113	5.50	14.40	40@3200	79@2000	2½
1936-46	IXA-5	4-L	3x4	113	5.50	14.40	40@3200	79@2000	2½
1936-46	IXB-3	4-L	3¼x4	133	5.20	16.90	47@3200	92@2000	2½
1936-46	IXB-5	4-L	3¼x4	133	5.20	16.90	47@3200	92@2000	2½
1936-46	JXA	6-L	3⅜x4¼	228	5.16	27.34	63@2800	141@1000	6
1936-46	JXB	6-L	3⅝x4¼	263	5.40	31.54	68@2800	195@1000	6
1936-46	JXC	6-L	3¾x4¼	282	5.90	33.75	73@2800	215@1000	6
1936-46	JXD	6-L	4x4¼	320	6.50	38.40	84@2800	243@1200	6
1941-46	JXE	6-L	3½x4¼	246	6.11	29.40	79@3000	169@1000	6
1941-46	JXF	6-L	3 13/32x4¼	232	6.16	17.84	75@3000	151@1200	6
1941-46	JXG	6-L	3½x4¼	246	6.11	29.40	79@3000	169@1000	6
1936-44	OOA	4-L	3½x4½	173	4.20	19.60	35@2000	107@1200	4
1936-44	OOB	4-L	3¾x4½	199	4.20	22.50	38@2000	125@1000	4
1936-44	OOC	4-L	4x4½	226	4.20	25.60	41@2000	143@1000	4
1936-43	OX	4-L	4x5	251	4.30	25.60	46@2000	155@1000	6
1936-43	OXC	4-L	4¼x5	284	4.30	28.90	56@2000	185@1000	6
1936-46	QXA	6-L	3⅛x4⅛	190	5.50	23.44	60@3400	130@1000	6
1936-46	QXB	6-L	3¼x4⅛	205	5.85	25.35	67@3500	150@1000	6
1936-46	QXC	6-L	3⅜x4⅛	221	5.85	27.34	70@3400	159@1000	6
1940-46	QXD	6-L	3 7/16x4⅛	230	6.50	28.36	73@3000	171@1100	6
1936-46	RXB	6-L	4½x5¼	501	5.41	48.60	110@2200	362@1100	10
1936-46	RXC	6-L	4⅝x5¼	529	5.41	51.34	115@2200	395@1000	10
1940-46	RXLC	6-L	4⅝x5¼	529	6.20	51.34	135@2200	413@1000	13
1940-46	RXLD	6-L	4¾x5¼	558	6.20	54.15	142@2200	438@1000	13
1936-46	WXC	6-L	4x4½	339	5.96	38.40	94@2800	255@1100	7
1936-46	WXC-2	6-L	4⅛x4½	361	5.96	40.84	100@2800	271@1100	7
1936-46	WXC-3	6-L	4¼x4½	383	5.96	43.35	106@2800	288@1100	7
1936-46	WXLC	6-L	4x4¾	358	6.29	38.40	104@2800	268@1100	7
1936-46	WXLC-3	6-L	4¼x4¾	404	6.29	43.35	118@2800	302@1000	7
1936	YXB	6-L	4x4¾	358	4.40	38.40	80@2200	231@1000	10
1936-45	YXC	6-L	4⅜x4¾	428	6.29	45.94	94@2200	335@1150	10
1936-45	YXC-2	6-L	4½x4¾	453	6.29	48.60	98@2200	357@1100	10
1936-45	YXC-3	6-L	4⅝x4¾	479	6.29	51.34	104@2200	374@1100	10

① Capacity shown for each model is to be considered in a general nature due to special oil pan installations. Always be guided by the markings on the oil level dip-stick rather than the quantity shown in the chart.

NOTE—For Tune Up Chart on these engines, see page 913.
NOTE—For Hercules engines developed since 1942, see page 915.

VALVE SYSTEM

Year	Engine Models	Stem Clearance		Tappet Guide Clearance	Tappet Clearance				Valve Spring Pressure Test		Valve Seat Angle Degrees
					Running, Hot		Timing				
		Intake	Exhaust		In-take	Ex-haust	In-take	Ex-haust	Free Length, Inches	Pounds at Inches, Length	
1936–46	HX	.002–.003	.002–.003	.001–.0015	.010	.016	.008	.014	---	③84@$3\frac{5}{8}$ ④45@$2\frac{15}{16}$	45①
1936–46	IX	.001–.0015	.001–.0015	.0008–.001	.006	.008	.006	.008	---	42@$1\frac{3}{16}$	30
1936–46	JX	.001–.0015	.001–.0015	.0008–.001	.008	.010	.008	.010	---	58@$1\frac{19}{32}$	45
1936–44	OO	.001–.0015	.001–.0015	.0008–.001	.008	.012	.008	.012	---	58@$1\frac{19}{32}$	45
1936–43	OX	.001–.0015	.001–.0015	.0008–.001	.008	.012	.008	.012	---	102@$2\frac{5}{32}$	45
1936–46	QX	.001–.0015	.001–.0015	.0008–.001	.008	.010	.008	.010	---	⑤	45
1936–46	RX	.0015–.002	.0015–.002	.0008–.001	.006	.010	.006	.010	---	102@$2\frac{5}{32}$	45
1936–46	RXL	.002–.003	.002–.003	.0008–.001	.006	.010	.006	.010	---	102@$2\frac{5}{32}$	45②
1936–46	WX	.001–.0015	.001–.0015	.0008–.001	.006	.010	.006	.010	---	102@$2\frac{5}{32}$	45
1936–45	YX	.0015–.002	.0015–.002	.0008–.001	.006	.010	.006	.010	---	102@$2\frac{5}{32}$	45

① A few early engines had 30-degree seats.

② Some RXLD engines had 30-degree intake seats.

③ Outer.

④ Inner.

⑤ Below 1600 R. P. M., 41@$1\frac{9}{32}$; above 1600 R. P. M., 37@$1\frac{9}{32}$.

PISTON AND RING CLEARANCES

Year	Engine Model	Piston Skirt, Inches		Fitting Pistons with Shim and Spring Scale		Ring End Gap, Inch ①		Ring and Groove, Inch	
		Top	Bottom	Shim Thickness	Pounds Pull on Scale	Com-pression	Oil	Com-pression	Oil
1936–46	HXB	.005	.005	.005⑧	.0055⑨	.020–.022	.020–.022	.0008–.0015	.0008–.0015
1936–46	HXC	.006	.006	.006⑧	.0065⑨	.020–.022	.020–.022	.0008–.0015	.0008–.0015
1936–46	HXD	.0065	.0065	.0065⑧	.007⑨	.020–.022	.020–.022	.0008–.0015	.0008–.0015
1936–46	HXE	.007② .0055③	.007② .0055③	.007④ .0055⑤	.0075⑥ .006⑦	.020–.022	.020–.022	.0008–.0015	.0008–.0015
1936–46	IX	.002	.002	.002⑧	.0025⑨	.015–.020	.015–.020	.0015–.0025	.0015–.0025
1936–46	IXA	.0025	.0025	.0025⑧	.003⑨	.015–.020	.015–.020	.0015–.0025	.0015–.0025
1936–46	IXB	.0025② .003③	.0025② .003③	.0025④ .003⑤	.003⑥ .0035⑦	.015–.020	.015–.020	.0015–.0025	.0015–.0025
1936–46	JXA	.0025② .003③	.0025② .003③	.0025④ .003⑤	.003⑥ .0035⑦	.015–.020	.015–.020	.0015–.003	.0015–.003
1936–46	JXB	.003② .0035③	.003② .0035③	.003④ .0035⑤	.0035⑥ .004⑦	.015–.020	.015–.020	.0015–.003	.0015–.003
1936–46	JXC	.003② .0035③	.003② .0035③	.003④ .0035⑤	.0035⑥ .004⑦	.015–.020	.015–.020	.0015–.003	.0015–.003
1936–46	JXD	.003② .0035③	.003② .0035③	.003④ .0035⑤	.0035⑥ .004⑦	.015–.020	.015–.020	.0015–.003	.0015–.003
1941–46	JXE	.0025② .003③	.0025② .003③	.0025④ .003⑤	.003⑥ .0035⑦	.015–.020	.015–.020	.0015–.003	.0015–.003
1941–46	JXF	.0025② .003③	.0025② .003③	.0025④ .003⑤	.003⑥ .0035⑦	.015–.020	.015–.020	.0015–.003	.0015–.003
1941–46	JXG	.0025② .003③	.0025② .003③	.0025④ .003⑤	.003⑥ .0035⑦	.015–.020	.015–.020	.0015–.003	.0015–.003
1936–44	OOA	.0025② .003③	.0025② .003③	.0025④ .003⑤	.003⑥ .0035⑦	.015–.020	.015–.020	.0008–.0015	.0008–.0015
1936–44	OOB	.003② .0035③	.003② .0035③	.003④ .0035⑤	.0035⑥ .004⑦	.015–.020	.015–.020	.0008–.0015	.0008–.0015

NOTE—For Hercules engines developed since 1942, see page 915.

Continued on next page

Continued from previous page

PISTON AND RING CLEARANCES

Year	Engine Model	Piston Skirt, Inches		Fitting Pistons with Shim and Spring Scale		Ring End Gap, Inch ①		Ring and Groove, Inch	
		Top	Bottom	Shim Thickness	Pounds Pull on Scale	Com-pression	Oil	Com-pression	Oil
1936–44	OOC	.003② .0035③	.003② .0035③	.003④ .0035⑤	.0035⑥ .004⑦	.015–.020	.015–.020	.0008–.0015	.0008–.0015
1936–43	OX	.004	.004	.004⑤	.0045⑦	.015–.020	.015–.020	.0008–.0015	.0008–.0015
1936–43	OXC	.004	.004	.004⑤	.0045⑦	.015–.020	.015–.020	.0008–.0015	.0008–.0015
1936–46	QXA	.0025② .003③	.0025② .003③	.0025④ .003⑤	.003⑥ .0035⑦	.015–.020	.015–.020	.0015–.003	.0015–.003
1936–46	QXB	.0025② .003③	.0025② .003③	.0025④ .003⑤	.003⑥ .0035⑦	.015–.020	.015–.020	.0015–.003	.0015–.003
1936–46	QXC	.0025② .003③	.0025② .003③	.0025④ .003⑤	.003⑥ .0035⑦	.015–.020	.015–.020	.0015–.003	.0015–.003
1940–46	QXD	.0025② .003③	.0025② .003③	.0025④ .003⑤	.003⑥ .0035⑦	.015–.020	.015–.020	.0015–.003	.0015–.003
1936–46	RXB	.004② .0055③	.004② .0055③	.004④ .0055⑤	.0045⑥ .006⑦	.015–.020	.015–.020	.0015–.003	.0015–.003
1936–46	RXC	.004② .006③	.004② .006③	.004④ .006⑤	.0045⑥ .0065⑦	.015–.020	.015–.020	.0015–.003	.0015–.003
1940–46	RXLC	.004② .006③	.004② .006③	.004④ .006⑤	.0045⑥ .0065⑦	.015–.020	.015–.020	.002–.0035	.002–.0035
1940–46	RXLD	.004② .0065③	.004② .0065③	.004④ .0065⑤	.0045⑥ .007⑦	.015–.020	.015–.020	.002–.0035	.002–.0035
1936–46	WXC	.0035② .004③	.0035② .004③	.0035④ .004⑤	.004⑥ .0045⑦	.015–.020	.015–.020	.0015–.003	.0015–.003
1936–46	WXC-2	.0035② .004③	.0035② .004③	.0035④ .004⑤	.004⑥ .0045⑦	.015–.020	.015–.020	.0015–.003	.0015–.003
1936–46	WXC-3	.0035② .0045③	.0035② .0045③	.0035④ .0045⑤	.004⑥ .005⑦	.015–.020	.015–.020	.0015–.003	.0015–.003
1936–46	WXLC	.0035② .004③	.0035② .004③	.0035④ .004⑤	.004⑥ .0045⑦	.015–.020	.015–.020	.0015–.003	.0015–.003
1936–46	WXLC-3	.0035② .0045③	.0035② .0045③	.0035④ .0045⑤	.004⑥ .005⑦	.015–.020	.015–.020	.0015–.003	.0015–.003
1936	YXB	.0035② .004③	.0035② .004③	.0035④ .004⑤	.004⑥ .0045⑦	.015–.020	.015–.020	.0015–.003	.0015–.003
1936–45	YXC	.0035② .0055③	.0035② .0055③	.0035④ .0055⑤	.004⑥ .006⑦	.015–.020	.015–.020	.0015–.003	.0015–.003
1936–45	YXC-2	.004② .0055③	.004② .0055③	.004④ .0055⑤	.0045⑥ .006⑦	.015–.020	.015–.020	.0015–.003	.0015–.003
1936–45	YXC-3	.004② .006③	.004② .006③	.004④ .006⑤	.0045⑥ .0065⑦	.015–.020	.015–.020	.0015–.003	.0015–.003

① End gaps are for cylinder bores without taper. Fit rings in tapered bores with not less than the maximum dimension given.

② For aluminum pistons.

③ For cast iron pistons.

④ Aluminum piston should pass on shim thickness shown.

⑤ Cast iron piston should pass on shim thickness shown.

⑥ Aluminum piston should lock on shim thickness shown.

⑦ Cast iron piston should lock on shim thickness shown.

⑧ Piston should pass on shim thickness shown.

⑨ Piston should lock on shim thickness shown.

NOTE—For Hercules engines developed since 1942, see page 915.

ENGINE BEARING SPECIFICATIONS

Year	Engine Model	Camshaft		Connecting Rod			Mains				
		Journal Diameter	Clearance	Journal Diameter	Clearance	Bearing Bolt Tension Lb. Ft.	Journal Diameter	Clearance	Bearing Bolt Tension Lb. Ft.	Thrust on No.	End-play
1936–46	HX	2⅜	.0015–.0025	2.997–2.998	.002–.0025	263	3.497–3.498	.003–.0035	210① 193②	7	.003–.004
1936–46	IX	1 7/16	.0015–.0025	1.747–1.748	.001–.0015	42	1.987–1.988	.002–.0025	77	3	.002–.004
1936–46	JX	2 1/16	.0015–.0025	1.987–1.988	④	53	2.497–2.498	③	70① 59½②	7	.002–.004
1936–44	OO	1 15/16	.0015–.0025	1.987–1.988	.001–.0015	53	1.987–1.988	.002–.0025	105	3	.002–.004
1936–43	OX	1 15/16	.0015–.0025	1.987–1.988	.002–.0025	56	1.987–1.988	.002–.0025	105	3	.002–.004
1936–46	QX	1¾	.0015–.0025	1.987–1.988	④	38½	2.497–2.498	.0015–.002	70① 59½②	7	.002–.004
1936–46	RX	2⅛	.0015–.0025	2.622–2.623	.0015–.002	105	2.997–2.998	.0025–.003	122½① 105②	7	.003–.005
1936–46	RXL	2⅛	.0015–.0025	2.997–2.998	.003–.0045	157½	3.497–3.498	.0045–.0055	175	7	.003–.005
1936–46	WX	2⅛	.0015–.0025	2.247–2.248	.0015–.002	63	2.622–2.623	.002–.003	105① 70②	7	.003–.005
1936–45	YX	2⅛	.0015–.0025	2.247–2.248	.0015–.002	105	2.997–2.998	.0025–.003	122½① 105②	7	.003–.005

① Front and intermediates.

② Center and rear.

③ Babbitt, .0015″–.002″; precision insert bearings, .0025″–.0035″.

④ Babbitt, .001″–.0015″; precision insert bearings, .0015″–.002″.

ENGINE

CYLINDER HEAD

1936-46 ALL: As no particular tightening sequence is recommended by the manufacturer, the cylinder head should be tightened down starting from the center, working outward toward the sides and to the ends. Draw down the nuts and bolts evenly and repeat the operation until all are normally tight. After the engine has been run sufficiently long to bring all the parts to normal operating temperature, a final tightening should be made.

When using a torque indicating wrench, the final tightening should be 52½ pounds feet on JX, QX, RX, WX and YX; 42 pounds feet on IX, O, OO and OX, and 73½ pounds feet on RXL.

CAUTION—When using a torque wrench, be sure the bolts and nuts are free from rust or dirt, otherwise a false reading will be obtained due to the increased friction.

NOTE—On HX series, whenever one head is removed, the stud nuts on the other head should be loosened to prevent the possibility of distortion. The final tightening on these heads should be made with a 14″ wrench.

ROCKER ARMS & PUSH RODS

1936-46: On overhead valve engines, it is good practice to remove the push rods before taking off the cylinder head to prevent the push rods from bending or twisting. Likewise, when installing the head, replace the push rods after the head is in position.

Whenever the rocker shaft is disassembled, place all parts on the bench in their relative position to assure correct assembly. And before assembling the rocker arms, be sure the faces are free from pits or rough spots, otherwise it will be difficult to maintain the proper tappet clearance.

VALVE STEM GUIDES

1936-46 ALL: When necessary to replace guides on L-head engines, run the tappet adjusting screw all the way down and crank the engine to bring the tappet on the low point of the cam. Then use a suitable drift, preferably one having a pilot the same size as the valve stem, to drive out the guide. If the guide comes in contact with the tappet before it is all the way out, break off the lower part.

NOTE—Install one guide at a time and measure the position of one which has not been removed to determine the correct depth of the guide being installed.

When installed, ream the guides to provide a clearance within the limits given in the VALVE SYSTEM table.

NOTE—On OX engines, the guides have shoulders at the top which must be broken off before the guides can be driven out. To do this, remove the manifold and use a chisel, working through the valve ports.

On IX-5 engines, two types of valve guides have been used. Engines having the type oil pressure regulator which is built into the cylinder block use guides with an outside diameter of .485″. Engines having the type oil pressure regulator which is a separate assembly use guides with an outside diameter of .532″.

VALVE TAPPETS & GUIDES

HX, RX, RXL, WX, YX: The tappets must be a free fit in their guides without excessive side play. If the fit is too loose, remove the guide cluster from the engine, take out the loose tappet, ream the guide hole and install an oversize tappet, being sure the tappet is provided with a clearance within the limits given in the VALVE SYSTEM table.

NOTE—If all or most of the tappets are too loose a fit, install a new cluster and standard size tappets.

IX: Tappets must be a free fit in their guides without excessive side play. If the fit is too loose, the guides should be reamed and oversize tappets fitted to provide a clearance within the limits given in the VALVE SYSTEM table.

To remove tappets, the camshaft will have to be taken out and, if the available reaming equipment requires the removal

NOTE—For Hercules engines developed since 1942, see page 915.

of valve stem guides, be sure to install new guides rather than attempt to make use of the old ones.

JX, QX, OO, OX: Tappet guides in these engines are removable bushings pressed in the block. When necessary to replace, the camshaft will have to be removed and the old bushings pressed out and new ones installed. Then ream the bushings to provide a clearance within the limits given in the VALVE SYSTEM table.

VALVE TIMING

1936-46 ALL: Valve timing is correct when the punch marks on the camshaft and crankshaft gears are meshed.

NOTE—When checking valve opening or closing in degrees of crankshaft travel, do so when the engine is at normal room temperature, and set the tappet clearance for timing as given in the VALVE SYSTEM table.

TIMING GEARS & COVER

1936-46. CAMSHAFT GEAR, ALL: On all engines except HX series, the camshaft must be removed in order to install a new camshaft gear. This is done by removing the gear cover, crankshaft oil slinger, oil pan, the oil pump (on engines where the oil pump is driven from the center of the camshaft), the valves, and lift the tappets up out of the way to prevent interference as the camshaft is being withdrawn.

On HX series, the cam gear can be removed by using a suitable puller, making use of the tapped screw holes in the gear, which are provided for that purpose.

NOTE—On IX and QX series, the cam gear can only be pressed on from the rear against the flange on the front of the shaft.

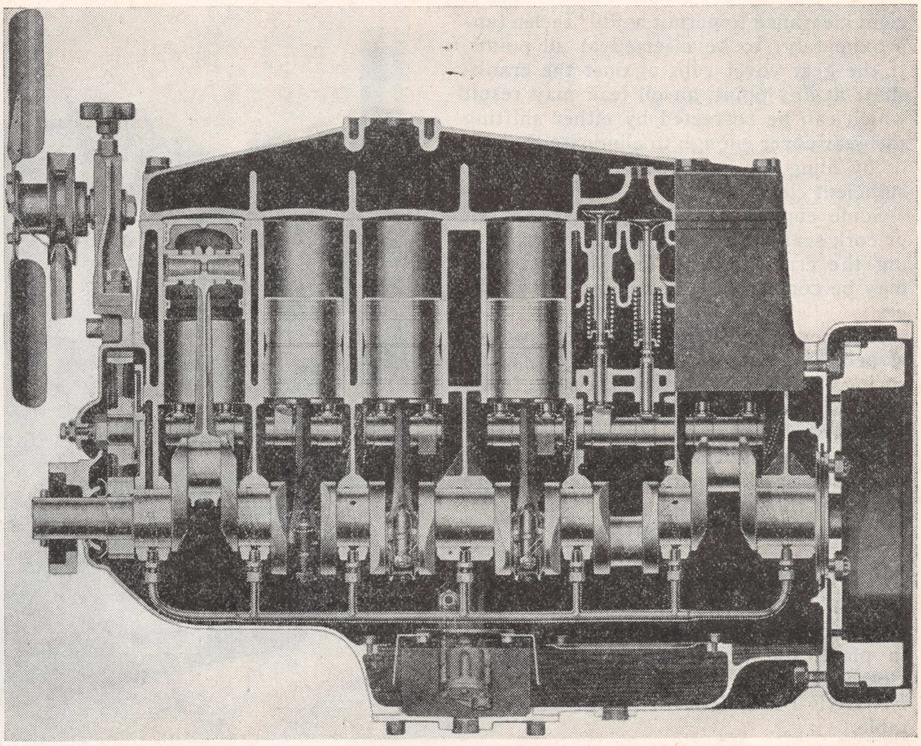
On all except the HX series, the cam gear is pressed on from the front and retained by a nut. Since no provision is made to pull the gear from the camshaft with the shaft in place, the shaft and gear will have to be removed from the engine, and the gear pressed off and on in an arbor press.

CRANKSHAFT GEAR, ALL: Since the crank gear will very likely be damaged when removed, a new one should be installed, and when doing so, heat the gear in boiling water to expand the metal and coat the shaft with white lead in order to make assembly easier.

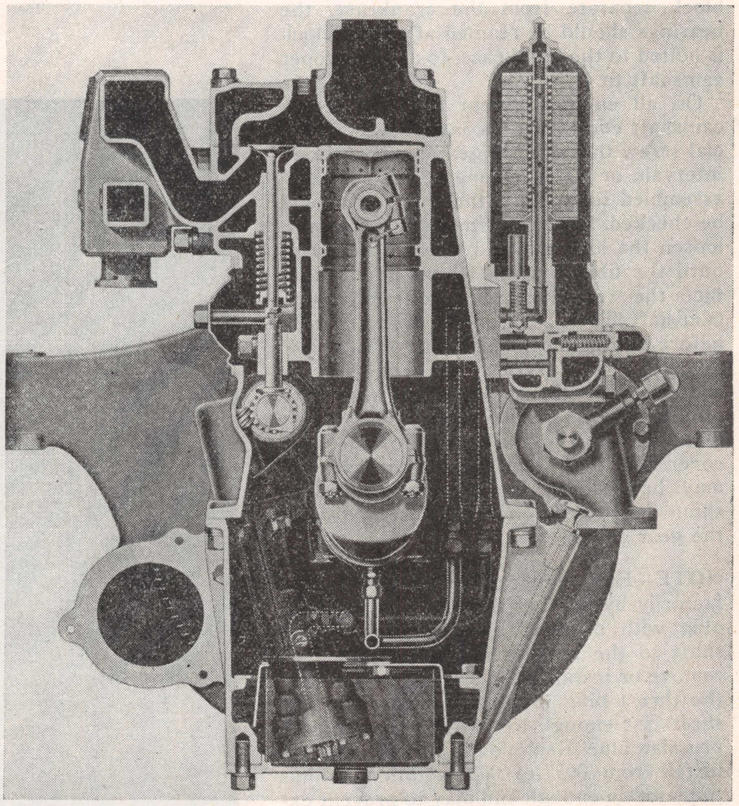
NOTE—With the camshaft and crankshaft gears installed, be sure that the punchmarks on these gears are meshed.

IDLER GEAR, ALL: The idler gear and shaft may easily be removed by pulling it forward out of the case. On IX, JX, QX series, the gear can only be pressed on from the rear against the flange on the front of the shaft.

NOTE—After engine number 227680 on the OO series, the idler bearing, shaft and gear are drilled to distribute oil to the timing gears. These parts may be used in earlier engines. Do not use parts which are not drilled in any engine after the above engine number.



WX SERIES. Side sectional view.



WX SERIES. End sectional view.

ACCESSORY DRIVE GEAR, ALL: The accessory drive shaft is supported in a removable sleeve casting bolted to the crankcase. This drive is variously used to drive a water pump and distributor or magneto. It is not necessary to remove the timing gear cover to remove this assembly.

GEAR COVER OIL LEAKS, ALL: To prevent oil leaks, the outside of the crankshaft and the boss of the gear cover (and oil pan on some engines) must have sufficient clearance to permit a .010" feeler (approximately) to be inserted at all points. If the gear cover rubs against the crankshaft at any point, an oil leak may result which can be corrected by either shifting the gear cover enough to eliminate the rub, or by filing the gear cover boss to obtain sufficient clearance.

Some engines are equipped with a felt or cork seal washer in the cover surrounding the crankshaft. A leak at this point may be corrected by installing new washers.

Another type of installation consists of a special leather held to the shaft by a coil spring. Should this leather become badly worn or coated over, install a new seal. If a steel enclosed type seal is used, care must be exercised to see that the contact edge is not nicked or turned back; be sure also, that the hole in the gear cover is concentric with the crankshaft.

CAMSHAFT & BEARINGS

1936-46 ALL: When necessary to renew camshaft bearings, they should be pressed in place and line reamed to provide a clearance within the limits given in the ENGINE BEARING SPECIFICATIONS table.

NOTE—On engines having the cylinder block separate from the crankcase, the bearings should be reamed **after** the block is bolted to the crankcase, to assure proper camshaft fit.

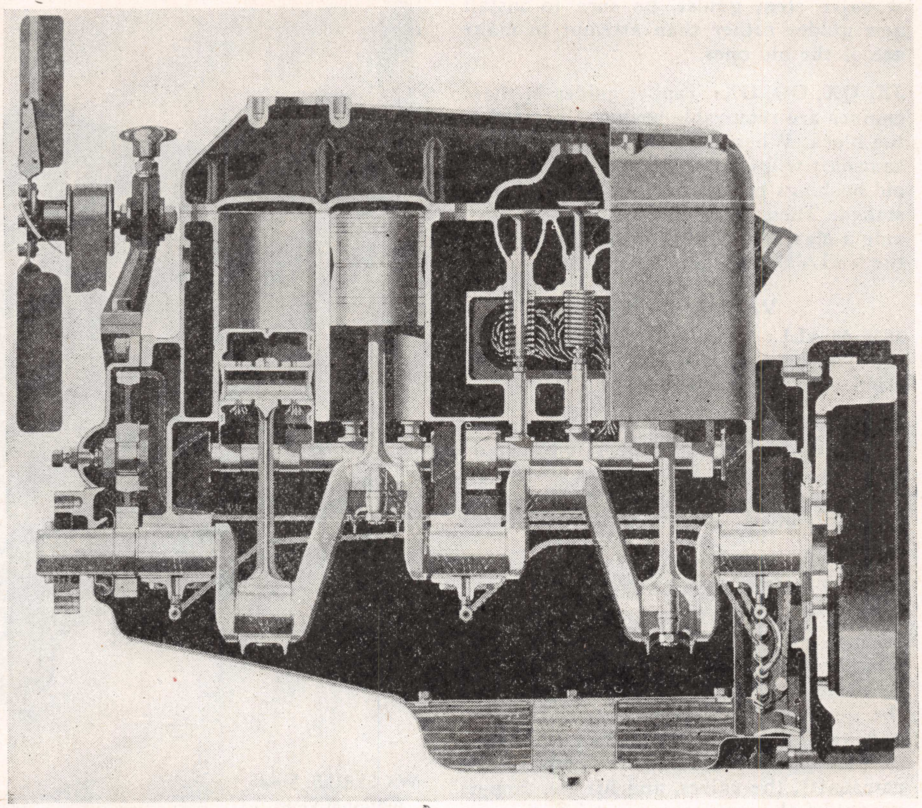
On all engines except the HX series, camshaft end thrust is controlled by a special screw through the gear cover. At long intervals, or when the engine has been disassembled for repairs, the end play should be checked. If an adjustment is necessary, loosen the lock nut and tighten the screw until the fibre plug in its inner end contacts the steel plug in the front end of the camshaft. Then back off the screw 1/8 turn before tightening the lock nut.

On the HX series, the end play is controlled by thrust plates to which are pinned bronze thrust plugs. The thrust plate is bolted to the outside of the gear cover and, if the end play is too great, it may be reduced by removing sufficient shims from between the thrust plate and the gear cover.

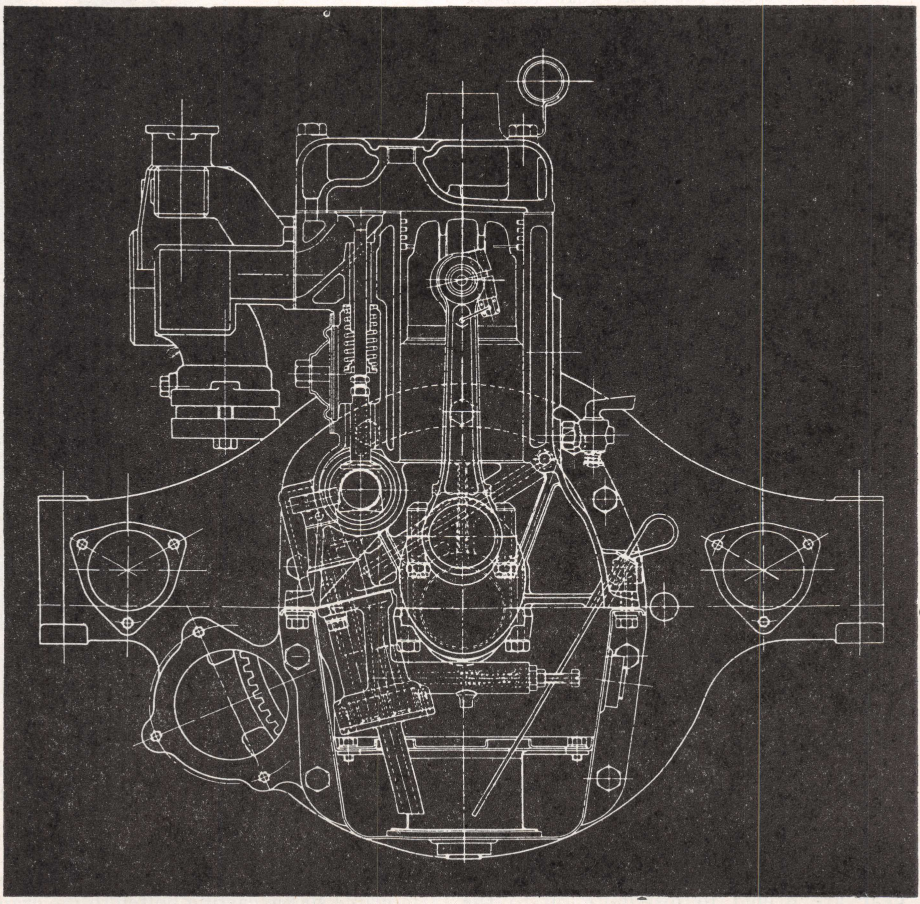
NOTE—End play can be checked satisfactorily by coating the end of the thrust plug with prussian blue. Then push the shaft to the rear as far as possible, and remove or install sufficient shims to permit the thrust plug to contact the end of the shaft just enough to transfer some of the prussian blue. Remove the thrust plate and install from .005" to .008" additional shims to maintain enough end play to prevent excessive pressure between the contacting surfaces, and to allow for heat expansion.

IDLER & ACCESSORY SHAFTS

1936-46 ALL: End thrust in these shafts is controlled in the same manner as described for the camshaft, and if an adjustment is required, the same procedure should be followed.



OX SERIES. Side sectional view.



JX SERIES. QX series is similar.

NOTE—For Hercules engines developed since 1942, see page 915.

PISTONS & RODS, REMOVE

1936-46 ALL: The piston and rod assemblies are removed from the top of the block. Although regular production rods are generally marked with the cylinder number in which they are installed, replacement rods are not; therefore, unmarked rods should be suitably identified with punch marks, as removed.

PISTON & ROD, ASSEMBLE

1936-46 ALL: Aluminum pistons should be assembled to the rods so that when installed in the cylinder bores, the slotted side of the piston must be on the left side or opposite the camshaft.

PISTONS, RENEW

1936-46 ALL: NOTE—A variation of 10 degrees between the temperature of the pistons and cylinder bores is sufficient to produce a difference of .0005". Therefore, both the pistons and cylinder bores should be at normal room temperature (about 70 degrees) when fitting pistons.

Before any attempt is made to fit new pistons, cylinder bores should be carefully indicated and refinished. If bores do not require refinishing, be sure to remove the ridge at the top of each bore. If refinishing is required, it is good practice to do so in alternate cylinders due to the localized temperature build-up. Cylinder bores should not be out-of-round or tapered more than .0005".

Before fitting pistons, wipe the cylinder walls and pistons to remove all chips, dirt or other foreign matter. The feeler ribbon used to check piston fit may be about 12" long and ½" wide. Consult the PISTON & RING CLEARANCES table for the thickness of shim to use, as well as the recommended pounds pull on a spring scale required to withdraw the feeler ribbon past the piston.

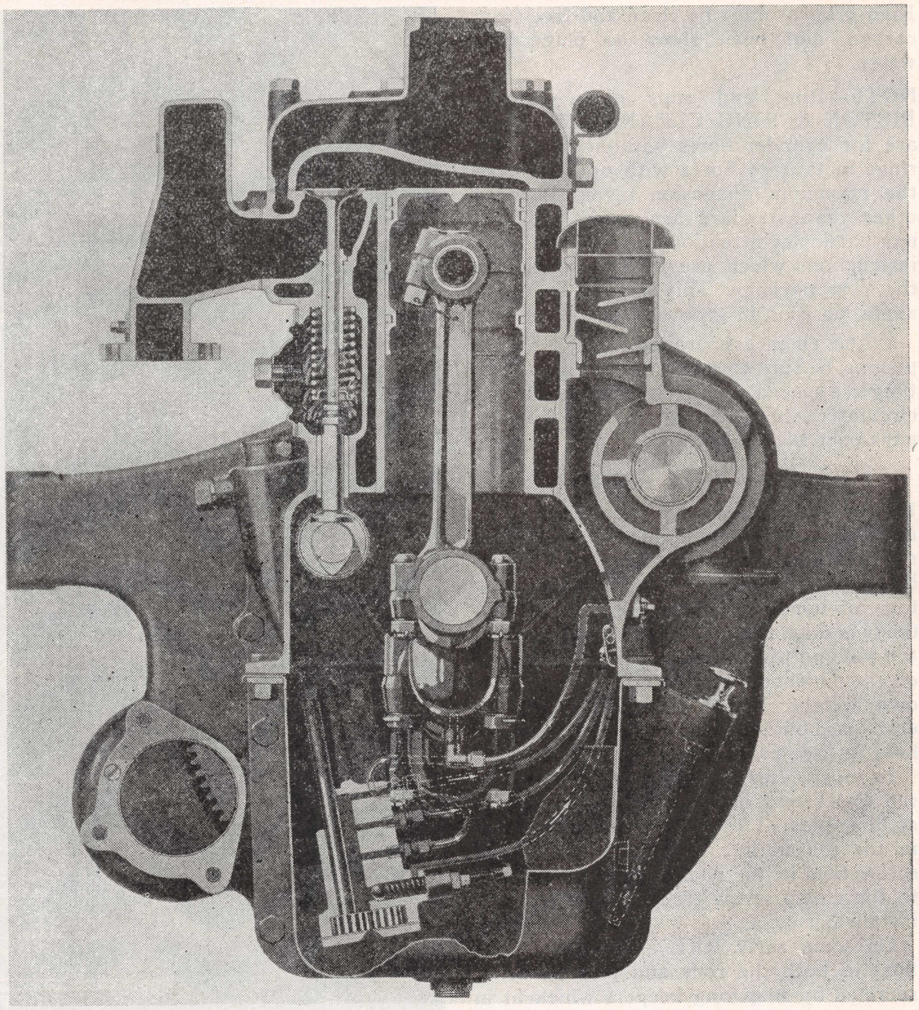
Insert the piston in the bore upside down and in its running position. Place the feeler ribbon between the cylinder wall and the thrust side of the piston (opposite slotted side on aluminum pistons) in a position at right angles to the piston pin hole.

After assembling the piston to the connecting rod, check the assembly for alignment on a suitable jig.

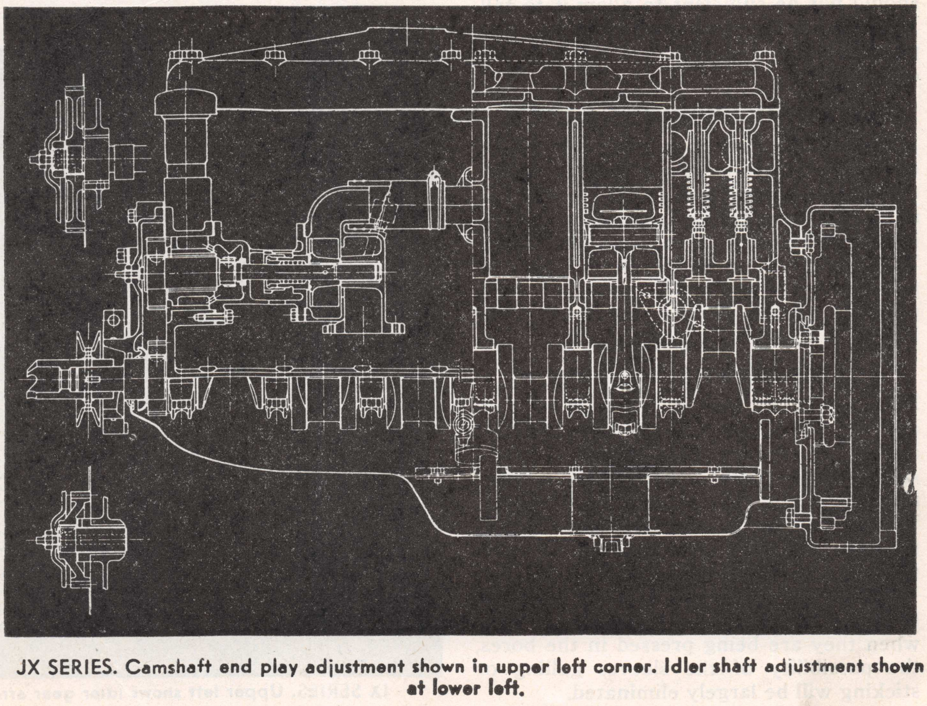
PISTON RINGS, RENEW

1936-46 ALL: NOTE—To prevent the possibility of bending or breaking the second ring land—thus ruining the piston—the ridge at the top of the cylinder bore should be carefully cut away before removing the piston and rod assemblies. If the available ridge reamer has no provision to control the depth of the cut, it is good practice to bring the piston far enough up into the cylinder to allow the reamer to rest on top of the piston. This will serve to prevent cutting down into the ring travel area. CAUTION—Never cut down into the ring travel area more than 1/32"—or more than half the depth of the top ring.

New rings should be fitted with end gaps and groove clearances as given in the PISTON & RING CLEARANCES table.



OX SERIES. End sectional view



JX SERIES. Camshaft end play adjustment shown in upper left corner. Idler shaft adjustment shown at lower left.

Ring grooves must be clean and free from carbon, and must show no perceptible wear.

NOTE—Ring end gaps given in the PISTON & RING CLEARANCES table are for cylinder bores without taper. Fit rings in tapered bores with not less than the maximum dimension given. If rings other than standard are being installed, pay particular attention to the installation instructions which usually are included in the ring package. This applies to clearances, position in grooves, etc.

When rings are properly fitted to the pistons, be sure to stagger the ring gaps so they are spaced equal distances around the circumference of the piston, yet having no gaps over the piston pins.

PISTON PINS, RENEW

1936-46 ALL: The correct fit of piston pins in cast iron pistons should be one which requires a light push with the palm of the band to insert the pin. For aluminum pistons, at normal room temperature (70°F) the pins should be fitted so that with the piston pin and piston pin hole dry and free of oil the pin should barely fall through by its own weight. When a small amount of crankcase oil is applied to the pin it should hold its weight.

In most cases, the pins are clamped in the upper end of the rod, and when installing pins of this type, turn the notch in the pin to line it up with the clamp screw hole in the rod, to prevent damage to the clamp screw threads as it is being installed.

On some early RXL engines, the pins float in both the rods and pistons, being retained by snap ring keepers which fit in grooves in the piston bosses.

To check the fit of pins after installation, hold the piston in both hands and, for aluminum pistons, the weight of the rod should not be sufficient to allow it to fall. When using the same method on cast iron pistons, the rod should drop easily by its own weight.

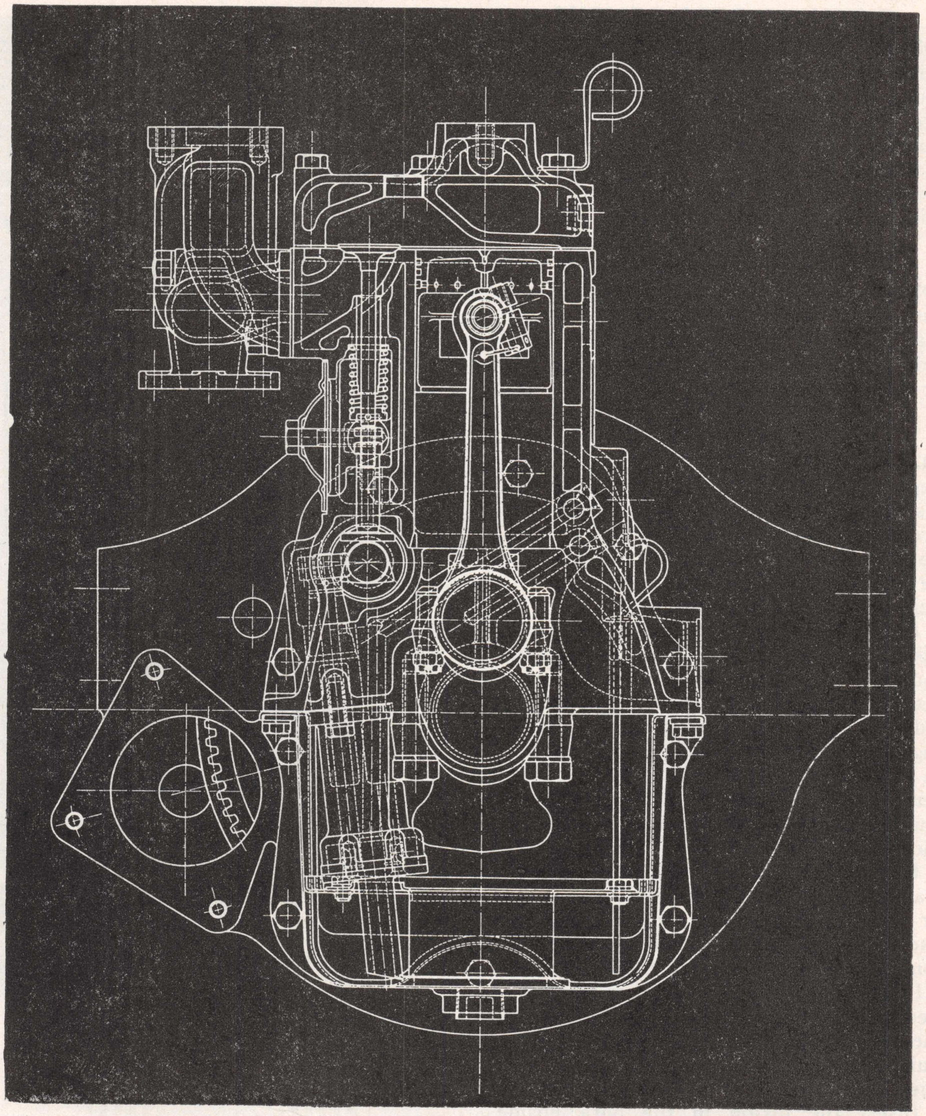
PISTON PIN BUSHINGS, RENEW

1936-46 ALL: Except in some early RXL engines, pins are locked in the rod with a clamp screw and float in the pistons. In most cast iron piston installations, bushings are pressed in the piston pin bosses. When required, new bushings should be pressed in and reamed to provide a light push fit of the pin as described under PISTON PINS, RENEW.

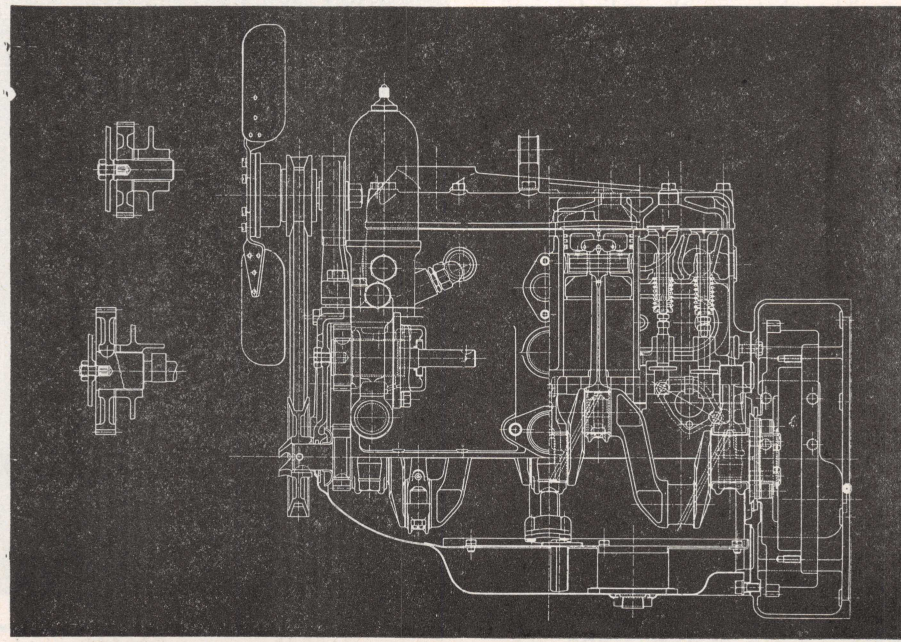
CYLINDER SLEEVES, RENEW

HX: Some engines in this series only are equipped with removable cylinder sleeves of the dry type. Some of these sleeves had a shoulder on the outside near the top while others have no shoulder. Whichever type is used, and when necessary to replace, be sure to install the same type as was used originally.

When new sleeves are being installed, coat the outside with white lead so that when they are being pressed in the bores, the possibility of the sleeves galling or sticking will be largely eliminated.



IX SERIES. End sectional view.



IX SERIES. Upper left shows idler gear arrangement. Lower left, camshaft gear arrangement.

NOTE—When installed, be sure to hone the sleeve bores, otherwise it will not be possible to obtain the proper piston fit.

CONNECTING ROD BEARINGS, RENEW

IX, OO, OX: These bearings are the spun type and are not replaceable. If bearings require adjustment, remove the same thickness of shims from each side until a metal-to-metal contact is established with the crankpin. The bearing may then be scraped to provide maximum bearing surface, and sufficient shims installed on both sides to provide a clearance within the limits given in the ENGINE BEARING SPECIFICATIONS table.

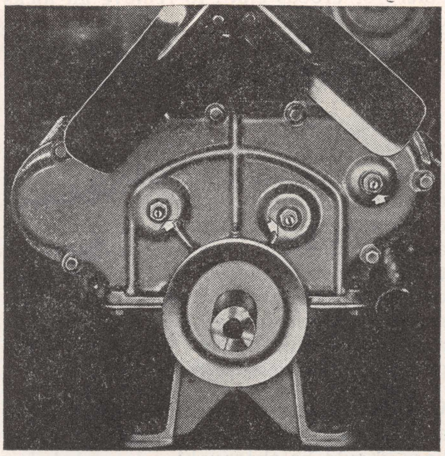
HX, JX, QX, RX, WX, YX: Some of these engines use spun type bearings while others are equipped with the precision insert type. If spun bearings are used, an adjustment may be made in the same manner as described for HX engines.

If equipped with the precision insert type, they may be replaced by simply taking off the bearing cap and slip the old shells out and new ones in. Bearings should be replaced in sets and under no circumstances should rods or caps be filed, altered or mutilated in any way in an attempt to obtain proper bearing fit.

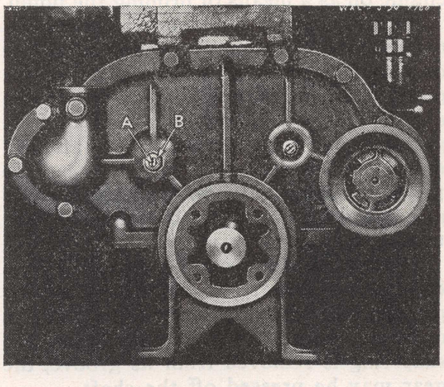
NOTE—Before replacing bearings, make sure that the crankpins are not nicked or scored, and that all parts are thoroughly clean. This is particularly important because the presence of one small particle of metal, carbon or other foreign matter, lodged between the back of the bearing and the rod, or between the face of the bearing and the crankpin, will very likely cause a hot spot due to the elimination of the oil clearance at that point, eventually resulting in a bearing failure or a scored crankpin.

CAUTION—Some of these engines use shims between the bearing cap and the rod **only** on the side opposite the bearing lock notch. When shims are used, never use more than a .009" shim pack to obtain proper bearing fit. On engines which do not use shims, do not attempt to obtain proper bearing fit by their use.

To check the fit of new bearings, use a piece of brass shim stock ¼" wide, the length of which should be ¼" less than the length of the bearing, while the thickness should be approximately the same as the minimum allowable clearance. To avoid damaging the bearing material, smooth down the edges of the shim stock on an oil stone so that no sharp edges remain. Install the shim between the bearing and the crankpin, in the center of the bearing, then tighten the cap bolts to the recommended torque tension. When fitted properly, it should not be possible to move the rod endwise by hand, but a light tap with a hammer should cause the rod to move endwise. Then remove the checking shim and re-install the cap, tightening the cap bolts with a torque wrench, after which, the rod should move endwise by hand. If the rod is too loose with the checking shim in place, the crankpin should be turned down and undersize bearings fitted.



SERIES IX, JX, OO and QX5. Showing adjusting screws controlling end play of camshaft, idler and accessory shafts.



SERIES OX, RX, RXL, WX and YX. Showing adjusting screws for controlling end play of camshaft and idler shaft.

RXL: On early engines of this series, a shell type bearing is used, and when replacing bearings, follow the procedure as described above except that no shims are used.

Later engines employ the spun type bearings which can be adjusted for wear by removing shims, as also described above.

MAIN BEARINGS, RENEW

1936-46 ALL: Two types of bearings have been used in all these engines. One type employs a babbitt-lined removable bearing for the upper half, while in the lower half, the babbitt is poured directly in the bearing caps.

The alternate type is the precision insert shell bearings which, when worn, can be replaced without removing the crankshaft.

To make an adjustment on the babbitt-lined type, remove the same thickness of shims from each side until a metal-to-metal contact is established with the crankshaft journal. If the bearing material is scored, rough or shows only partial contact, the bearing may be scraped to obtain maximum contact.

Then install the same thickness of shims on each side to provide a clearance within the limits given in the ENGINE BEARING SPECIFICATIONS table.

If the babbitt is cracked or worn excessively, new bearings should be fitted and line reamed to fit the crankshaft.

NOTE—Bearings of the precision insert type should be replaced in sets and under no circumstances should any attempt be made to file, alter or otherwise mutilate the bearing caps to obtain proper bearing fit. Shims are usually provided between the bearing cap and support on both sides, and when servicing these bearings, use care to see that these shims do not project between the edges of the bearing shells because they will cause the bearings to buckle when the cap bolts are tightened.

When this type bearing becomes worn, replacement can be accomplished without removing the crankshaft in the following manner: Remove the bearing cap and take out the worn lower shell. A suitable tool can be made to remove the upper shell by using a cotter pin with the rounded end flattened to form a T shape. Insert the T-shaped end of the pin in the oil passage hole in the crankshaft journal and, by rotating the crankshaft in the reverse direction, the T-shaped head will contact the bearing and force it out.

To install, place a new upper shell on the crankshaft journal with the locating notch in the correct position, and rotate the shaft to turn the shell in place. Then install the lower shell in the cap and replace the cap, being sure the proper thickness shim pack (if used) is placed between the cap and support. Then tighten the cap bolts to the recommended torque tension which will be found in the ENGINE BEARING SPECIFICATIONS table.

CAUTION—On some RXL engines fitted with precision insert bearings, no shims are used between the bearing cap and support and under no circumstances should shims be used in this installation because the proper "crush" fit will not be obtained. Similarly, if the bearing design calls for the use of shims, and if the shims are eliminated, the bearings will buckle when the cap bolts are tightened. Usually, the shim pack thickness is .009" on each side of the bearing although, in some cases, a .006" shim pack is used. Whenever bearings are to be serviced, it is good practice to measure the thickness of shims used and never install more than this amount.

To check the fit of new bearings, use a piece of brass shim stock ¼" wide, the length of which should be ¼" less than the length of the bearing, while the thickness should be about the same as the minimum allowable clearance.

CAUTION—To avoid damaging the bearing material, smooth down the edges of the shim stock to remove sharp edges or turned over corners. And before inserting this checking shim in place, it should be coated on both sides with a light film of engine oil.

Lay this checking shim lengthwise in the center of the bearing and install the bearing cap to the crankshaft, being sure the shim packs are properly placed between the cap and bearing support. Then tighten the cap bolts to the recommended torque tension which can be found in the ENGINE BEARING SPECIFICATIONS table. Test the fit of the bearing by rocking the crankshaft through an arc of 2"—not more than 1" in either direction. The bearing may be considered fitted properly if the shaft is movable with a fairly heavy drag.

Bearing clearance may be reduced .001" at a time by removing a .003" shim from each side and putting in a .002" shim on each side. To increase clearance .001" at a time, remove a .002" shim and install a .003" shim on each side.

NOTE—Remove the checking shim and replace the cap, but do not tighten the cap bolts, as this bearing must be loose in order to check the fit of the other bearings. It is good practice to fit bearings by starting at the center—or one of the intermediates on a four-bearing job—then the rear bearing, the front, and finally, the intermediates.

CRANKSHAFT END THRUST

1936-46 ALL: Crankshaft end thrust is controlled by flanges on a bearing (see the ENGINE BEARING SPECIFICATIONS table for the bearing which takes the thrust and for the proper end play limits).

Through normal wear, the end play will seldom become excessive but, whenever new bearings are fitted, the clearance should be carefully checked and, if required, the bearing flanges may be dressed down to obtain the desired end play.

BELLHOUSING & OIL SEAL

1936-46 ALL: If a new bellhousing is being installed or if the engine has been disassembled for repairs, the clearance between the crankshaft oil slinger flange and the bellhousing must be carefully controlled when assembling the engine, to prevent oil leaks.

To measure the clearance, force the crankshaft back to the limit of its end play and insert a feeler gauge between the oil slinger flange and the bellhousing chamfer. The clearance should not be less than .012" nor more than .025". If necessary to increase clearance, scrape the bellhousing chamfer or install an additional gasket between the bellhousing and the case. To prevent oil leaks, all possible chance of interference or rubbing should be eliminated at this point.

NOTE—Bellhousings on some of these engines are equipped with a special type oil seal and when this type is used, it is important that the seal be concentric with the crankshaft. To prevent rapid wear of this seal, the external pilot of the flywheel hub should be polished with a very fine emery or crocus cloth to remove all nicks or rough spots.

ENGINE OILING

OIL PUMP

1936-46: NOTE—On all engines, if the oil pressure drops below normal, do not remove the oil pump until the oil gauge is checked with another gauge known to be accurate. Check the oil level and examine the condition of the oil. If these items are correct and the pressure continues to drop, remove and clean the oil pan thoroughly, and disassemble, clean and inspect the pump and oil pressure regulator.

CAUTION—Before replacing the oil pump and oil pan, the oil screen, oil tubes and lines should be thoroughly cleaned, being sure that all openings in the screen are free and clean. If the screen has been crushed, it is better to replace it rather than attempt to make a repair. When assembling the pump, dip the gears in fresh engine oil as a means of priming the pump.

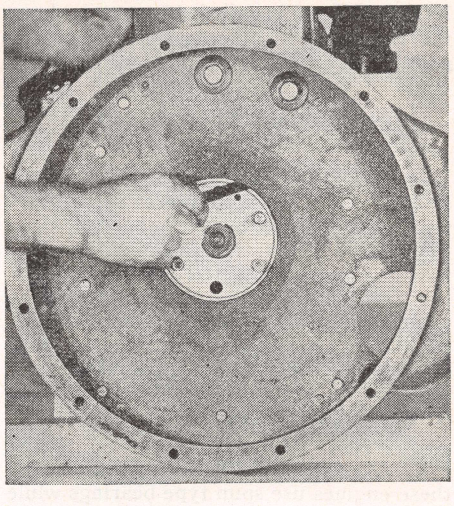
On all engines, the pump is easily removed for inspection or repairs after the oil pan is removed. To disassemble the pump (except HX engines), drive the pin out of the hub of the upper spiral drive gear and pull the gear from the shaft. Remove the key from the keyway near the top of the shaft, take off the bottom cover and withdraw the shaft through the bottom of the pump housing.

The driven gears can be removed from either the main shaft or idler shaft by pressing the gear further on the shaft in order to expose the snap ring. When the snap ring is removed from its groove, the gear may be pressed off the shaft.

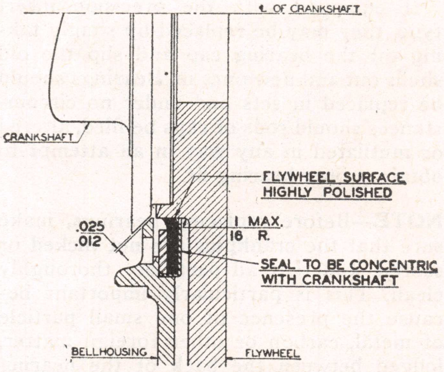
Clearance between the gears and cover may be checked by placing a steel scale across the face of the housing, and a feeler ribbon between the steel scale and gears. If the clearance is excessive, it may be reduced by grinding the lower face of the housing, using an abrasive compound evenly distributed on a perfectly flat surface.

HX: The pump used on these engines consists of the conventional pressure gear pump and two auxiliary pumps contained in the one housing. The pressure pump gears are located in the lower half of the housing while the auxiliary pump gears are contained in the upper half of the housing. The purpose of the auxiliary pump is to scavenge any oil which will flow to the front or rear of the oil pan when the engine is tipped to an extreme angle, as when operating on steep grades.

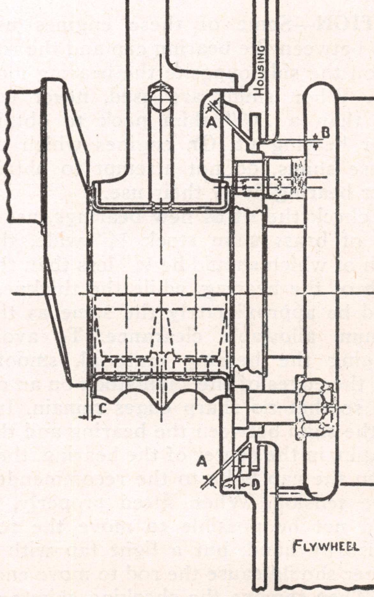
The upper half of the pump housing is doweled and bolted to the lower half and the assembly may be easily taken apart for repairs or inspection. To disassemble the pump, remove the nut which fastens the upper spiral drive gear and pull off the gear. Pick out the washers and roller bearing from the top of the housing. Disconnect the upper and lower housings and lower cover, and when this is done, the shafts and gears can readily be removed.



ALL SERIES. Showing method of checking clearance between crankshaft oil slinger flange and bellhousing.


℄ OF CRANKSHAFT
CRANKSHAFT
FLYWHEEL SURFACE HIGHLY POLISHED
.025
.012
1/16 MAX. R.
SEAL TO BE CONCENTRIC WITH CRANKSHAFT
BELLHOUSING
FLYWHEEL

ALL SERIES. Showing special oil seal installation.



ALL SERIES. Clearance between crankshaft oil slinger and bellhousing chamfer ("A" in cut) must be from .012" to .025".

NOTE—In order to insure the proper mesh of the gears which drive the oil pump, the camshaft should be located so that the center of the drive gear on the camshaft is exactly in the center of the pilot hole in the crankcase which guides the top end of the oil pump body. Whenever any adjustments or replacements are necessary, and the gear on the camshaft does not line up with the pilot hole, the position of the gear can be changed by thinning down the thrust washer between the flange on the camshaft and the crankcase, or by installing suitable shims between the crankcase and the washer.

OIL PRESSURE REGULATOR

1936-46 ALL: Oil pressure is automatically controlled by a compression spring which controls the action of a relief or by-pass valve. Oil pressure should not be judged to be too high or too low until it is known whether the proper weight of oil is used, and the engine is warmed up to normal operating temperature.

As the engine bearings become worn, the oil pressure will be slightly lower due to more oil escaping around the bearings. It is not advisable to try to correct this slight pressure loss by an adjustment of the pressure regulator, because the extra amount of oil being thrown off by the worn bearings is already over-oiling the cylinder walls.

HX: The regulator is incorporated in the filter, and when it is desired to make an adjustment, remove the acorn nut which covers the adjusting screw. Then loosen the lock nut and turn the adjusting screw clockwise to increase pressure, and counter-clockwise to decrease the pressure. When satisfactory, tighten the lock nut and replace the acorn nut.

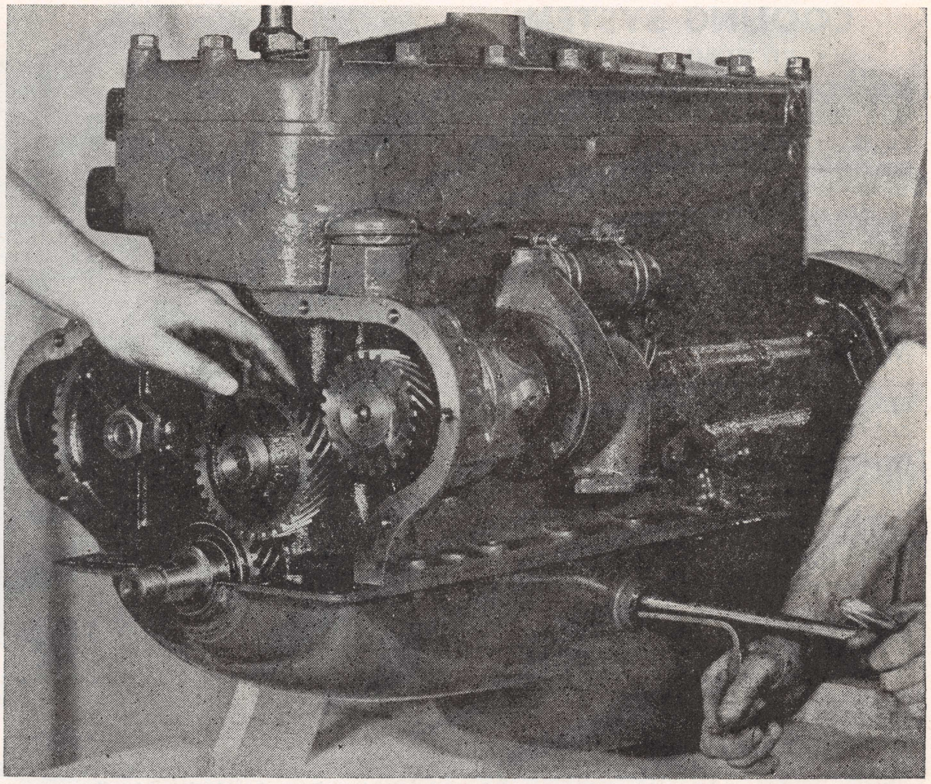
JX, OO, OX, QX: In these engines, the pressure regulator is incorporated in the oil pump and can be adjusted without taking off the oil pan. Remove the pipe plug from the side of the oil pan (opposite camshaft side) and, with the use of special wrenches, an adjustment can be made. Using a special "crow foot" wrench through the oil plug hole, loosen the lock nut and then, with a T handle socket, turn the adjusting screw clockwise to increase pressure and counter-clockwise to decrease the pressure. Be sure to tighten the lock nut when the adjustment is satisfactory.

IX: On some IX engines, the pressure regulator is a separate assembly bolted to the crankcase above the accessory drive gear. On other IX engines, the regulator is built into the crankcase in the same approximate position.

On all installations, the pressure is regulated by turning the adjusting screw in to increase pressure, and out to decrease it.

RX, RXL, WX, YX: When these engines are equipped with an oil filter, the regulator is usually incorporated within the unit, and if an adjustment is required, it can be done in the same manner as described for the HX series.

Engines not equipped with a filter have the regulator bolted to the water pump side of the cylinder block. When an adjustment is required, remove the acorn nut which covers the adjusting screw, loosen the lock nut and turn the adjusting screw in (clockwise) to increase pressure, and out to decrease it.



Showing method of removing idler gear assembly on all engines. The operation being performed in the side of the oil pan shows the method of adjusting oil pressure on JX and QX series. On O, OO and OX engines, the method is the same except that the adjustment is toward the rear of the pan but on the same side.

OIL FILTER

1936-46: Several types of filters are used in these engines and usually, complete maintenance instructions accompany each filter in the form of a sticker pasted on the filter itself. If additional information is required, see the chapter devoted to OIL FILTERS elsewhere in this book.

At frequent intervals, the filter should be drained to get rid of any solid matter which may have settled in the filter sump. Whenever this is done, be sure to add sufficient oil to the crankcase to compensate for the oil drained.

Filters should be cleaned thoroughly every time the oil is changed and after every thousand miles of operation, or after every 50 hours of operation in industrial units. If the dip stick shows that the oil is thick and very dirty, it indicates that the filter element requires service.

CRANKCASE VENTILATOR

1936-46: The crankcase ventilator breather should be inspected at least every 2000 miles, and if a sludge formation is evident, remove the breather and clean it thoroughly in gasoline. Allow it to soak in the gasoline for about 30 minutes, then blow it out with compressed air, and at the same time, tap it lightly to dislodge any solid particles of sludge.

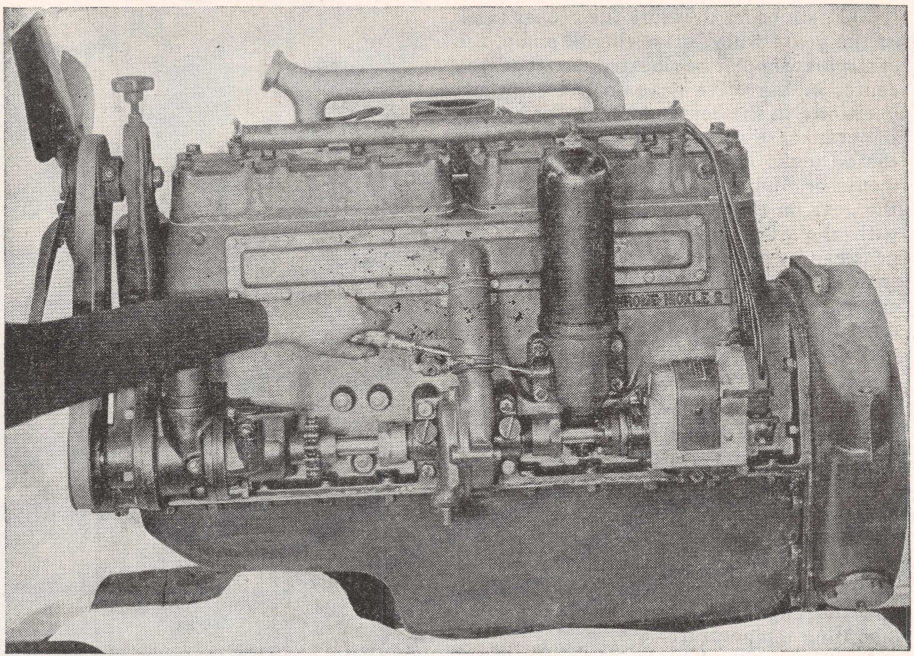
If the breather is fitted with an air cleaner, it should be removed and washed every 1000 miles. After the element is washed, blow it dry with compressed air and, if the cleaner is of the oil-wetted type, dip the element in fresh engine oil before assembling. If it is of the oil bath type, wipe out the oil reservoir with a clean cloth and fill it to the proper level with fresh engine oil.

NOTE—The interval at which the ventilator and air cleaner should be cleaned can only be determined by the type of service to which the vehicle is subjected. Vehicles operating in dusty or sandy areas require more frequent service than vehicles operating under more favorable conditions.

IMPORTANT—For vehicles operating in dust storm areas, the cleaner should be cleaned immediately after such storms occur.

COOLING SYSTEM

WATER PUMP, OVERHAUL



SERIES RX, WX and YX. Showing oil pressure adjustment when these engines are equipped with filter.

HX, JX, OX, QX5: The pumps commonly used on these engines are of the regular packing type and can be removed from the engine without taking off the timing gear cover; it will be necessary, however, to remove the magneto or distributor.

To disassemble the pump, remove the pump body and impeller from the shaft. Pull the key from the shaft and push the shaft through the sleeve, after which, the water pump drive gear may be pressed from the shaft.

Examine the parts and replace where necessary, then assemble in the reverse order.

IX: To disassemble the pump, take off the fan blade and pulley. Release the lock ring from in front of the bearing. Remove the back cover. Support the pump body in an arbor press and press the shaft and bearing out of the impeller, then remove the shaft and bearing from the housing.

CAUTION—Since the pump shaft bearing is of the shielded type, packed with lubricant at the time of manufacture to last the life of the bearings, it should never be immersed in cleaning fluid, because this fluid will dissolve the lubricant, thereby quickly ruining the bearing when used in this condition.

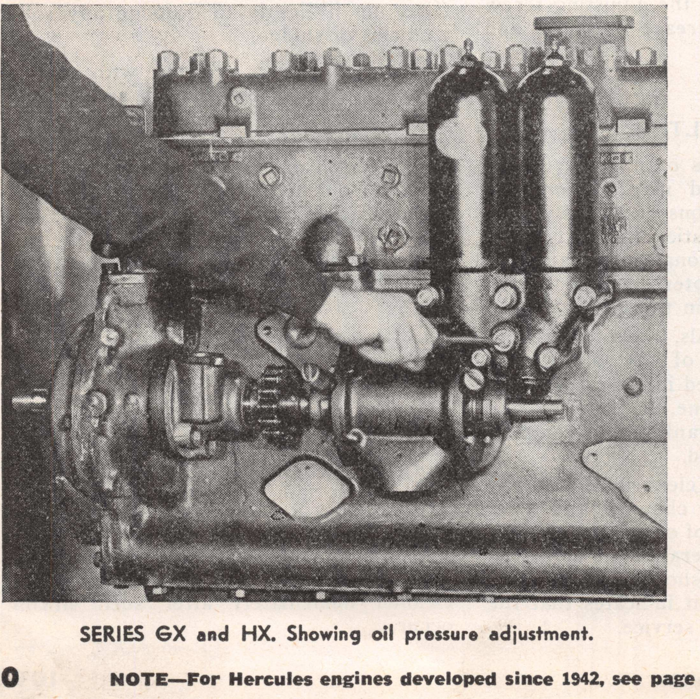
NOTE—When pump is disassembled, wash the body thoroughly and clean gasket surfaces. The seal surface on the pump body should be refaced with a suitable refacing tool, and, before assembling the pump, apply a coating of grease to the seal surface.

To assemble the pump, press the shaft and bearing into the pump body, pressing on the outer race of the bearing and not the end of the shaft. Install a new bearing lock wire. Coat the shaft with oil or grease and then press on the impeller, supporting the end of the pump shaft and not the pump body. Complete the assembly by pressing on the pulley flange, replace gasket and cover, and drive pulley and blade assembly.

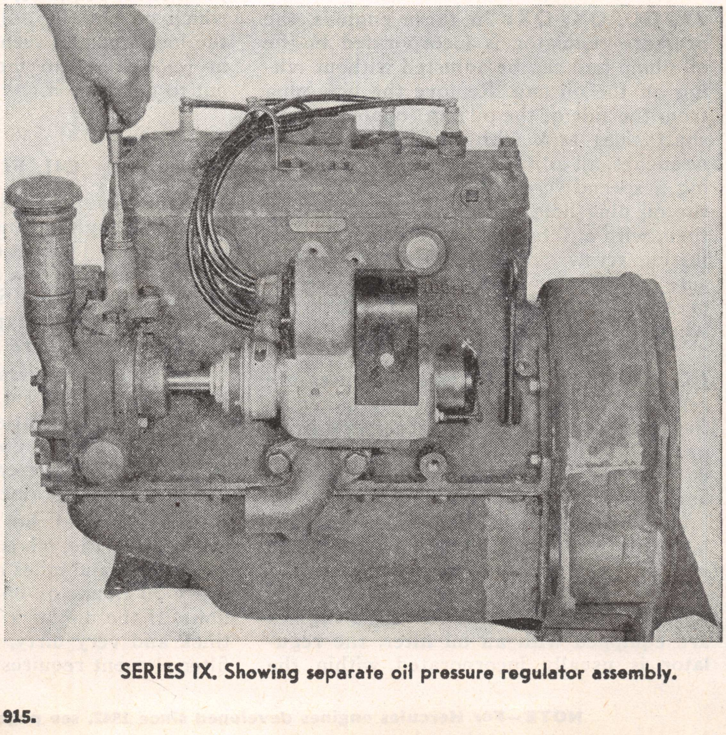
OO, QX3, RXL: Pumps commonly used on these engines are of the auto seal or packless type, requiring no adjustments or lubrication. A leak can be remedied by installing new parts.

To disassemble the pump, remove the bolts and separate the cover from the pump body. Drive out the pin which holds the impeller to the shaft and pull the impeller from the shaft. Insert a screw driver through one of the four slots in the impeller hub and press the snap ring out of the groove, after which, take out the seal parts.

Assemble the pump in the reverse order, bearing in mind that the metal ring acts as a seat for the seal spring and presses the rubber seal squarely against

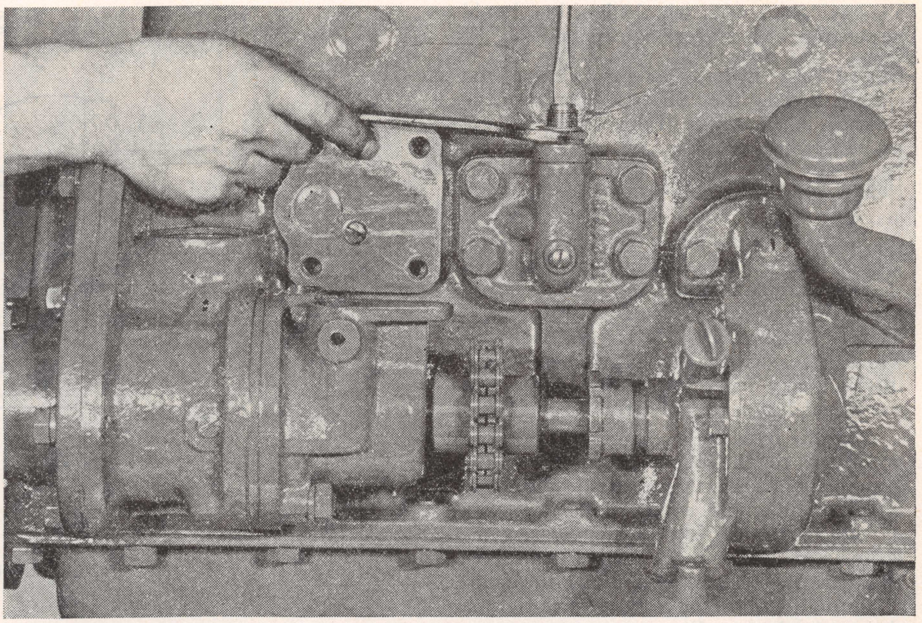


SERIES GX and HX. Showing oil pressure adjustment.

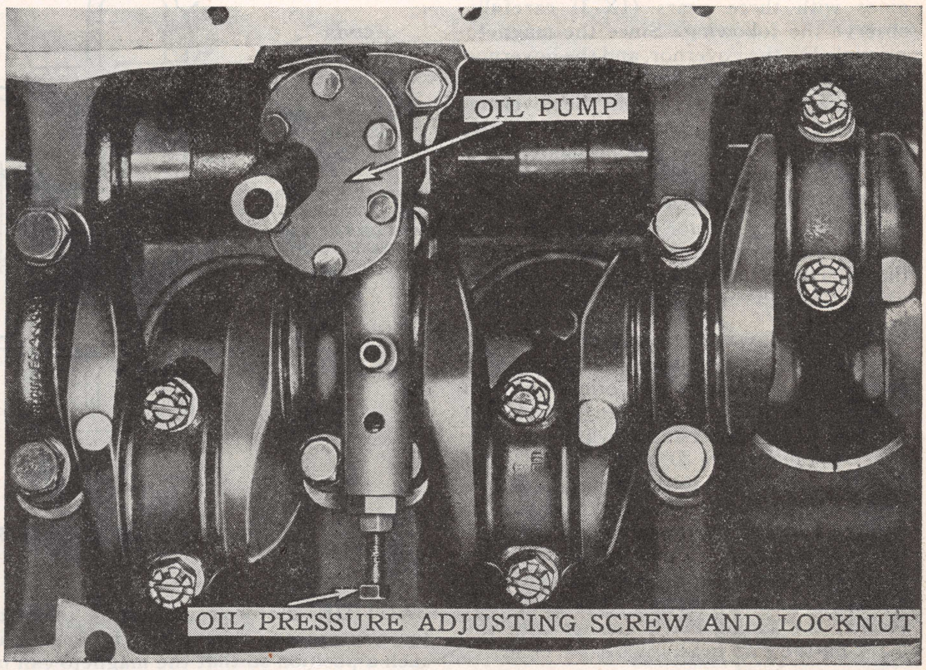


SERIES IX. Showing separate oil pressure regulator assembly.

NOTE—For Hercules engines developed since 1942, see page 915.



SERIES RX, WX and YX. Showing oil pressure adjustment when these engines are not equipped with filter.



SERIES JX, OO, OX and QX.

the carbon disc. The clamping ring keeps the rubber tight around the shaft.

RX, WX, YX: Pumps commonly used on these engines are easily disassembled by simply separating the pump housing, and when this is done, the internal parts are accessible and readily removed. When ordering parts, however, it is important to give the engine number, as the parts in some of these pumps vary in detail.

ENGINE WATER THERMOSTAT

1936-46 ALL: If the thermostat is not functioning properly, remove the assembly from the water outlet and see if the bellows and valve are in good condition. If they are, test its operation by completely submerging the assembly in water, heating the water gradually until it reaches the opening temperature of the thermostat, which is approximately 145 degrees. When the water reaches a temperature of about 170 degrees, the thermostat should be fully open.

NOTE—When taking temperature readings, agitate the water thoroughly. And if the unit fails to function properly, it should be replaced rather than attempt to make a repair. Before installing a new unit, it is good practice to give it a test as directed, above.

FUEL SYSTEM

NOTE—For service information on Carburetors, Automatic Chokes, Governors, Fuel Pumps, Air Cleaners and Gasoline Gauges, see the Table of Contents on page 1.

ELECTRIC SYSTEM

NOTE—For service information on Distributors, Magnetos, Generators, Generator Controls, Starting Motors and Starting Switches, see the Table of Contents on page 1.

IGNITION TIMING

NOTE—Instructions for ignition timing will differ slightly with different makes of electrical equipment and the following is to be considered general. After the initial setting has been made, the spark may be advanced or retarded to compensate for the grade of fuel being used and for the type of operation to which the vehicle is subjected. For best performance and fuel economy, the spark setting should be one which will provide smooth engine performance with a slight "ping" on wide-open throttle at comparatively low vehicle speed.

GX, HX: Firing order, 1-5-3-6-2-4. Breaker point gap, battery ignition, .018" to .020"; magneto ignition, .015" to .018".

With battery ignition, crank the engine to bring No. 1 piston up on its compression stroke and stop when the "DC-1-6" mark on the flywheel is in line with the pointer on the flywheel housing. In this position, the points should just begin to open—with the spark retarded and the distributor rotor in the No. 1 firing position.

If equipped with a magneto, bring No. 1 piston up on its firing position in the same manner as above. Loosen the coupling connection between the magneto shaft and the engine shaft. Remove the breaker cover and the distributor cover. Move the advance arm to the retarded position—which is when the arm is moved as far as it will go in the direction of rotation. Then turn the magneto in the direction of rotation until the points just begin to open, being sure the rotor is in line with the proper segment to distribute spark to No. 1 cylinder. With the magneto in this position, connect the coupling and replace the breaker and distributor covers.

NOTE—If the magneto is equipped with an impulse coupling, turn the magneto until the impulse coupling trips, then turn it back until the points close, then forward again until the points just open.

The above instructions are for magnetos having a variable spark. If the magneto is one having a fixed spark, the ignition should be set to fire 19 degrees before TDC.

IX: Firing order, 1-2-4-3. Crank the engine to bring the "SPARK" mark on the flywheel in the center of the indicating hole in the flywheel housing.

NOTE—If the engine is equipped with a magneto and impulse coupling, crank the engine until the impulse trips and back up until the "SPARK" mark lines up. For fixed spark ignition and speeds up to 2,000 RPM, the "SPARK" mark is usually about 14 degrees before TDC ("DC" mark on flywheel). Measured in inches on the flywheel, this will vary according to the diameter of the wheel, but is roughly from 1" to 1⅜".

With the flywheel in the correct position according to the above instructions, the breaker points should be just beginning to open. On magneto equipped engines, if a change in timing is required, loosen the large nut which locks the driving and driven members of the coupling and turn the coupling until the timing is correct; then tighten the nut to the coupling.

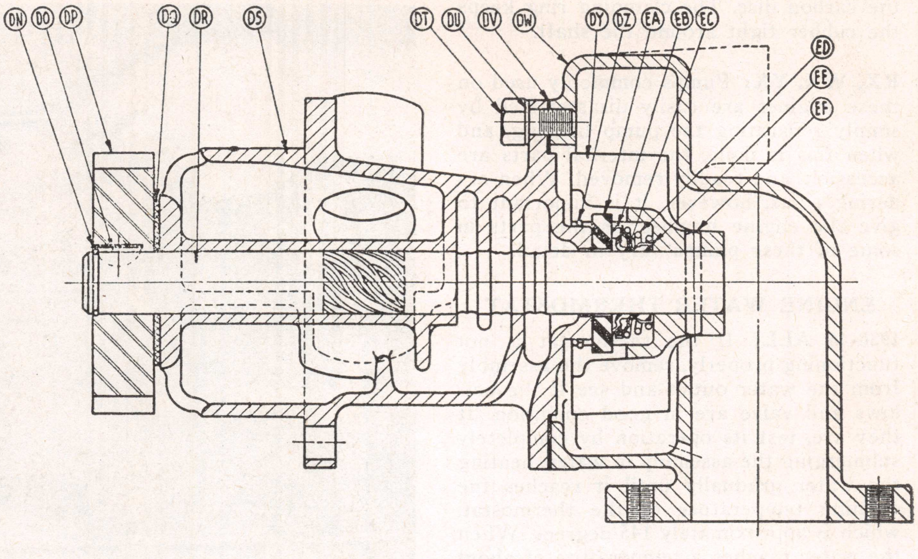
NOTE—The above instructions are for IX-5 engines, which means that there are five gears used in the timing case. For engines with three gears (IX-3) carefully observe the following: Since the magneto is coupled to the governor, and the governor is driven by a gear meshing with the camshaft gear, it is important that the governor be timed correctly with camshaft gear, otherwise the magneto will be inoperative. This operation is performed after the timing gear cover is installed.

To time the governor gear with the camshaft gear, rotate the engine clockwise until the punch mark on the camshaft gear is visible through the governor cover opening.

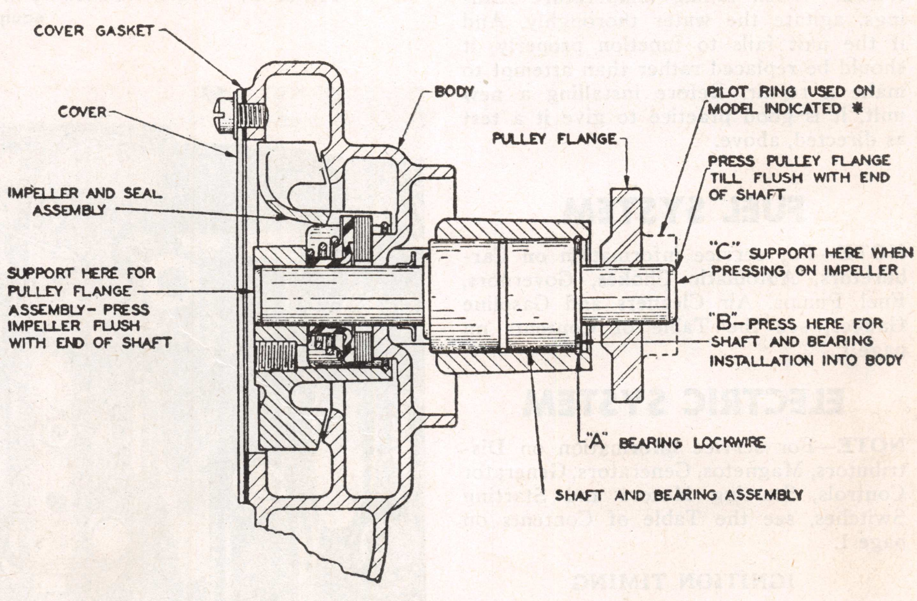
CAUTION—Two different types of governor gears have been used: one having only one punch mark and the other has two designating timing marks. In some cases the gear is marked 2 and 3, while on other gears, the marks are 20° and 34°. The 2 and 3 marks correspond to the 20 and 34 degree marks. The flange on the magneto is marked with the degree of timing to which the governor gear is timed to the camshaft gear. After determining the correct timing mark, insert the governor gear and shaft so that the timing mark meshes with the mark on the cam gear.

Then install the balance of the governor, using extreme care to see that the engine is not turned. In this position, the slot in the governor gear is in the correct position for timing the engine on No. 1 cylinder.

Now rotate the magneto (which is off the engine) until it is ready to fire on No. 1 cylinder, and while holding it in this position, connect the magneto to the governor gear, tightening the cap screws or stud nuts finger tight so that the magneto can be moved or rotated. Then rotate the engine until the "SPARK" mark on the flywheel is in the center of the indicating hole in the flywheel housing. Remove the breaker cap and rotate the magneto until the breaker points just start to open.



WATER PUMP. Series JX and QX.


COVER GASKET
COVER
BODY
IMPELLER AND SEAL ASSEMBLY
SUPPORT HERE FOR PULLEY FLANGE ASSEMBLY- PRESS IMPELLER FLUSH WITH END OF SHAFT
PILOT RING USED ON MODEL INDICATED ✱
PULLEY FLANGE
PRESS PULLEY FLANGE TILL FLUSH WITH END OF SHAFT
"C" SUPPORT HERE WHEN PRESSING ON IMPELLER
"B"- PRESS HERE FOR SHAFT AND BEARING INSTALLATION INTO BODY
"A" BEARING LOCKWIRE
SHAFT AND BEARING ASSEMBLY

WATER PUMP. Series IX. Pilot ring not used on IX-3 pumps.

CAUTION—Before removing the magneto for any reason, always set the engine in such a position so that the magneto can be retimed without removing the governor.

JX, QX: Firing order, 1-5-3-6-2-4. Breaker gap, battery ignition, .018" to .020"; magneto ignition, .015" to .018".

Some flywheels on these engines are marked "IGN," while others are marked "DC." Timing instructions are the same as described for the GX series except that the flywheel should be spotted 1⅝" before TDC and QX engines, and 1⅞" on the JX series. At these points, the breaker points should just begin to break.

OO, OX: Firing order, 1-2-4-3. Breaker gap, battery ignition, .018" to .020"; magneto ignition, .015" to .018".

The ignition timing is set in the same manner as described for the HX engines, On engines equipped with battery ignition or with variable spark magnetos, the points should break when the "DC" mark is in line with the center of the indicator hole in the flywheel housing. With a fixed spark magneto, points should break when the "SPARK" mark (about 16 degrees before TDC) is in line with the hole.

NOTE—Consult the chapter for HX series engines for general notes on battery or magneto ignition timing.

RX, RLX, WX, YX: Instructions are the same as described for the HX series engines except that when equipped with a fixed spark magneto, the ignition should be set to fire 20 degrees before TDC.

INTERNATIONAL GASOLINE ENGINES

Year	Engine Model	Number Cylinders and Valve Arrangement	Bore and Stroke	Displacement Cubic Inches	Compression Ratio	Taxable H. P.	Brake H. P. at R. P. M.	Maximum Torque at R. P. M. Pounds Feet	Oil Capacity Quarts
1942-46	BLD-250	6-I	3 7/16x4½	250.56	6.3	28.36	100@3200	200@800	7¼
1942-46	BLD-269	6-I	3 9/16x4½	269.10	6.3	30.46	103@3000	222@800	7¼
1942-46	BLD-269A	6-I	3 9/16x4½	269.10	6.3	30.46	103@3000	222@800	7¼
1937-40	FAB-241	6-I	3⅜x4½	241.54	5.8	27.3	84@3200	176@800	6½
1937-40	FAB-259	6-I	3½x4½	259.76	5.74	29.4	89@3200	192@800	6½
1941-42	FAC-241	6-I	3⅜x4½	241.54	5.8③	27.3	84@3200①	176@800②	6½
1941-42	FAC-241A	6-I	3⅜x4½	241.54	5.8	27.3	84@3200	176@1200	6½
1941-42	FAC-259	6-I	3½x4½	259.76	5.74⑧	29.4	89@3200④	192@800⑥	6½
1941-42	FAC-259A	6-I	3½x4½	259.76	5.74⑨	29.4	89@3200⑤	192@800⑦	6½
1937-40	FBB-298	6-I	3¾x4½	298.20	5.7	33.7	94@2800	218@1600	8½
1937-40	FBB-298A	6-I	3¾x4½	298.20	5.7	33.7	94@2800	218@1600	8½
1937-40	FBB-361	6-I	4⅛x4½	360.82	5.2	40.8	111@2700	268@1500	8½
1937-40	FBB-361A	6-I	4⅛x4½	360.82	5.2	40.8	111@2700	268@1500	8½
1937-40	FBB-401	6-I	4⅛x5	400.92	5.2	40.8	114@2600	308@800	8½
1937-40	FBB-401A	6-I	4⅛x5	400.92	5.2	40.8	114@2600	308@800	8½
1939-40	FBB-450A	6-I	4⅜x5	450.99	5.2	45.9	120@2400	331@800	8½
1941-42	FBC-318	6-I	3⅞x4½	318.41	5.38	36.03	100@2800	241@800	8½
1941-42	FBC-318A	6-I	3⅞x4½	318.41	5.38	36.03	100@2800	241@800	8½
1941-42	FBC-361	6-I	4⅛x4½	360.82	5.2	40.08	111@2700	268@1500	8½
1941-42	FBC-361A	6-I	4⅛x4½	360.82	5.2	40.08	111@2700	268@1500	8½
1941-42	FBC-401	6-I	4⅛x5	400.92	5.2	40.08	114@2600	308@800	8½
1941-42	FBC-401A	6-I	4⅛x5	400.92	5.2	40.08	114@2600	308@800	8½
1941-42	FBC-450A	6-I	4⅜x5	450.99	5.2	45.9	120@2400	331@800	8½
1936-38	FC-132	4-L	3¼x4	132.73	6.0	16.8	33@2800	90@1200	4
1936-38	FC-132A	4-L	3¼x4	132.73	6.0	16.8	33@2800	90@1200	4
1936-42	FEB-648	6-I	5x5½	648	4.4	60.0	140@2100	460@1000	22
1941-46	GRD-175	6-L	3x4⅛	174.93	6.7	21.6	64@3400	120@1000	5
1941-46	GRD-175A	6-L	3x4⅛	174.93	6.7	21.6	64@3400	120@1000	5
1941-46	GRD-214	6-L	3 5/16x4⅛	213.24	6.3	26.3	82@3400	160@1200	5
1941-46	GRD-214A	6-L	3 5/16x4⅛	213.24	6.3	26.3	82@3400	160@1200	5
1941-46	GRD-233	6-L	3 5/16x4½	232.65	6.3	26.3	93@3400	181@1000	5
1941-46	GRD-233A	6-L	3 5/16x4½	232.65	6.3	26.3	93@3400	181@1000	5
1937-40	HD-174	6-L	3x4⅛	174.93	6.0	21.6	46@3000	107@800	6
1937-40	HD-174A	6-L	3x4⅛	174.93	6.0	21.6	46@3000	107@800	6
1937-40	HD-174B	6-L	3x4⅛	174.93	6.0	21.6	46@3000	107@800	6
1937-40	HD-174C	6-L	3x4⅛	174.93	6.0	21.6	46@3000	107@800	6
1937-40	HD-213	6-L	3 5/16x4⅛	213.24	6.3	26.3	78@3400	155@1000	6
1937-40	HD-213A	6-L	3 5/16x4⅛	213.24	6.3	26.3	78@3400	155@1000	6
1937-40	HD-213B	6-L	3 5/16x4⅛	213.24	6.3	26.3	78@3400	155@1000	6
1937-40	HD-213C	6-L	3 5/16x4⅛	213.24	6.3	26.3	78@3400	155@1000	6
1937-40	HD-232	6-L	3 5/16x4½	232.65	6.0	26.3	81@3200	170@1000	6
1937-40	HD-232A	6-L	3 5/16x4½	232.65	6.0	26.3	81@3200	170@1000	6

NOTE—Engine models with suffix letter "A" indicate updraft carburetion.

① After Eng. No. 2400, 95 at 3200.
② After Eng. No. 2400, 192 at 1200.
③ After Eng. No. 2400, 6.2.
④ After Eng. No. 3300, 101 at 3000.
⑤ After Eng. No. 750, 101 at 3000.
⑥ After Eng. No. 3300, 211 at 1600.
⑦ After Eng. No. 750, 211 at 1600.
⑧ After Eng. No. 3300, 6.2.
⑨ After Eng. No. 750, 6.2.

NOTE—For International engines developed since 1942, see page 915.

TUNE UP CHART

Year	Engine Model	Firing Order	Spark Plug Gap	Breaker Gap	Cam Angle, Degrees	Timing Mark Location	Spark Timing, Degrees	Tappet Clearance For Running, Hot Int.	Tappet Clearance For Running, Hot Exh.	Tappet Clearance For Timing, Intake	Battery Terminal Grounded
1942–46	BLD-250	153624	.028–.032	.018–.024	35	Vib. Damp.	3BTDC	.015	.015	.023	Positive
1942–46	BLD-269(A)	153624	.028–.032	.018–.024	35	Vib. Damp.	3BTDC	.015	.015	.023	Positive
1937–40	FAB-241	153624	.020–.025	.018–.024	35	Vib. Damp.	3BTDC	.015	.015	.024	Positive
1937–40	FAB-259	153624	.020–.025	.018–.024	35	Vib. Damp.	3BTDC	.015	.015	.024	Positive
1941–42	FAC-241(A)	153624	.028–.032	.018–.024	35	Vib. Damp.	3BTDC	.018	.018	.023	Positive
1941–42	FAC-259(A)	153624	.028–.032	.018–.024	35	Viv. Damp.	3BTDC ①	.018	.018	.023	Positive
1937–40	FBB-298(A)	153624	.020–.025	.018–.024	35	Vib. Damp.	10BTDC	.015	.015	.016	Positive
1937–40	FBB-361(A)	153624	.020–.025	.018–.024	35	Vib. Damp.	10BTDC	.015	.015	.016	Positive
1937–41	FBB-401(A)	153624	.020–.025	.018–.024	35	Vib. Damp.	6BTDC	.015	.015	.016	Positive
1939–40	FBB-450A	153624	.020–.025	.018–.024	35	Vib. Damp.	10BTDC	.015	.015	.016	Positive
1941–42	FBC-318(A)	153624	.028–.032	.018–.024	35	Vib. Damp.	10BTDC	.015	.015	.0167	Positive
1941–42	FBC-361(A)	153624	.028–.032	.018–.024	35	Vib. Damp.	10BTDC	.015	.015	.0167	Positive
1941–42	FBC-401(A)	153624	.028–.032	.018–.024	35	Vib. Damp.	6BTDC	.015	.015	.0167	Positive
1941–42	FBC-450A	153624	.028–.032	.018–.024	35	Vib. Damp.	10BTDC	.015	.015	.0167	Positive
1936–38	FC-132(A)	1342	.020–.025	.018–.024	51	Flywheel	TDC	.006	.011	.005	Positive
1936–42	FEB-648	153624	.025–.028	.018–.024	35	Flywheel	5BTDC	.011	.013	.011	Positive
1941–46	GRD-175(A)	153624	.028–.032	.018–.024	35	Vib. Damp.	4BTDC	.015	.015	.020	Positive
1941–46	GRD-214(A)	153624	.028–.032	.018–.024	35	Vib. Damp.	4BTDC	.015	.015	.020	Positive
1941–46	GRD-233(A)	153624	.028–.032	.018–.024	35	Vib. Damp.	4BTDC	.015	.015	.020	Positive
1937–40	HD-174	153624	.020–.025	.018–.024	35	Vib. Damp.	10BTDC	.008	.010	.010	Positive
1937–40	HD-213	153624	.020–.025	.018–.024	35	Vib. Damp.	4BTDC	.008	.010	.010	Positive
1937–40	HD-232(A)	153624	.020–.025	.018–.024	35	Flywheel	TDC	.008	.010	.010	Positive

① After Eng. No. 3300 on FAC-259 or Eng. No. 750 on FAC-259A, 7BTDC.

VALVE SYSTEM

Year	Engine Model	Stem Clearance Intake	Stem Clearance Exhaust	Tappet Guide Clearance	Tappet Clearance Running, Hot In-take	Tappet Clearance Running, Hot Ex-haust	Tappet Clearance Timing In-take	Tappet Clearance Timing Ex-haust	Valve Spring Pressure Test Free Length, Inches	Valve Spring Pressure Test Pounds at Inches, Length	Valve Seat Angle Degrees
1942–46	BLD-250	.0015–.0035	.002–.004	.001–.003	.015	.015	.023	.023	$2\frac{33}{64}$	116@$1\frac{45}{64}$	45
1942–46	BLD-269(A)	.0015–.0035	.002–.004	.001–.003	.015	.015	.023	.023	$2\frac{33}{64}$	116@$1\frac{45}{64}$	45
1937–40	FAB-241	.0015–.0025	.003–.004	.0005–.003	.015	.015	.024	.024	$2\frac{23}{64}$	93@$1\frac{45}{34}$	45
1937–40	FAB-259	.0015–.0025	.003–.004	.0005–.003	.015	.015	.024	.024	$2\frac{23}{64}$	93@$1\frac{45}{64}$	45
1941–42	FAC-241(A)	.0015–.0035	.002–.004	.0005–.003	.018	.018	.023	.023	$2\frac{33}{64}$	116@$1\frac{45}{64}$	45
1941–42	FAC-259(A)	.0015–.0035	.002–.004	.0005–.003	.018	.018	.023	.023	$2\frac{33}{64}$	116@$1\frac{45}{64}$	45
1937–40	FBB-298(A)	.0015–.0025	.002–.004	.0005–.0015	.015	.015	.016	.016	I $2\frac{9}{32}$ O $2\frac{15}{32}$	I 46@$1\frac{19}{32}$ O 90@$1\frac{25}{32}$	45 45
1937–40	FBB-361(A)	.0015–.0025	.002–.004	.0005–.0015	.015	.015	.016	.016	I $2\frac{9}{32}$ O $2\frac{15}{32}$	I 46@$1\frac{19}{32}$ O 90@$1\frac{25}{32}$	45 45
1937–41	FBB-401(A)	.0015–.0025	.002–.004	.0005–.0015	.015	.015	.016	.016	I $2\frac{9}{32}$ O $2\frac{15}{32}$	I 46@$1\frac{19}{32}$ O 90@$1\frac{25}{32}$	45

NOTE—For International engines developed since 1942, see page 915.

VALVE SYSTEM

Year	Engine Model	Stem Clearance		Tappet Guide Clearance	Tappet Clearance				Valve Spring Pressure Test		Valve Seat Angle, Degrees
					Running Hot		Timing				
		Intake	Exhaust		Intake	Exhaust	In-take	Ex-haust	Free Length, Inches	Pounds at Inches, Length	
1939–40	FBB-450A	.0015–.0025	.002–.004	.0005–.0015	.015	.015	.016	.016	I 2 9/32 O 2 15/32	I 46@1 19/32 O 90@1 25/32	45
1941–42	FBC-318(A)	.0015–.0035	.002–.004	.001–.003	.015	.015	.0167	.0167	I 2 9/32 O 2 15/32	I 60@1 33/64 O 108@1 23/32	45 ①
1941–42	FBC-361(A)	.0015–.0035	.002–.004	.001–.003	.015	.015	.0167	.0167	I 2 9/32 O 2 15/32	I 60@1 33/64 O 108@1 23/32	45 ①
1941–42	FBC-401(A)	.0015–.0035	.002–.004	.001–.003	.015	.015	.0167	.0167	I 2 9/32 O 2 15/32	I 60@1 33/64 O 108@1 23/32	45 ①
1941–42	FBC-450A	.0015–.0035	.002–.004	.001–.003	.015	.015	.0167	.0167	I 2 9/32 O 2 15/32	I 60@1 33/64 O 108@1 23/32	45 ①
1936–38	FC 132(A)	.0015–.0025	.003–.004	.0005–.002	.006	.011	.005	.010	2 1/4	74@1 5/8	45
1936–42	FEB-648	.0015–.0025	.002–.004	.001–.003	.011	.013	.011	.013	---	I 79@1 25/32 O 140@2 1/16	45
1941–46	GRD-175(A)	.0015–.0035	.002–.004	.0005–.0015	.015	.015	.020	.020	2 11/16	85 1/2@1 15/16	45
1941–46	GRD-214(A)	.0015–.0035	.002–.004	.0005–.0015	.015	.015	.020	.020	2 11/16	85 1/2@1 15/16	45
1941–46	GRD-233(A)	.0015–.0035	.002–.004	.0005–.0015	.015	.015	.020	.020	2 11/16	85 1/2@1 15/16	45
1937–40	HD-174, A, B, C	.0015–.0025	.003–.004	.0005–.0015	.008	.010	.010	.012	2 11/16	85 1/2@1 15/16	45
1937–40	HD-213, A, B, C	.0015–.0025	.003–.004	.0005–.0015	.008	.010	.010	.012	2 11/16	85 1/2@1 15/16	45
1937–40	HD-232(A)	.0015–.0025	.003–.004	.0005–.0015	.008	.010	.010	.012	2 11/16	85 1/2@1 15/16	45

① **NOTE—15-degree intake valves used starting with following FBC engine serial numbers: 318 No. 5682; 318A No. 591; 361 No. 1953; 361A No. 648; 401 No. 1189; 401A No. 552; 450 No. 1110; 450A No. 664.**

PISTON AND RING CLEARANCES

Year	Engine Model	Piston Skirt, Inches		Fitting Pistons with Shim and Spring Scale		Ring End Gap, Inch ①		Ring and Groove, Inch	
		Top	Bottom	Shim Thickness	Pounds Pull on Scale	Com-pression	Oil	Com-pression	Oil
1942–46	BLD-250	.0015	.0015	.0015	5 to 12	.010–.020	.010–.018	.0015–.003	.0015–.003
1942–46	BLD-269(A)	.0015	.0015	.0015	5 to 12	.013–.023	.013–.021	.0015–.003	.0015–.003
1937–40	FAB-241	.004②	.004②	.004②	5 to 9②	.007–.015	.007–.015	.0015	.0005–.0015
1937–40	FAB-259	.004②	.004②	.004②	5 to 9②	.007–.015	.007–.015	.0015	.0005–.0015
1941–42	FAC-241(A)	.004	.004	.004	5 to 12	.010–.020	.010–.018	.0025–.004④	.0015–.003
1941–42	FAC-259(A)	.004	.004	.004	5 to 12	.013–.023	.013–.021	.0025–.004④	.0015–.003
1937–40	FBB-298(A)	.004	.004	.0015	5 to 12	.007–.015	.007–.015	.0015	.0005–.0015
1937–40	FBB-361(A)	.0015–.002	.0015–.002	.0015	5 to 12	.007–.015	.007–.015	.0015	.0005–.0015
1937–41	FBB-401(A)	.0015–.002	.0015–.002	.0015	5 to 12	.007–.015	.007–.015	.0015	.0005–.0015
1939–40	FBB-450A	.0015–.002	.0015–.002	.0015	5 to 12	.007–.015	.007–.015	.0015	.0005–.0015

NOTE—For International engines developed since 1942, see page 915.

PISTON AND RING CLEARANCES

Year	Engine Model	Piston Skirt, Inches		Fitting Pistons with Shim and Spring Scale		Ring End Gap, Inch ①		Ring and Groove, Inch	
		Top	Bottom	Shim Thickness	Pounds Pull on Scale	Com-pression	Oil	Com-pression	Oil
1941–42	FBC-318(A)	.0015–.002	.0015–.002	.0015	5 to 12	.010–.020	.010–.020	.0025–.004⑤	.0015–.003
1941–42	FBC-361(A)	.0015–.002	.0015–.002	.0015	5 to 12	.013–.023	.013–.021	.0015–.003	.0015–.0035
1941–42	FBC-401(A)	.0015–.002	.0015–.002	.0015	5 to 12	.013–.023	.013–.021	.0015–.003	.0015–.0035
1941–42	FBC-450A	.0015–.002	.0015–.002	.0015	5 to 12	.013–.023	.013–.021	.0015–.003	.0015–.0035
1936–38	FC-132(A)	.003–.004	.003–.004	.0035	5 to 12	.007–.015	.007–.015	.0015	.001–.0025
1936–42	FEB-648	.005	.005	.005	5 to 12	.015–.020	.015–.020	.0015–.003	.0015–.0035
1941–46	GRD-175(A)	.0035	.0035	.0035	5 to 12	.007–.017	.007–.015	.0015–.003⑧	.001–.0025
1941–46	GRD-214(A)	.0035	.0035	.0035	5 to 12	.007–.017	.013–.021	.002–.0035④	.001–.0025
1941–46	GRD-233(A)	.0035	.0035	.0035	5 to 12	.007–.017	.007–.017	.002–.0035④	.001–.0025
1937–40	HD-174, A, B, C	.0035	.0035	.0035	5 to 12	.007–.015	.007–.015	.0015	.001–.0025
1937–40	HD-213, A, B, C	.0035	.0035	.0035	5 to 12	.007–.015	.007–.015	.0015	.001–.0025
1937–40	HD-232(A)	.004	.004	.004	5 to 12	.007–.015	.007–.015	.0015	.001–.0025

① End gaps are for cylinder bores without taper. Fit rings in tapered bores with not less than the maximum dimension given.

② For cast iron pistons, .0035" clearance with a 5 to 12 pound pull.

⑧ For top ring only; 2nd and 3rd rings, .001"–.0025".

④ For top ring only; 2nd and 3rd rings, .0015"–.003".

⑤ For top ring only; 2nd and 3rd rings, .002"–.0035".

ENGINE BEARING SPECIFICATIONS

Year	Engine Model	Camshaft		Connecting Rod			Mains				
		Jour-nal Diam-eter	Clear-ance	Journal Diameter	Clear-ance	Bear-ing Bolt Ten-sion Lb. Ft.	Journal Diameter	Clear-ance	Bear-ing Bolt Ten-sion Lb. Ft.	Thrust on No.	End-play
1942–46	BLD-250	①	.002–.0035	2.122–2.123	.0015–.0035	56–70	2.7005–2.7015	.0015–.004	⑥	7	.0035–.0075
1942–46	BLD-269(A)	①	.002–.0035	2.122–2.123	.0015–.0035	56–70	2.7005–2.7015	.0015–.004	⑥	7	.0035–.0075
1937–40	FAB-241	①	.002–.0035	2.122–2.123	.0015–.0035	60	2.372–2.373	.0015–.004	⑥	7	.0035–.0075
1937–40	FAB-259	①	.002–.0035	2.122–2.123	.0015–.0035	60	2.372–2.373	.0015–.004	⑥	7	.0035–.0075
1941–42	FAC-241(A)	①	.002–.0035	2.122–2.123	.0015–.0035	56–70	2.372–3.373	.0015–.004	⑥	7	.0035–.0075
1941–42	FAC-259(A)	①	.002–.0035	2.122–2.123	.0015–.0035	56–70	2.372–2.373	.0015–.004	⑥	7	.0035–.0075
1937–40	FBB-298(A)	②	.002–.0035	2.247–2.248	.0015–.0035	60	2.7005–2.7015	.0015–.004	⑥	7	.0035–.0075
1937–40	FBB-361(A)	②	.002–.0035	2.247–2.248	.0015–.0035	60	2.7005–2.7015	.0015–.004	⑥	7	.0035–.0075
1937–41	FBB-401(A)	②	.002–.0035	2.247–2.248	.0015–.0035	60	2.7005–2,7015	.0015–.004	⑥	7	.0035–.0075
1939–40	FBB-450A	②	.002–.0035	2.247–2.248	.0015–.0035	60	2.7005–2.7015	.0015–.004	⑥	7	.0035–.0075
1941–42	FBC-318(A)	②	.002–.0035	2.247–2.248	.0015–.0035	56–70	2.7005–2.7015	.0015–.004	⑥	7	.0035–.0075
1941–42	FBC-361(A)	②	.002–.0035	2.247–2.248	.0015–.0035	56–70	2.7005–2.7015	.0015–.004	⑥	7	.0035–.0075
1941–42	FBC-401(A)	②	.002–.0035	2.247–2.248	.0015–.0035	56–70	2.7005–2.7015	.0015–.004	⑥	7	.0035–.0075
1941–42	FBC-450A	②	.002–.0035	2.247–2.248	.0015–.0035	56–70	2.7005–2.7015	.0015–.004	⑥	7	.0035–.0075
1936–38	FC-132(A)	③	.001–.0025	1.749–1.750	.001–.003	60	2.124–2.125	.001–.0025	⑥	2	.0025–.0065
1936–42	FEB-648	⑤	.002–.0035	2.749–2.750	.0025–.0045	60	3.245–3.246	.003–.005	⑥	---	.0035–.0075
1941–46	GRD-175(A)	④	.001–.0025	2.000–2.001	.001–.0025	56–70	2.635–2.636	.0015–.003	⑥	1	.0035–.0075

NOTE—For International engines developed since 1942, see page 915.

ENGINE BEARING SPECIFICATIONS

Year	Engine Model	Camshaft		Connecting Rod			Mains				
		Journal Diameter	Clearance	Journal Diameter	Clearance	Bearing Bolt Tension Lb. Ft.	Journal Diameter	Clearance	Bearing Bolt Tension Lb. Ft.	Thrust on No.	End-play
1941-46	GRD-214(A)	④	.001-.0025	2.000-2.001	.001-.0025	56-70	2.635-2.636	.0015-.003	⑥	1	.0035-.0075
1941-46	GRD-233(A)	④	.001-.0025	2.000-2.001	.001-.0025	56-70	2.635-2.636	.0015-.003	⑥	1	.0035-.0075
1937-40	HD-174, A B C	④	.001-.0025	2.000-2.001	.001-.0025	60	2.635-2.636	.0015-.003	⑥	1	.0035-.0075
1937-40	HD-213, A B C	④	.001-.0025	2.000-2.001	.001-.0025	60	2.635-2.636	.0015-.003	⑥	1	0035-.0075
1937-40	HD-232(A)	④	.001-.0025	2.000-2.001	.001-.0025	60	2.635-2.636	.0015-.003	⑥	1	.0035-.0075

① No. 1—1.811″-1.812″. No. 2—1.577″-1.578″. No. 3—1.562″-1.563″. No. 4—1.499″-1.500″.

② No. 1—2.109″-2.110″. No. 2—2.089″-2.090″. No. 3—2.069″-2.070″. No. 4—1.4995″-1.5005″.

③ No. 1—2.1230″-2.1235″. No. 2—1.8730″-1.8735″. No. 3—1.4980″-1.4985″.

④ No. 1—2.1855″-2.1860″. Nos. 2 and 3—1.9335″-1.9340″. No. 4—1.6220″-1.6225″.

⑤ No. 1—2.745″. No. 2—2.558″. No. 3—2.495″. No. 4—2.058″.

⑥ For ½″ and 9/16″ bolts, 75 to 85 pounds feet; for ⅝″ bolts, 90 to 100 pounds feet.

ENGINE

CYLINDER HEAD

1936-46: Tighten cylinder head nuts or capscrews in the order shown in illustrations. Recommended tension when using a tension indicating wrench is 60 lbs. ft. for L-head engines and 77 lbs. ft. for overhead valve engines. Increase tension evenly and after cylinder head has been tightened run the engine for a few minutes to bring it to operating temperature, then retighten to recommended tension.

NOTE—Be sure cylinder head and block are smooth and clean. Coat both sides of gasket with clear sealing compound such as shellac and allow to dry until tacky. Install gaskets on GRD and HD engines to control water circulation by placing the small graduated water holes toward the valve side of the engine and the large water holes toward the rear of the engine.

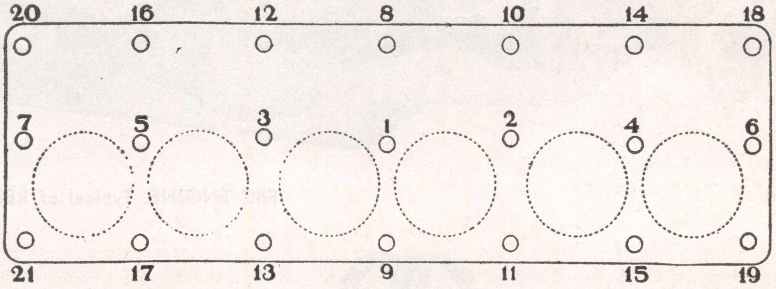
ROCKER ARMS & SHAFTS

1936-46: When a rocker arm bushing or end contact surface becomes worn, it is recommended that rocker arm and bushing be replaced as a unit. Rocker arm bushing are burnished and are reamed at assembly to .875″-.876″. See that oil holes in bushings line up with holes in rocker arms.

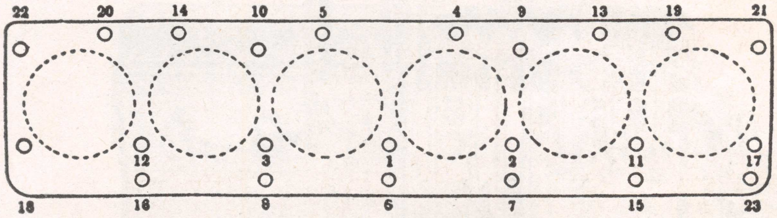
In some cases it is possible to touch up the valve stem and rocker arm end surfaces to obtain correct contact, as illustrated, for quiet operation at maximum clearance.

The valve stem end must be square with the valve stem. The radius on the rocker arm end must be held to .485″-.515″ as shown and **under no circumstances** should the end be ground off more than .010″. Valve stem and rocker arm ends are casehardened; hence, if too much metal is removed, the contact surfaces will be soft

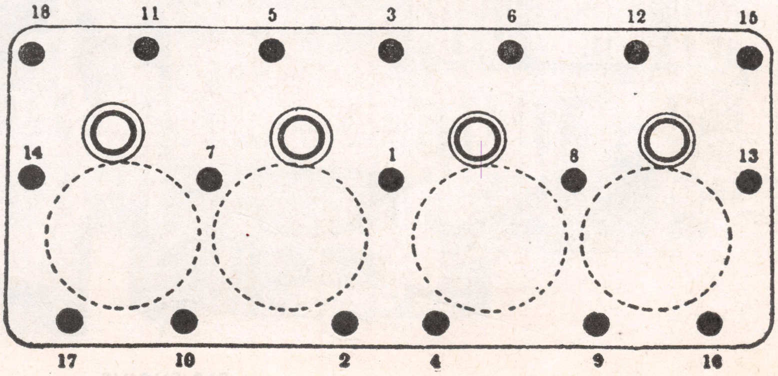
(Continued on page 121)



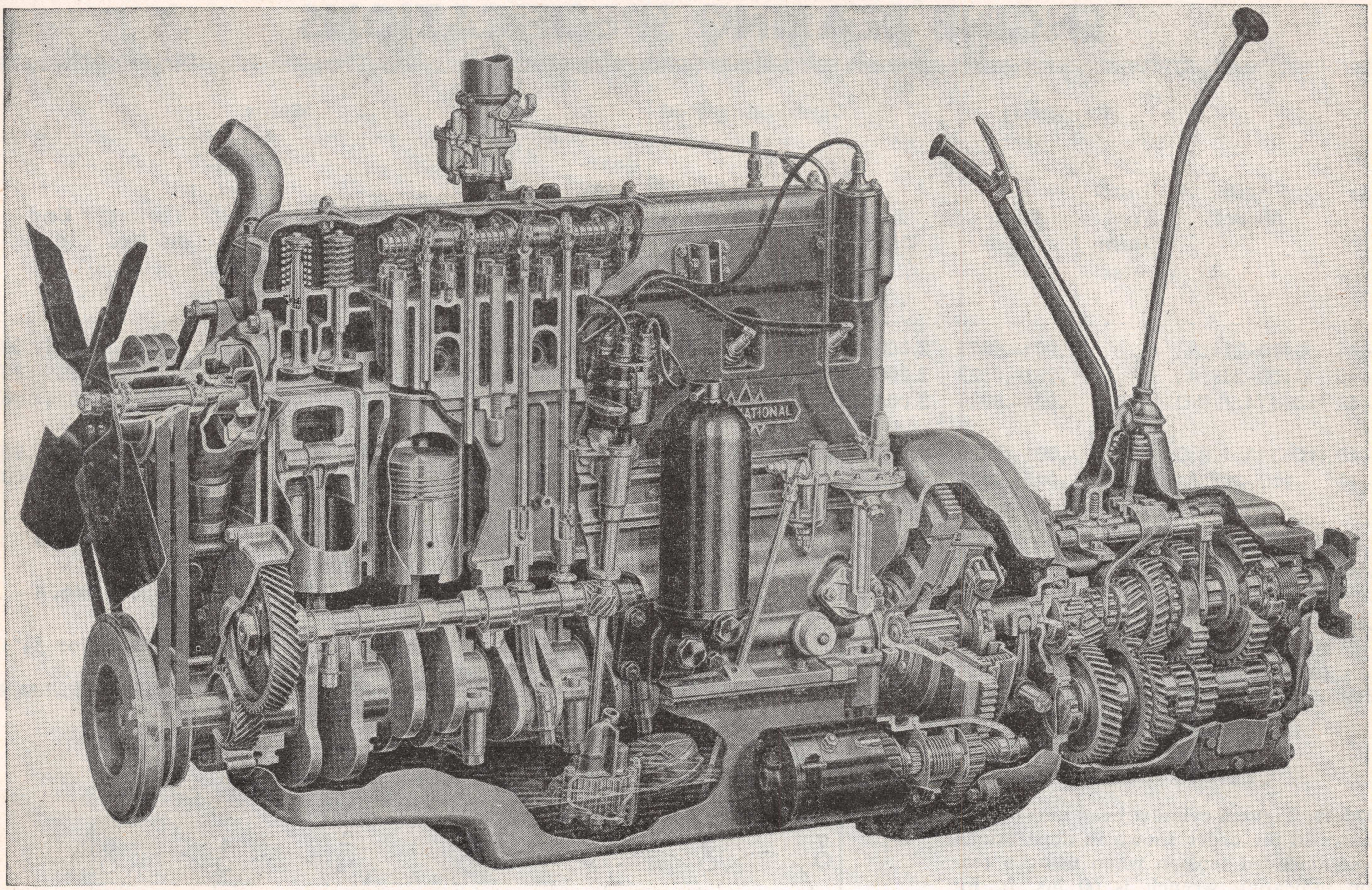
Cylinder Head Tightening Sequence. Engine GRD.



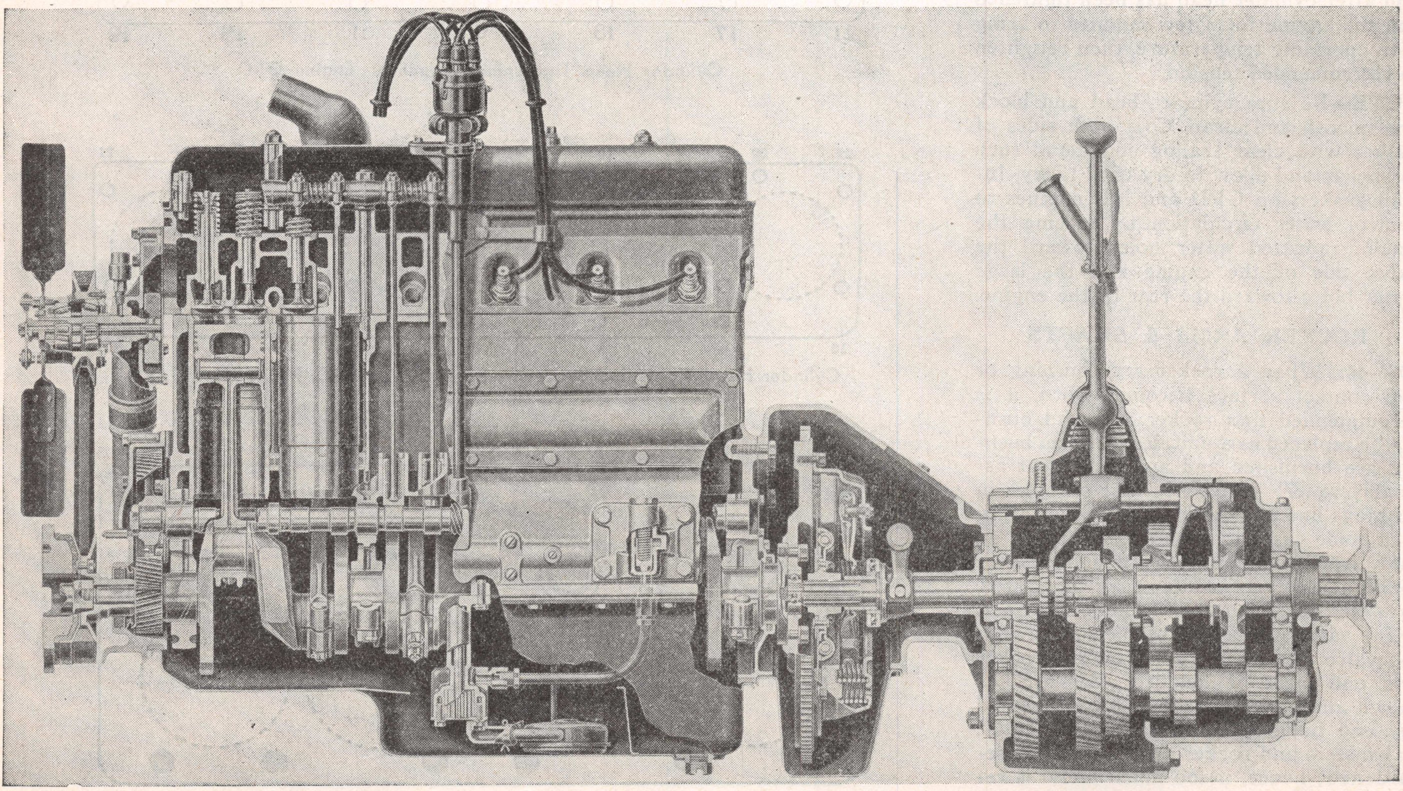
Cylinder Head Tightening Sequence. Engines FAB, FAC, FBB, FBC, HD, RED



Cylinder Head Tightening Sequence. Engine FC.

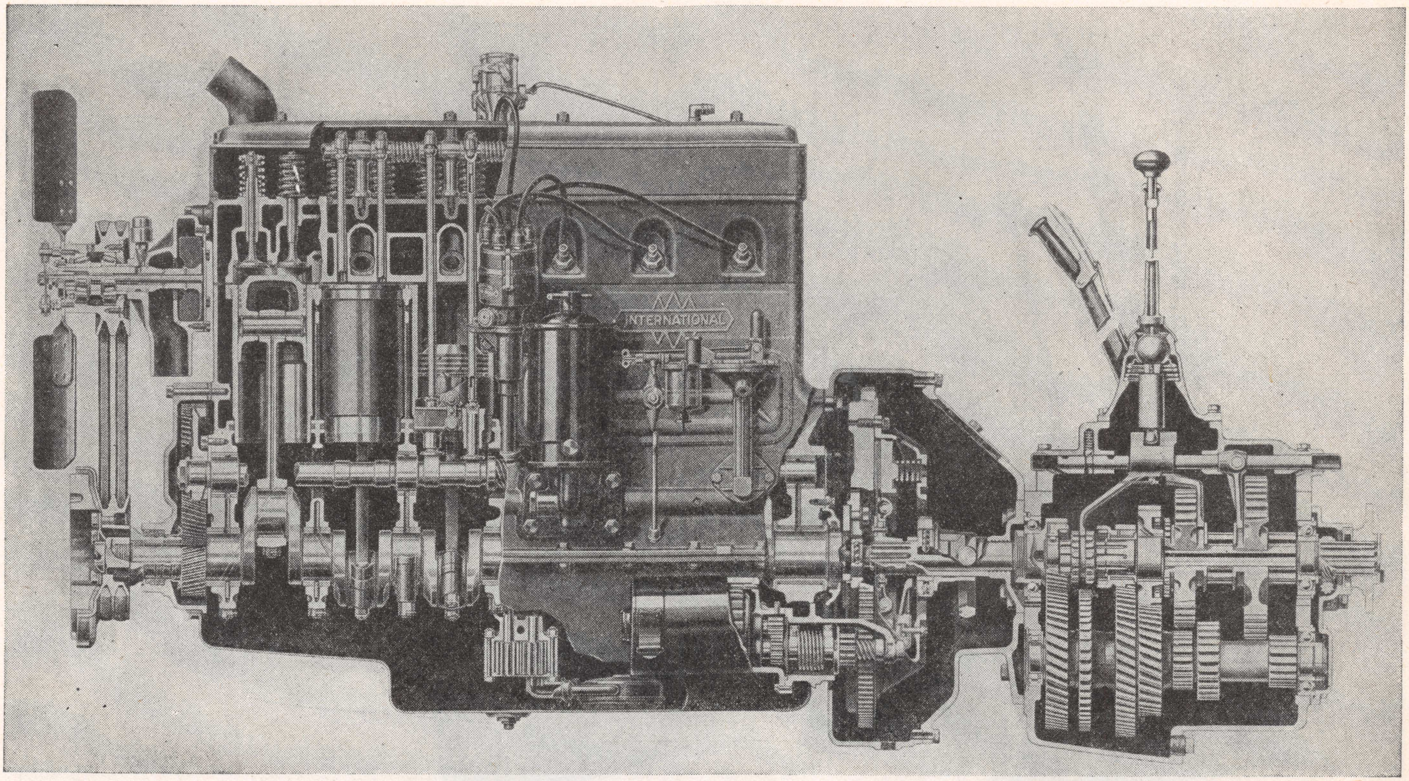

INTERNATIONAL

FBC ENGINE. Typical of RED

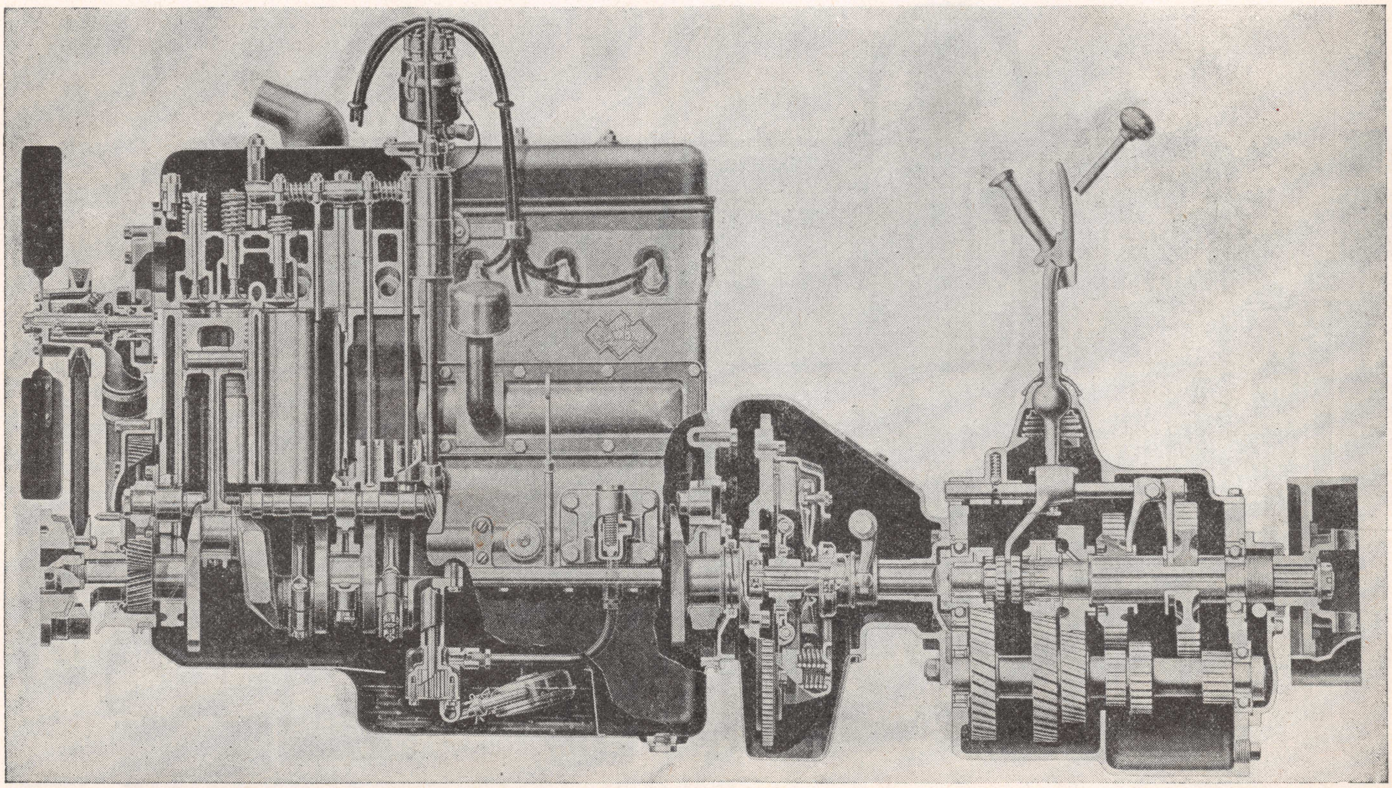


FAB ENGINE

NOTE—For International engines developed since 1942, see page 915.

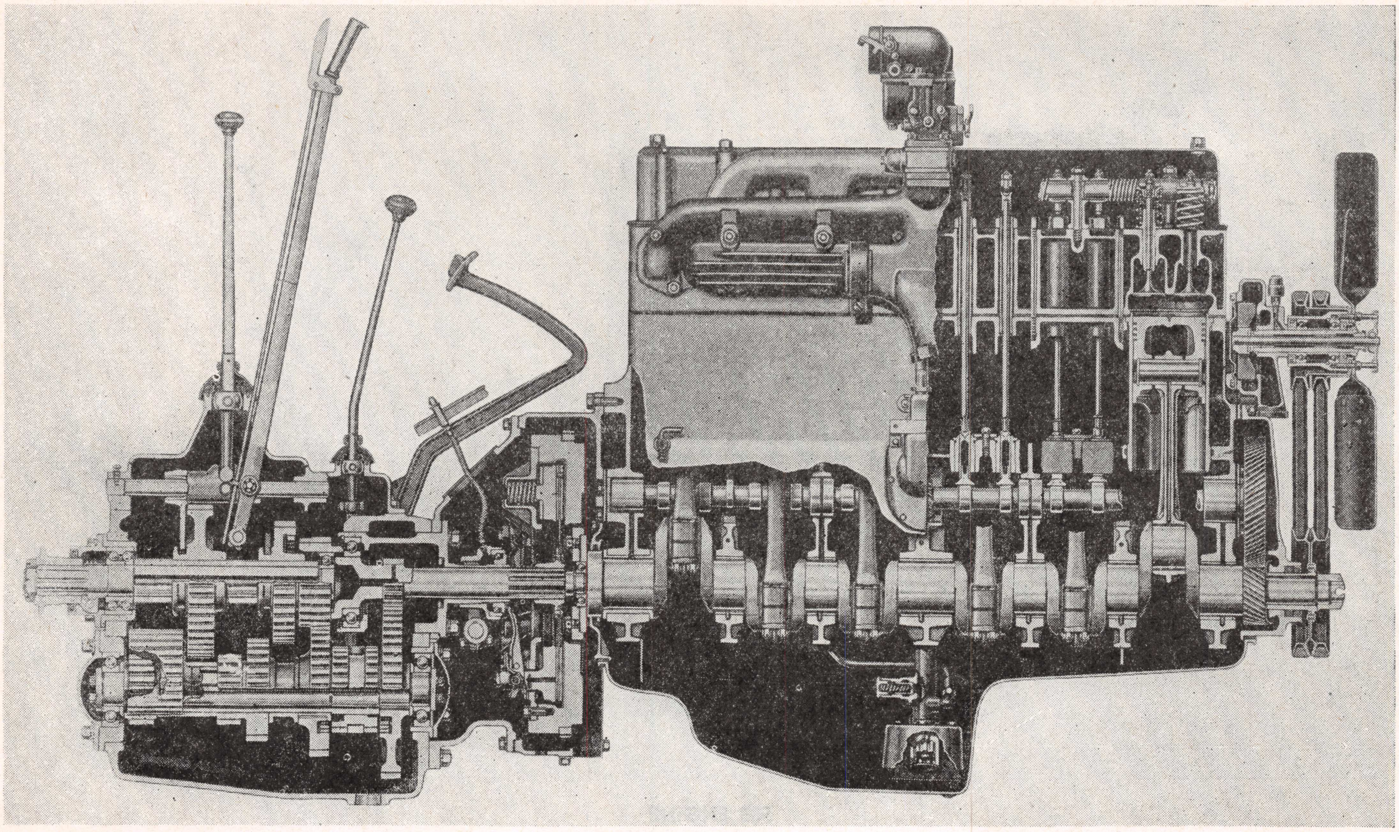

INTERNATIONAL

FBB ENGINE

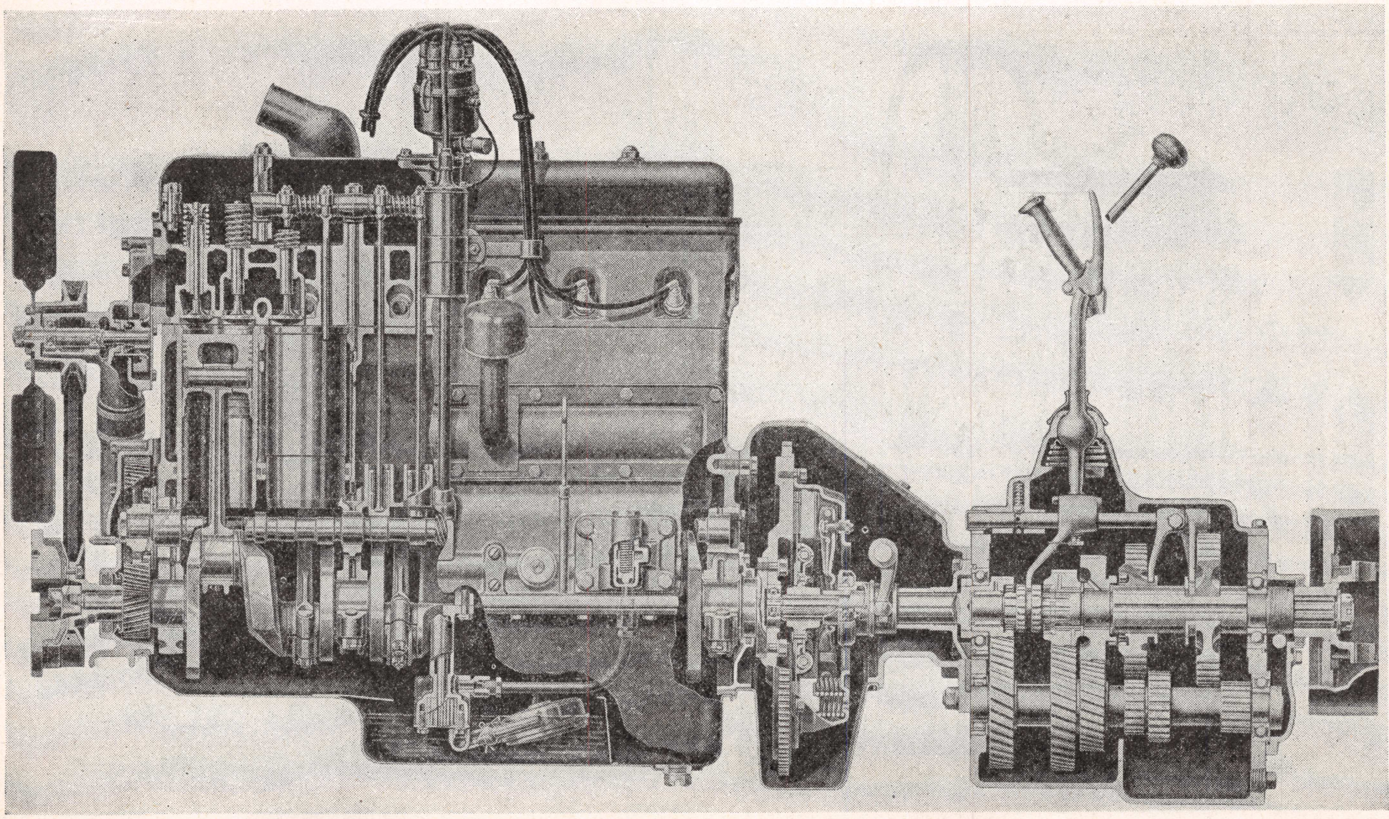


BLD ENGINE

NOTE—For International engines developed since 1942, see page 915.

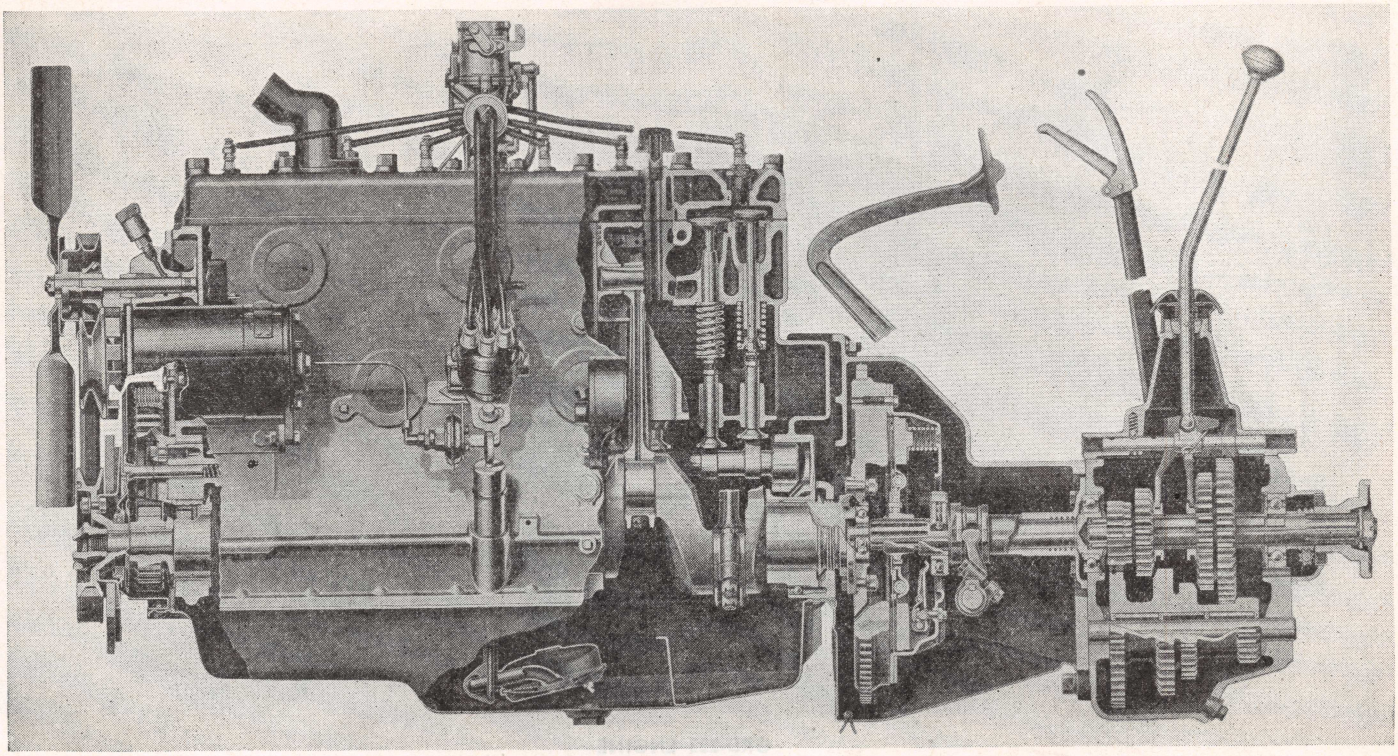


FEB ENGINE

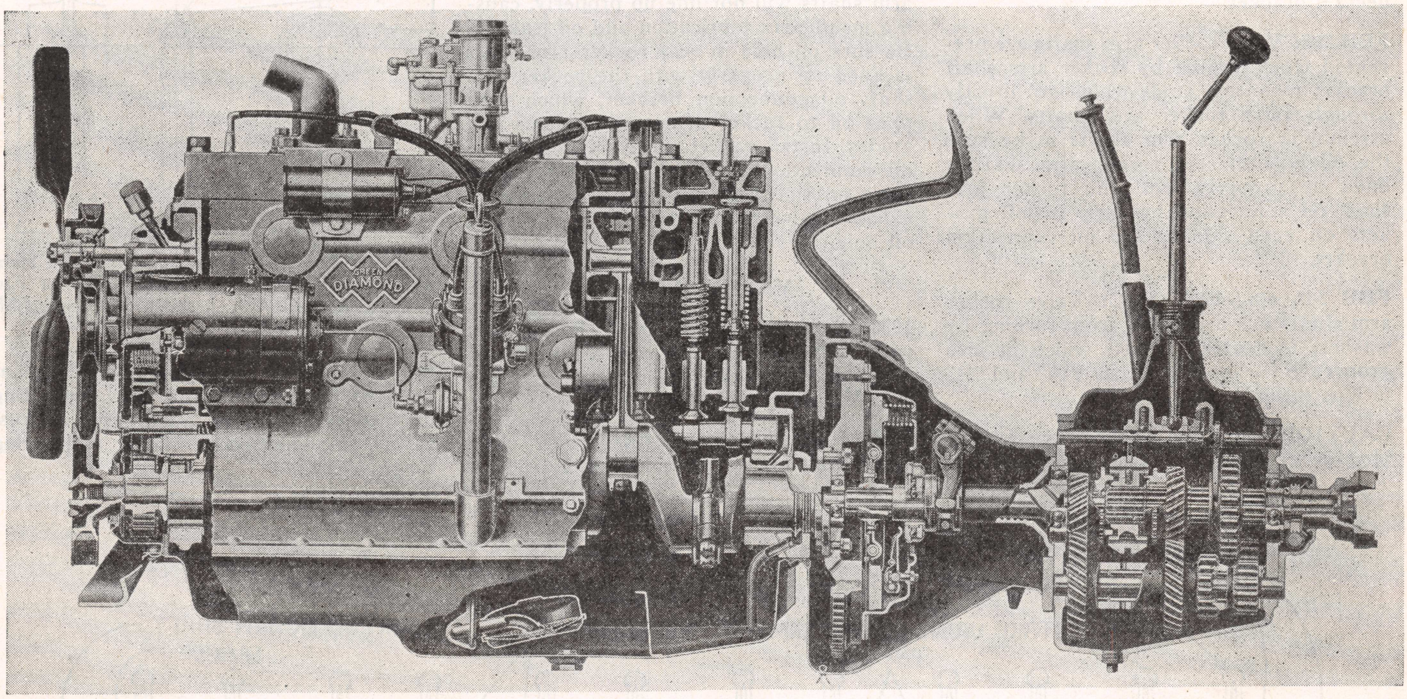


FAC-241 ENGINE

NOTE—For International engines developed since 1942, see page 915.



HD ENGINE



GRD-214 ENGINE

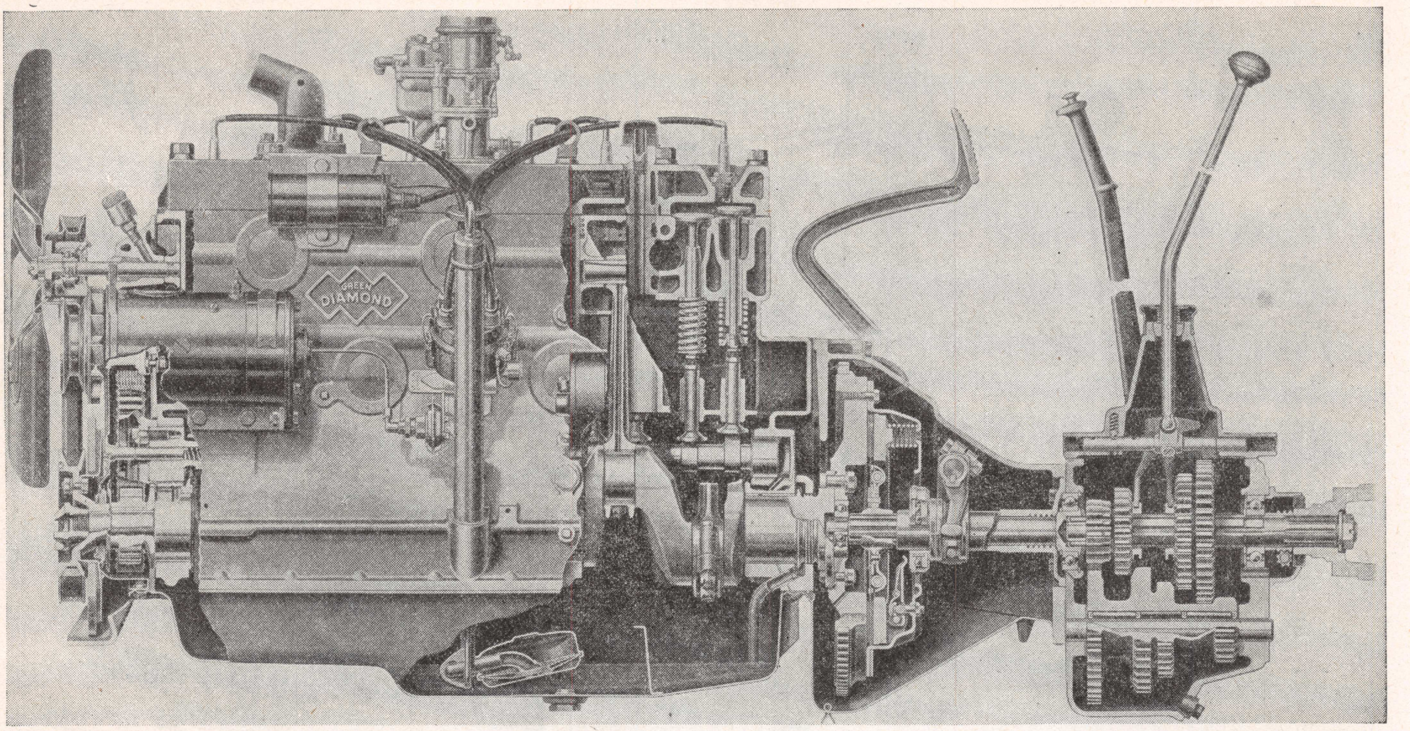
(Continued from page 117)

and rapid wear will follow. The rocker arm end must be parallel with the bushing bore within .002″ indicator reading at 2″. If valve stem and rocker arm ends are not in proper relation to each other, the valve stem is forced to one side and rapid wear of the valve guide will result.

Assembly of valve rocker arms, springs, brackets, and washers on valve rocker arm shafts is illustrated. Note that exhaust valve rocker arms are drilled for additional lubrication to exhaust valve stems and guides, while intake valve rocker arms are not drilled.

FAB, FAC: Valve rocker arm shafts are prevented from turning by a rocker arm shaft bracket mounting stud, front and rear, which fits into a notch or groove in the shaft. Oil holes in rocker arm shafts should be up; hence it is important that the front and rear shafts are not reversed.

NOTE—For International engines developed since 1942, see page 915.


GREEN DIAMOND

GRD-233 ENGINE

Install gaskets on each side of the oil connection bracket.

FBB 298: Valve rocker arm shafts are prevented from turning by rocker arm shaft bracket mounting studs which go directly through valve rocker arm shafts. When assembling rocker arm shafts make sure the oil hole in **rear** rocker arm shaft is lined up properly with the rocker arm shaft oil connection bracket. Install gaskets on each side of the oil connection bracket.

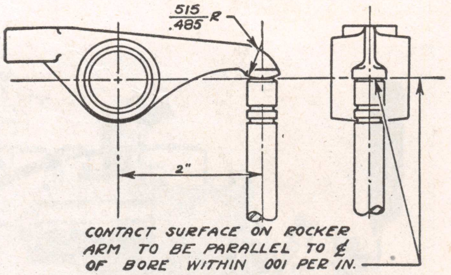
FBB 361, 401, 450A, FBC: Valve rocker arm shafts are prevented from turning by washers in center brackets which fit into grooves in rocker arm shafts ("A" and "B" in illustration).

CAUTION—Be sure washers are assembled in grooves. If washers are not assembled in grooves, the oil holes in rocker arm shafts will not line up properly, causing insufficient lubrication and oil leakage. Be sure oil hole in **rear** rocker arm shaft is lined up properly with the rocker arm shaft oil connection bracket, which supplies oil to rocker arms, valve stems and guides. Install gaskets on each side of the oil connection bracket. Assemble rocker arms on shafts in the proper positions—exhaust valve rocker arms have the extra oil hole.

VALVE SPRINGS

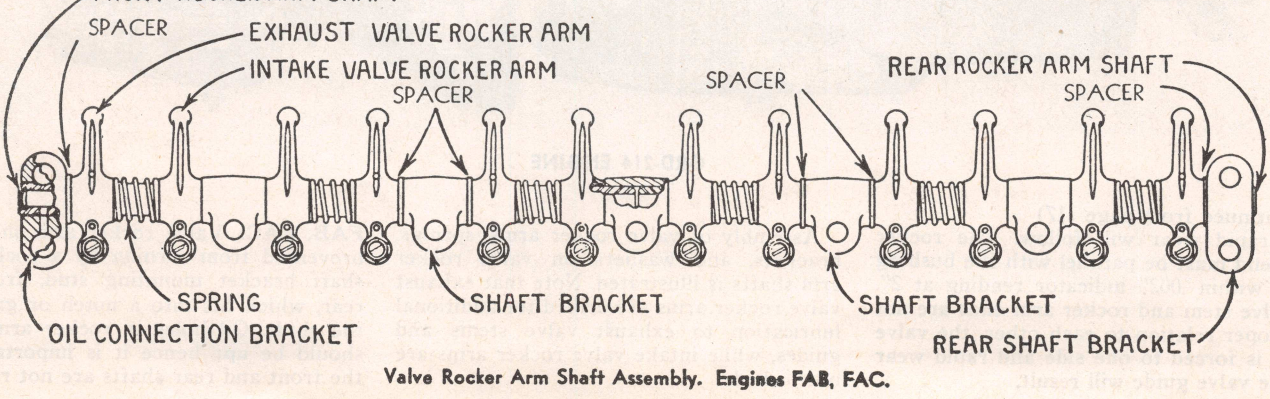
1936-46: Valve springs should be checked with Valve Spring Tester and replaced if they do not meet specifications. See VALVE SYSTEM table.

FAB: Install valve springs with close coiled ends against cylinder head.

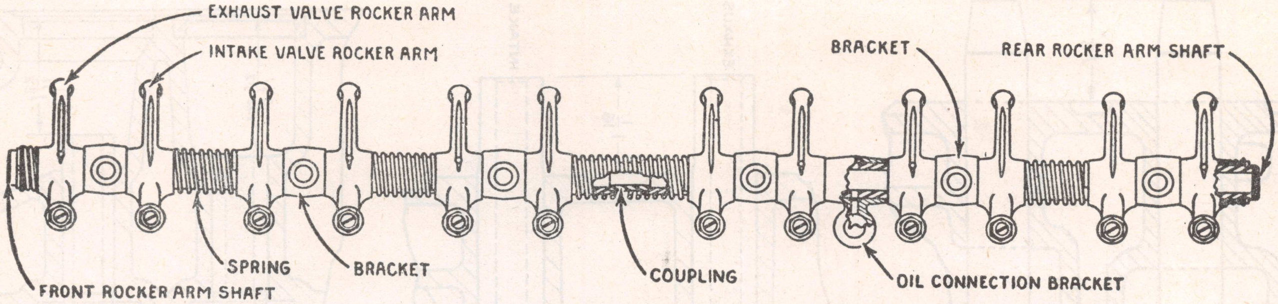

.515
.485 R
2"
CONTACT SURFACE ON ROCKER ARM TO BE PARALLEL TO ℄ OF BORE WITHIN .001 PER IN.

Showing Correct Contact Between Valve Stem and Rocker Arm and Relation of Rocker Arm End to Rocker Arm Bushing. Engines FAB, FAC, FBB, FBC.

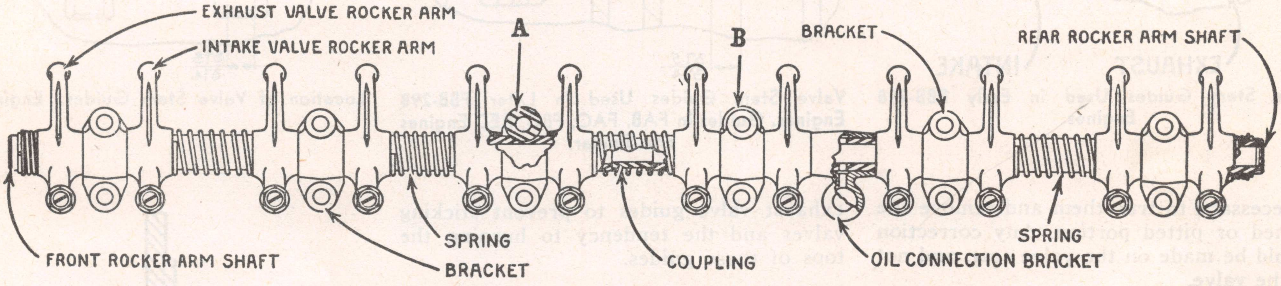
NOTE—Service Bulletin No. 80, 1939, announced the incorporation of valve spring dampeners for both intake and exhaust valves, to reduce valve clatter and spring surge.


FRONT ROCKER ARM SHAFT
SPACER
EXHAUST VALVE ROCKER ARM
INTAKE VALVE ROCKER ARM
SPACER
SPACER
REAR ROCKER ARM SHAFT
SPACER
SPRING
OIL CONNECTION BRACKET
SHAFT BRACKET
SHAFT BRACKET
REAR SHAFT BRACKET

Valve Rocker Arm Shaft Assembly. Engines FAB, FAC.


EXHAUST VALVE ROCKER ARM
INTAKE VALVE ROCKER ARM
BRACKET
REAR ROCKER ARM SHAFT
SPRING
BRACKET
COUPLING
OIL CONNECTION BRACKET
FRONT ROCKER ARM SHAFT

Valve Rocker Arm Shaft Assembly. Engine FBB-298.


EXHAUST VALVE ROCKER ARM
INTAKE VALVE ROCKER ARM
A
B
BRACKET
REAR ROCKER ARM SHAFT
SPRING
SPRING
BRACKET
COUPLING
OIL CONNECTION BRACKET
FRONT ROCKER ARM SHAFT

Valve Rocker Arm Shaft Assembly. Engines FBB-361, 401, 450A, All FBC and RED.

FAC, FBB, FBC: Install valve springs with close coiled ends against cylinder head.

FC, GRD, HD: Install valve springs with close coiled ends against cylinder block.

VALVE CLEARANCE ADJUSTMENT

1936-46: It is important to run the engine at a fast idle to allow all the parts, which affect the proper adjustment of the valves, to expand to their normal operating condition.

During this warm-up period, tighten the cylinder head bolts, manifold and exhaust flange bolts. Then slow down the engine to normal idle speed and adjust the tappets to the clearances shown in the VALVE SYSTEM table. Accelerate the engine fairly fast for about 3 minutes to allow the tappets to settle and then re-check all clearances.

On the HD and GRD engines, it is necessary to remove the manifolds to adjust the tappets.

VALVE SEAT INSERTS

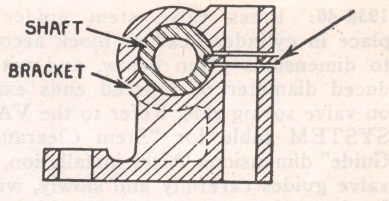
1936-46 (except FC): Since these inserts are too hard to reface by the ordinary grinding methods, a high-speed grinding stone or a special lapping tool should be used to perform this operation. When using this equipment, be sure valve guides are clean and that the valve guide pilot is a snug fit in order to assure a concentric finish. Finished seats should be checked with a dial indicator and run-out should not exceed .0005".

NOTE—Inserts supplied in service are .030" larger in diameter than those used in production, which permits a tight fit in the cylinder head or block—as the case may be. Special oversize cutters are available to facilitate the installation of inserts. When installed, be sure to peen the inserts securely in place, using a dull-pointed chisel, ¼" wide, or a special peening tool to peen the cylinder head (or cylinder block) metal over the outer edge. Letter "M" is stamped on top of the inserts and must be installed with this side out.

If special insert replacement equipment is not available, the following procedure may be followed when replacing inserts: Use a drill which is smaller in diameter than the insert width and drill two holes at opposite sides, but not all the way through. Cut through the undrilled portion of the insert with a sharp chisel and remove the two pieces.

To install, pack the insert in "dry ice" for at least fifteen minutes to allow the metal to contract, and heat the valve port area gradually, to permit this material to expand. Then press the insert into the cylinder head, using extreme care to see that it is not cocked or misaligned. When installed, finish the seats with the grinding or lapping equipment already mentioned.

NOTE—Valve seat position should approximate the dimensions shown in sketches "B" and "C." In general, the width of exhaust seats should range between the average and maximum specifications while intake seats should be between the minimum and average specifications. The center area of the valve face or an area slightly above the center should rest on the valve seat. This will limit the amount of valve head that protrudes into the combustion chamber and the consequent valve heating. New valves should not be refaced, but should be checked for trueness. No more material should be removed from the face of used valves than


SHAFT
BRACKET

Valve Rocker Arm Shaft Locking Washers. Engines FBB-361, 401, 450A, All FBC, RED.

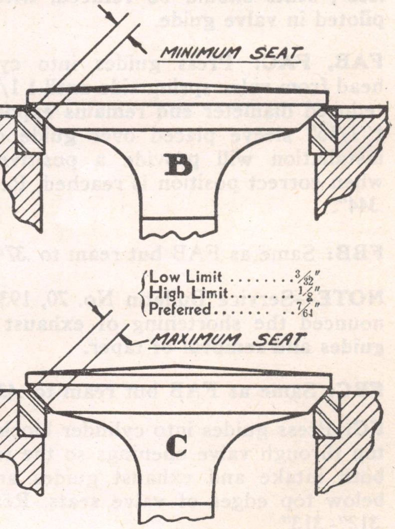
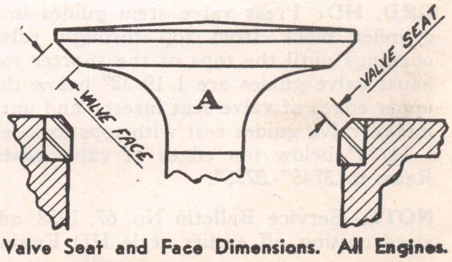
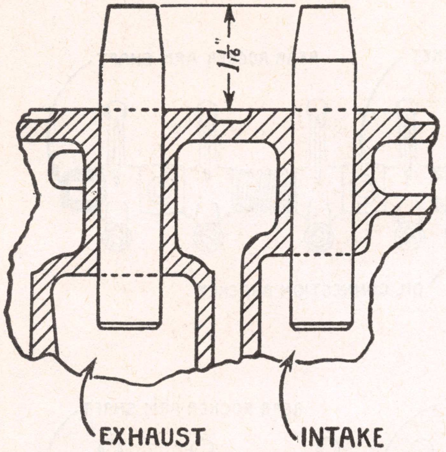

MINIMUM SEAT
B
Low Limit .... 3/32"
High Limit .... 1/8"
Preferred .... 7/64"
MAXIMUM SEAT
C

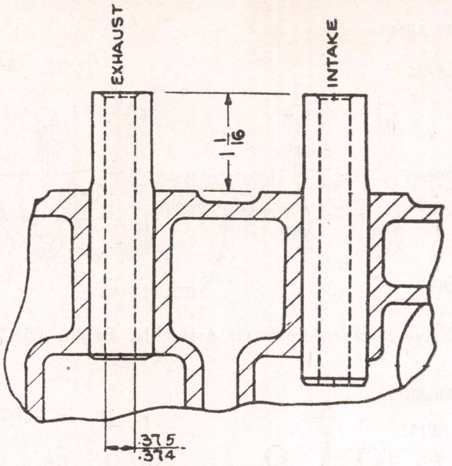
Fig. 9


VALVE SEAT
VALVE FACE
A

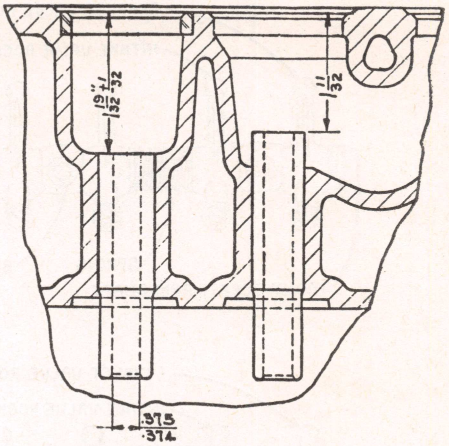
Valve Seat and Face Dimensions. All Engines.



Valve Stem Guides Used in Early FBB-298 Engines.



Valve Stem Guides Used in Later FBB-298 Engines. Guides in FAB, FAC, FBC, RED Engines are Similar.



Location of Valve Stem Guides. Engine GRD.

is necessary to true them and remove the burned or pitted portion. Any correction should be made on the valve seat, and not on the valve.

VALVE STEM GUIDES

1936-46: Press valve stem guides into place in cylinder head or block according to dimensions given below, and with reduced diameter or tapered ends exposed on valve spring side. Refer to the VALVE SYSTEM table for "Stem Clearance in Guide" dimensions. After installation, ream valve guides carefully and slowly, without forcing. After reaming valve guides, check valve seats and if runout exceeds .002" to .003", seats should be refaced, with tool piloted in valve guide.

FAB, FAC: Press guides into cylinder head from valve spring side until 1 1/16" of reduced diameter end remains exposed. A 1 1/16" sleeve placed over guide during installation will provide a positive stop when correct position is reached. Ream to .344".

FBB: Same as FAB but ream to .374".

NOTE—Service Bulletin No. 70, 1939, announced the shortening of exhaust valve guides and removal of taper.

FBC: Same as FAB but ream to .4365".

FC: Press guides into cylinder block from top through valve openings so the tops of both intake and exhaust guides are ¾" below top edges of valve seats. Ream to .312"-.313".

GRD, HD: Press valve stem guides into cylinder block from top through valve openings until the tops of the shorter exhaust valve guides are 1 19/32" below the upper edges of valve seat inserts, and until intake valve guides rest with tops exposed 1 11/32" below top edges of valve seats. Ream to .3745"-.3755".

NOTE—Service Bulletin No. 67, 1938, advised cutting off earlier style HD Engine exhaust valve guides to prevent sticking valves and the tendency to burning the tops of these guides.

VALVE TAPPETS & GUIDES

FAB, FAC: Valve tappet guides are integral with crankcase. Valve tappets, or lifters, can be removed from engine by taking off cover on side of cylinder block. Tappets then can be lifted out, which will permit easy removal of camshaft.

FBB 298: Valve tappet guides are separate from crankcase and are in two sections, each section taking six tappets. Valve tappets are held in guides by small lock rings fitted into grooves at end of tappets. The lock rings prevent tappets from falling out when camshaft is removed.

FBB 361, 401, 450A; FBC: Valve tappet guides are integral with crankcase and have valve tappet retainers pressed into place. To remove camshaft, valve tappets are pushed upward which permits valve tappet retainers to snap into grooves at end of tappets as illustrated. Camshaft then may be removed without danger of tappets falling out. After camshaft is reassembled, tappets may be pushed down into position by the push rods.

FC, GRD, HD: Valve tappet guides are integral with crankcase. Camshaft must be removed to disassemble valve tappets.

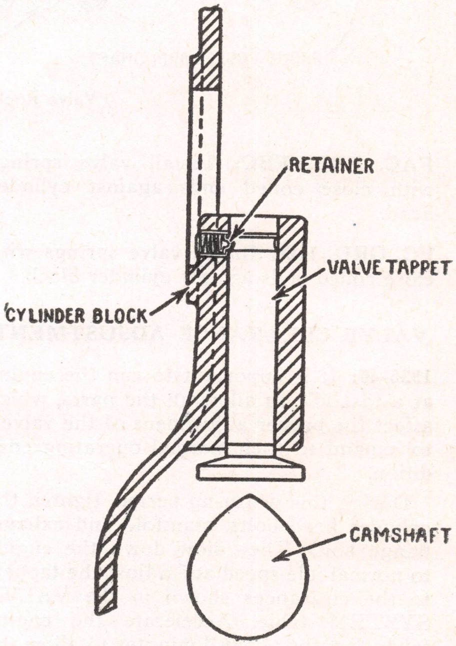
VALVE TIMING

1936-46: Check the timing with the engine at normal room temperature and adjust the valve lash to the clearance for timing as given in the VALVE SYSTEM table.

Engine Model	Intake Opens	Exhaust Closes
BLD	5 BTDC	10 ATDC
HD	TDC	4 ATDC
FC	5 ATDC	5 ATDC
FAB	10 ATDC	15 ATDC
FBB-298	10 ATDC	15 ATDC
FBB-298A	10 ATDC	15 ATDC
FBB-361	5 ATDC	10 ATDC
FBB-361A	5 ATDC	10 ATDC
FBB-401	5 ATDC	10 ATDC
FBB-401A	5 ATDC	10 ATDC
FBB-450A	5 ATDC	10 ATDC
FEB	10 ATDC	10 ATDC
GRD	10 BTDC	5 ATDC
FAC*	2 BTDC	9½ ATDC
FAC**	5 BTDC	10 ATDC
FBC	5 ATDC	10 ATDC

*Before Eng. No. 2400 on FAC-241; before Eng. No. 3300 on FAC-259; before Eng. No. 750 on FAC-259A.

**Valve timing after the above engine numbers.

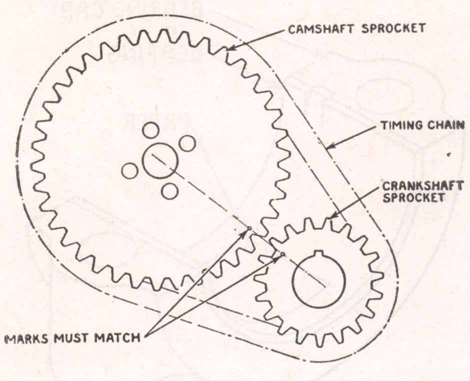


Valve Tappet Retainers. Engines FBB-361, 401, 450A, All FBC and RED.

TIMING CHAIN & SPROCKETS

GRD, HD: Always use puller or pusher tools to remove or replace timing chain sprockets. To obtain correct relation be-

NOTE—For International engines developed since 1942, see page 915.



Alignment of Timing Marks. Engines GRD, HD.

tween crankshaft and camshaft when installing the chain, turn the sprockets so that the timing marks are in a direct line through the centers of both shafts, as illustrated. With chain in position check alignment of marks with straight edge or timing gear indicator tool.

TIMING GEARS

FAB, FAC, FBB, FBC, FC: Always use puller or pusher tools to remove or replace timing gears. Do not drive gears on or off. To obtain correct relation between crankshaft and camshaft install the gears so that the timing marks match, as illustrated.

CAMSHAFT & BEARINGS

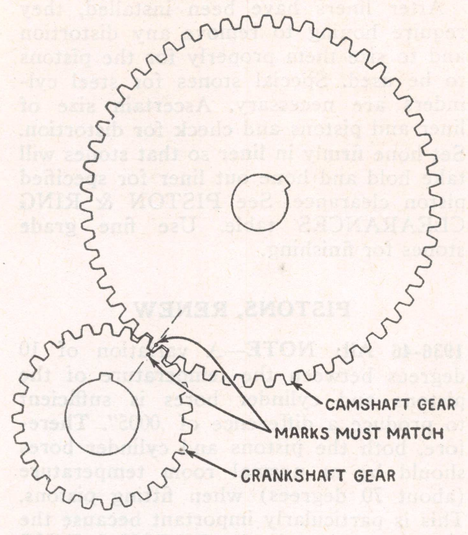
GRD, HD: Examine camshaft bearing journals and if grooved or scored, shaft should be replaced. Only the front camshaft bearing is replaceable, the second, third, and rear bearings being integral with the crankcase. The front bearing must be installed so the oil hole lines up with the oil supply hole in cylinder block. The bearing must be line-reamed to size after installation in crankcase. A Bushing Removing and Installing Tool and a Camshaft Bushing Line-Reamer are available.

FAB, FAC, FBB, FBC, FC: Check runout of camshaft, using a dial gauge with the shaft mounted in "V" blocks or in a lathe. Examine bearing journals and if grooved or scored, regrind or install a new shaft and bearings.

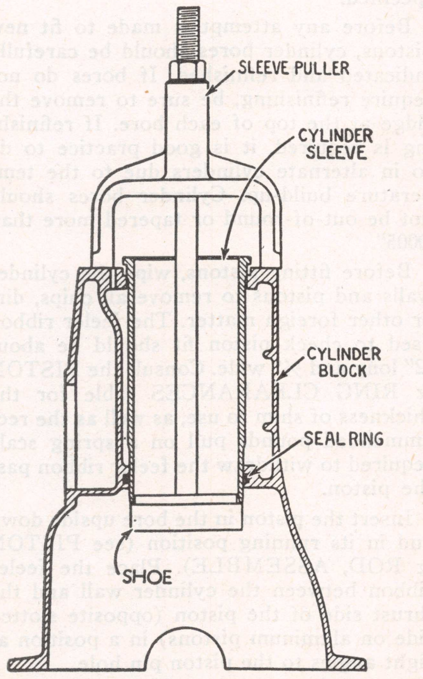
Camshaft bearings must be installed so the oil hole lines up with the oil supply hole in cylinder block and must be line-reamed to size after installation in crankcase.

PISTONS & RODS, REMOVE

FAB, FAC, FBB, FBC, FC, GRD, HD: Remove pistons and connecting rod assemblies from the top of the cylinder block after reaming out the ridge at top of cylinder bore which might damage a ring land. Avoid cutting into ring travel area. Cylinder numbers are stamped on a flat space on regular production rods and caps but not on replacement units. Look for numbers as rods are removed and put the proper number of punch marks on the camshaft side of any unnumbered units.



Alignment of Timing Marks. Engines FAB, FAC, FBB, FBC, FC, RED.



Cylinder Sleeve Puller for Engines FAB, FAC, FBB-298.

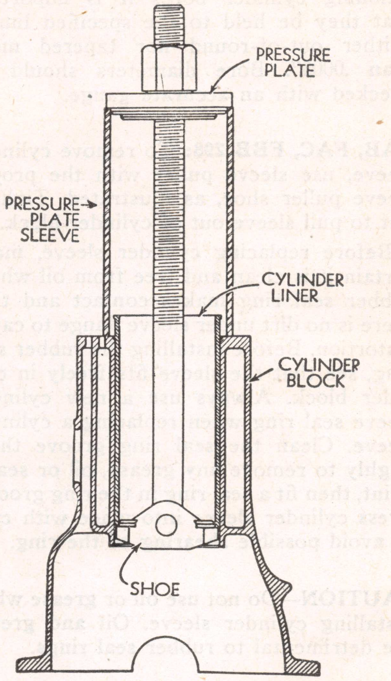
PISTONS & RODS, ASSEMBLE

Install connecting rod assemblies always with cylinder numbers toward camshaft side of engine.

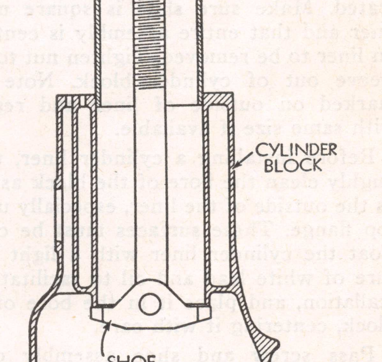
FBB, FBC: Assemble pistons to connecting rod with vertical slot toward camshaft.

CYLINDER BORES, SLEEVES & LINERS

NOTE—Examine cylinder bores before installing new pistons and rings. If necessary, the bores should be reconditioned especially if they are out-of-round or tapered. If bores do not require refinishing, be sure to remove any ridge at the top of each bore so when new rings are installed trouble will not be experienced with the top rings striking. It is good practice to refinish alternate cylinders to avoid temperature rise and expansion. When recon-



Cylinder Liner Removal. Engines FBB-361, 401, 450A, All FBC and RED.



Cylinder Liner Installation. Engines FBB-361, 401, 450A, All FBC and RED.

ditioning cylinder bores it is important that they be held to the specified limits, neither out-of-round nor tapered more than .0005". Bore diameters should be checked with an accurate gauge.

FAB, FAC, FBB 298: To remove cylinder sleeve, use sleeve puller with the proper sleeve puller shoe, as illustrated. Tighten nut to pull sleeve out of cylinder block.

Before replacing cylinder sleeve, make certain it is clean and free from oil where rubber seal ring makes contact and that there is no dirt under sleeve flange to cause distortion. Before installing the rubber seal ring, see that the sleeve fits freely in cylinder block. Always use a new cylinder sleeve seal ring when replacing a cylinder sleeve. Clean the seal ring groove thoroughly to remove any grease, oil or sealer paint, then fit a seal ring in the ring groove. Press cylinder sleeve into place with care to avoid possible shearing of the ring.

CAUTION—Do not use oil or grease when installing cylinder sleeve. Oil and grease are detrimental to rubber seal rings.

NOTE—To facilitate installation, the rubber seal ring may be lubricated by being dipped into a solution consisting of two tablespoonfuls of hand soap flakes dissolved in one quart of hot water with one ounce of glycerine added.

FBB 361, 401, 450A, FBC: Cylinder liners may be rehoned to take .005" and .010" oversize pistons. If necessary to exceed .010" oversize, cylinder liner should be replaced. To remove cylinder liner, use screw with pressure plate and sleeve as illustrated. Make sure shoe is square under liner and that entire assembly is centered on liner to be removed. Tighten nut to pull sleeve out of cylinder block. Note size marked on outside of liner and replace with same size if available.

Before installing a cylinder liner, thoroughly clean the bore of the block as well as the outside of the liner, especially under top flange. These surfaces must be clean. Coat the cylinder liner with a light mixture of white lead and oil to facilitate installation, and place it in the bore of the block, centering it with care.

Pass screw and shoe assembly down through liner and bore, bringing the shoe to rest against the boss or wall of the cylinder bore, as illustrated. Turn the shoe on an angle to obtain maximum bearing. Place pressure plate squarely on top of liner and turn nut down to the plate. Start the liner into bore by hand pressure on nut.

After the liner has been started smoothly into the bore, use ratchet wrench, continuing with care until the liner is almost in its final position, then release nut slightly and check to see that the shoe has not slipped and still is well supported on the boss of the cylinder bore. See that flange is clean, tighten nut again and press liner into position.

After liners have been installed, they require honing to remove any distortion and to size them properly for the pistons to be used. Special stones for steel cylinders are necessary. Ascertain size of liner and pistons and check for distortion. Set hone firmly in liner so that stones will take hold and hone out liner for specified piston clearance. See PISTON & RING CLEARANCES table. Use fine grade stones for finishing.

PISTONS, RENEW

1936-46 All: NOTE—A variation of 10 degrees between the temperature of the pistons and cylinder bores is sufficient to produce a difference of .0005". Therefore, both the pistons and cylinder bores should be at normal room temperature (about 70 degrees) when fitting pistons. This is particularly important because the clearances given in the PISTON & RING CLEARANCES table are minimum and pistons must not be fitted with less than specified.

Before any attempt is made to fit new pistons, cylinder bores should be carefully indicated and refinished. If bores do not require refinishing, be sure to remove the ridge at the top of each bore. If refinishing is required, it is good practice to do so in alternate cylinders due to the temperature build-up. Cylinder bores should not be out-of-round or tapered more than .0005".

Before fitting pistons, wipe the cylinder walls and pistons to remove all chips, dirt or other foreign matter. The feeler ribbon used to check piston fit should be about 12" long and ½" wide. Consult the PISTON & RING CLEARANCES table for the thickness of shim to use, as well as the recommended pounds pull on a spring scale required to withdraw the feeler ribbon past the piston.

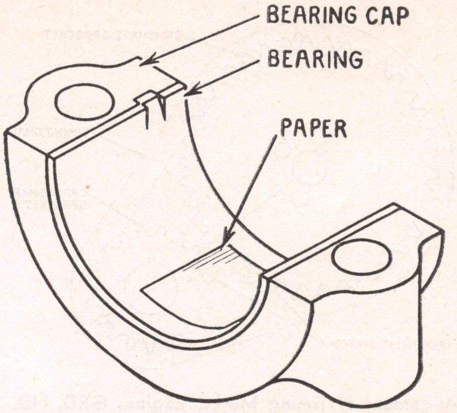
Insert the piston in the bore upside down and in its running position (see PISTON & ROD, ASSEMBLE). Place the feeler ribbon between the cylinder wall and the thrust side of the piston (opposite slotted side on aluminum pistons) in a position at right angles to the piston pin hole.

After assembling the piston to the connecting rod, check the assembly for alignment on a suitable jig.

PISTON RINGS, RENEW

1936-46 All: NOTE—To prevent the possibility of bending or breaking the second ring land—thus ruining the piston—the ridge at the top of the cylinder bore should be cut away before removing the piston and rod assemblies. If the available ridge reamer has no provision to control the depth of the cut, it is good practice to bring the piston far enough up into the cylinder to allow the reamer to rest on top of the piston. This will serve to prevent cutting down into the ring travel area.

CAUTION—Never cut down into the ring travel area more than 1/32"—or more than half the depth of the top ring.



Checking Connecting Rod Bearing Clearance. All Engines.

New rings should be fitted with end gaps and groove clearances as given in the PISTON & RING CLEARANCES table. Ring grooves must be clean and free from carbon, and must show no perceptible wear. Always abide by the instructions accompanying each set of rings.

When rings are properly fitted to the pistons, be sure to stagger the ring gaps so they are spaced equal distances around the circumference of the piston. However, see that no gaps are over the piston pins.

NOTE—If cylinder sleeves or liners are to be replaced, fit rings to these parts after they have been installed and honed.

PISTON PINS, RENEW

1936-46: Piston pins float in rod and piston and are held in the piston by retainer rings that fit into grooves in the piston pin bosses.

Select pins that can be installed by pushing with the palm of the hand, with piston at normal room temperature of about 70 degrees, first making sure that pin and bore as smooth and clean.

PISTON PIN BUSHINGS, RENEW

1936-46: Piston pin bushings should be burnished with burnishing bar and reamed to provide a hand push fit of the pin. Make sure that the oil holes in the bushings line up with the oil holes in the connecting rods.

CONNECTING ROD BEARINGS, RENEW

1936-46: When replacing connecting rod bearings, be sure that rods and caps as well as backs of bearing shells are clean and smooth and free from oil. This is of utmost importance. Wash rods and caps in a good cleaning solution and dry thoroughly. This will remove oil as well as dirt and insure even contact between backs of bearing shells and rods, with no hot spots to cause bearing failure or a scored crankpin.

CAUTION—Before installing new bearings, be sure to clean drilled oil passages in crankshaft and block. Run a rifle barrel brush or a brass rod through the oil passages to dislodge sludge, grit or bearing material.

When assembling new connecting rod bearings with shims, always start out with the specified quantity of shims in place. Then, if bearing is loose, remove shims to obtain proper clearance. Never build up clearance by adding shims, but reduce clearance by removing shims. This will prevent damaging bearing shells by crushing, due to insufficient clearance.

NOTE—Be sure that shims are properly aligned so they do not rest between the bearing shells when cap is tightened. Especially see to it that shims do not get between the small tongues in the bearings and the grooves in rod and cap.

A clearance check may be made with a one-inch square of paper .0015" to .0025" thick. Place the paper in the cap between bearing and crankpin, as illustrated, and tighten the cap. This thickness of paper should produce a fairly heavy drag on the crankshaft.

After the bearings have been checked for specified clearances, remove bearing caps and apply a generous coating of engine lubricating oil to the crankpins, then replace caps. See ENGINE BEARING SPECIFICATIONS for connecting rod bolt nut tension.

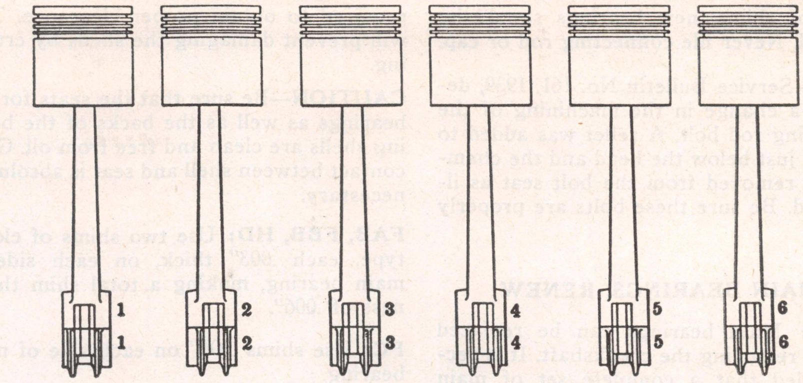
NOTE—Cylinder numbers are stamped on a flat space on rod and cap, and rods always should be assembled with these numbers toward camshaft side of crankcase. Connecting rods for FBB 361, 401 and 450A engines and for FBC engines are offset and must be installed as shown in illustration.

FAB, FBB: Early FAB engines had four .003" shims and early FBB engines had two .003" shims on the side of the connecting rod bearing opposite the tongue and groove bearing lock. Later models have .006" laminated shim packs, one on each side. If bearing wear cannot be compensated for by removal of shims, new bearings should be installed. Never file or grind the rod or cap to reduce clearance. When rebuilding engines having connecting rod bearing shims only on one side, it is suggested that the arrangement with .006" laminated shim packs on each side be used.

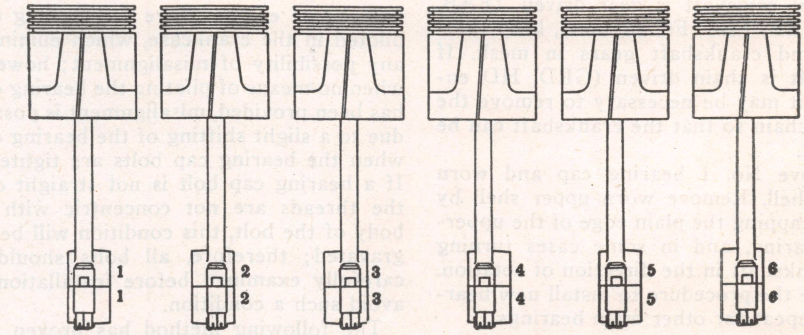
FC: Install connecting rod bearings flush with the face of connecting rod and cap on both sides. Use .006" shim packs on each side of the rod. If bearing wear cannot be compensated for by removal of shims, new bearings should be installed. Never file connecting rod or cap.

GRD: Install connecting rod bearings flush with the face of connecting rod and cap on both sides. No shims are used.

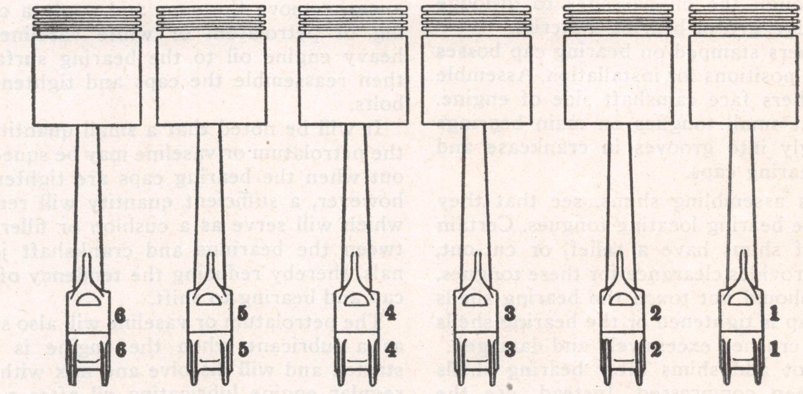
HD: Install connecting rod bearings flush with the face of connecting rod and cap on both sides. Use two .003" shims on tongue and groove side and three .003" shims opposite tongue and groove side. If bearing wear cannot be compensated for by re-



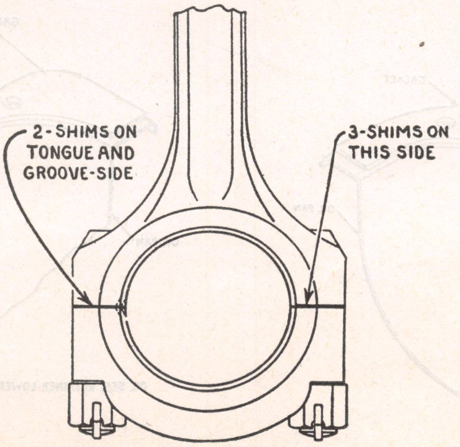
Install Connecting Rods as Shown. Engines FAB, FAC.



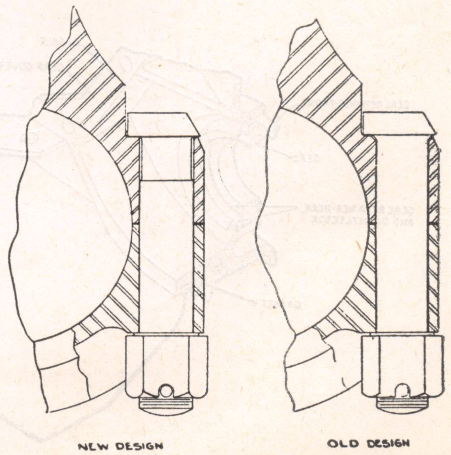
Install Connecting Rods as Shown. Engines FBB-361, 401, 450A and All FBC.



Install Connecting Rods as Shown. Engines GRD, HD.



Connecting Rod Bearing. Engine HD.



New and Old Connecting Rod Bolts. Engine HD.

moval of shims, new bearings should be installed. Never file connecting rod or cap.

NOTE—Service Bulletin No. 161, 1939, described a change in the machining of the connecting rod bolt. A relief was added to the bolt just below the head and the chamfer was removed from the bolt seat as illustrated. Be sure these bolts are properly seated.

MAIN BEARINGS, RENEW

1936-46: Main bearings can be replaced without removing the crankshaft. It is recommended that a complete set of main bearings be used when replacement is made. Loosen all main bearing caps slightly but if camshaft is gear driven, (FAB, FAC, FBB, FBC, FC engines), keep camshaft and crankshaft gears in mesh. If camshaft is chain driven (GRD, HD engines), it may be necessary to remove the timing chain so that the crankshaft can be lowered.

Remove No. 1 bearing cap and worn lower shell. Remove worn upper shell by lightly tapping the plain edge of the upper-half bearing, and in some cases turning the crankshaft in the direction of rotation. Reverse the procedure to install new bearings. Repeat for other main bearings.

Before installing new bearings, clean out drilled oil passages in crankshaft and block by running a rifle barrel brush or a brass rod through the oil passages to dislodge any sludge, grit or bearing material.

Numbers stamped on bearing cap bosses indicate positions for installation. Assemble so numbers face camshaft side of engine. See that small tongues on main bearings fit snugly into grooves in crankcase and main bearing caps.

When assembling shims, see that they clear the bearing locating tongues. Certain types of shims have a relief, or cut-out, which provides clearance for these tongues. Shims should not touch the bearing shells when cap is tightened or the bearing shells may be crushed excessively and damaged.

Do not add shims after bearing shells have been compressed. Instead, use the specified quantity of shims and remove as required to obtain proper clearance. This will prevent damaging the shells by crushing.

CAUTION—Be sure that the seats for the bearings as well as the backs of the bearing shells are clean and free from oil. Good contact between shell and seat is absolutely necessary.

FAB, FBB, HD: Use two shims of closed type, each .003" thick, on each side of main bearing, making a total shim thickness of .006".

FC: Use shims .006" on each side of main bearing.

NOTE—It is essential that main bearings be in alignment with the crankshaft journals. Some engines have the bearing caps piloted in the crankcase, which eliminates any possibility of misalignment; however, when no means of piloting the bearing caps has been provided, misalignment is possible due to a slight shifting of the bearing caps when the bearing cap bolts are tightened. If a bearing cap bolt is not straight or if the threads are not concentric with the body of the bolt, this condition will be aggravated; therefore, all bolts should be carefully examined before installation, to avoid such a condition.

The following method has proven successful in holding the caps and bearings in alignment with the crankshaft. After bearings have been fitted to specified clearances, remove the caps and apply a coating of petrolatum or white vaseline, or heavy engine oil to the bearing surfaces, then reassemble the caps and tighten the bolts.

It will be noted that a small quantity of the petrolatum or vaseline may be squeezed out when the bearing caps are tightened; however, a sufficient quantity will remain which will serve as a cushion or filler between the bearings and crankshaft journals, thereby reducing the tendency of the cap and bearing to shift.

The petrolatum or vaseline will also serve as a lubricant when the engine is first started and will dissolve and mix with the regular engine lubricating oil after a few revolutions.

Under no circumstances should anything other than petrolatum or vaseline or heavy engine oil be used due to the possibility of chemical reactions which would cause damage to the bearing material.

CRANKSHAFT & END THRUST

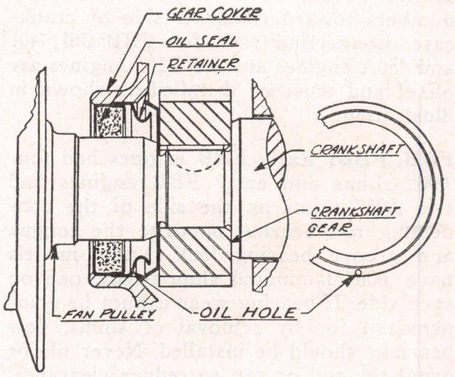
1936-46: See ENGINE BEARING SPECIFICATIONS for Crankshaft End Play and location of thrust bearing. Check crankshaft journals and crankpins for taper and out-of-round. If this exceeds .003", it is recommended that the shaft be reground. Examine the bearing surfaces for flat spots, grooves or scores, and if excessive, regrind or replace the shaft.

GRD, HD: Shims are provided between the crankshaft and the crankshaft thrust washer at the front end. Their purpose is to maintain the specified end play of the shaft.

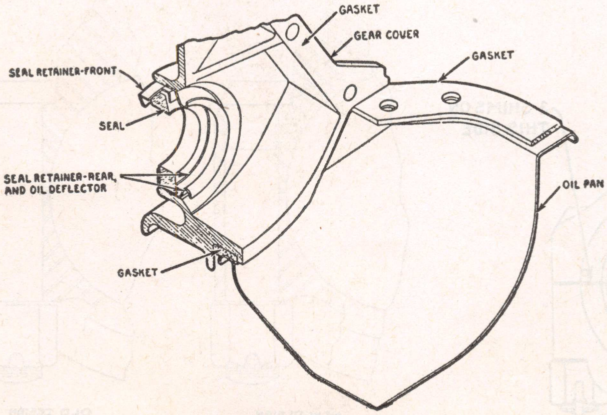
MAIN BEARING OIL SEALS, RENEW

1936-46: Assemble front and rear main bearing oil seals, retainers and gaskets as illustrated. When replacing seals or gaskets, make certain that no foreign matter is adhering to the surfaces to prevent tight contact. Dip felt seals in oil before assembly.

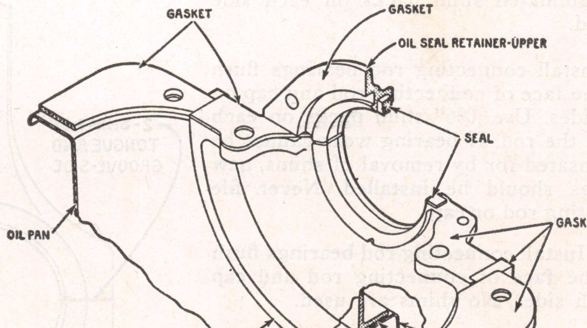
FAB, FAC: Assemble front seal retainer with the oil drain hole at the bottom. See illustration.



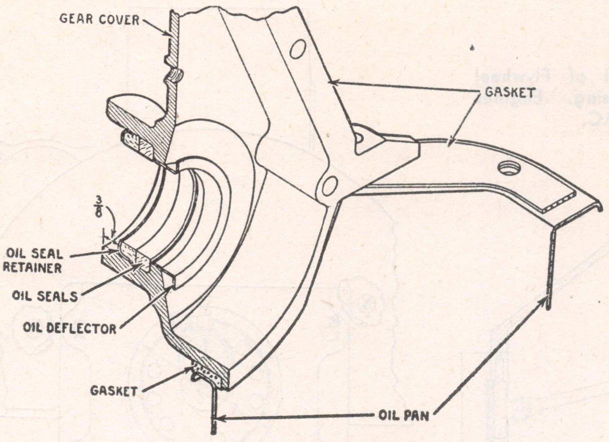
Crankshaft Front Oil Seal and Retainer. Engines FAB, FAC.



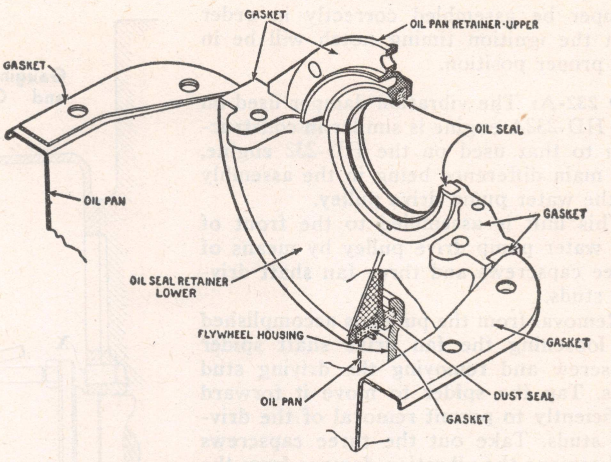
Crankshaft Front Oil Seal. Engines FAB, FAC.



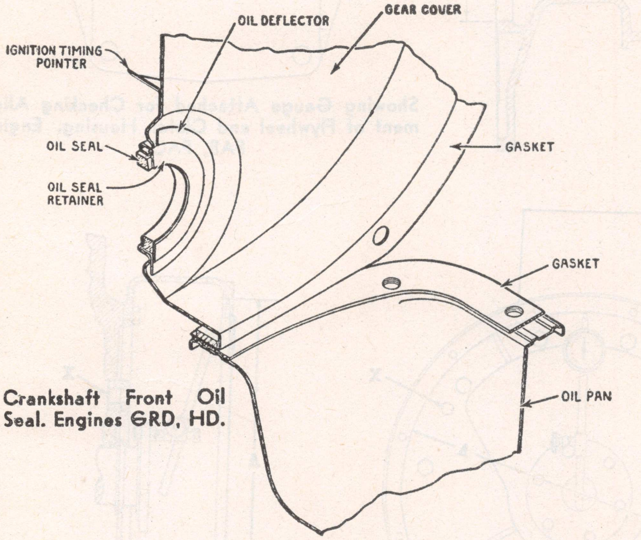
Crankshaft Rear Oil Seal. Engines FAB, FAC.


GEAR COVER
GASKET
3/8
OIL SEAL RETAINER
OIL SEALS
OIL DEFLECTOR
GASKET
OIL PAN

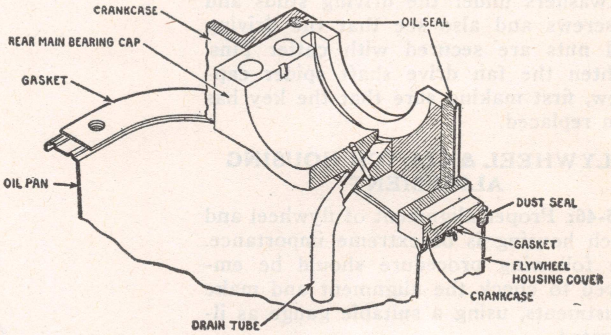
Crankshaft Front Oil Seal. Engines FBB, FBC.


GASKET
OIL PAN RETAINER-UPPER
GASKET
OIL SEAL
OIL PAN
GASKET
OIL SEAL RETAINER LOWER
FLYWHEEL HOUSING
GASKET
DUST SEAL
OIL PAN
GASKET

Crankshaft Rear Oil Seal. Engines FBB, FBC.


OIL DEFLECTOR
GEAR COVER
IGNITION TIMING POINTER
GASKET
OIL SEAL
OIL SEAL RETAINER
GASKET
OIL PAN

Crankshaft Front Oil Seal. Engines GRD, HD.


CRANKCASE
OIL SEAL
REAR MAIN BEARING CAP
GASKET
OIL PAN
DUST SEAL
GASKET
FLYWHEEL HOUSING COVER
CRANKCASE
DRAIN TUBE

Crankshaft Rear Oil Seal. Engines GRD, HD.

VIBRATION DAMPERS

IMPORTANT—Under no circumstances should the crankshaft vibration damper be removed permanently from the engine.

The fit of the damper hub on the crankshaft must be tight (.0005″ to .0002″ press fit). If there is less than .0005″ press fit between the hub and shaft, a new hub should be installed. Damper hubs may be heated in boiling water to facilitate installation.

Do not permit this unit to become saturated with oil or grease which will cause rapid deterioration of the rubber.

CAUTION—Do not wash vibration dampers in kerosene or any other fluid that is injurious to rubber.

FAB, FAC: The damper unit is attached to the fan drive pulley by six capscrews. and forms the outer flange of the pulley. If necessary to remove the vibration damper and fan drive pulley hub assembly, the vibration damper unit first should be disassembled from the fan drive pulley hub. This is accomplished by removing the six nuts, using an offset box wrench.

After the vibration damper unit has been disassembled, the fan drive pulley hub can be removed, using a puller attached to two long capscrews inserted in the hub.

CAUTION—Do not use a claw-type puller to remove vibration damper and fan drive pulley hub as an assembly. This will damage the vibration damper. Do not use a pry bar or strike with a hammer in an attempt to drive off this assembly. These units must be disassembled for removal.

To reinstall, make a bench assembly of the vibration damper and fan drive pulley hub. This is important in order to fasten the two units together securely. Then install assembly as one unit, using a pusher tool. Make sure that the assembly is a tight fit on the crankshaft; also tighten starting crank jaw nut securely. Be sure the nuts and lockwashers on the six fan drive pulley capscrews are tight.

FBB, FBC: This damper unit is attached to the fan drive pulley by six capscrews and forms the outer flange of the pulley. Two dowel holes are reamed at assembly to .43775″-.43675″ and dowels are pressed in, which help take the load from the capscrews.

These dowels as well as the capscrews must be tight and in the event the vibration damper is removed from the fan drive pulley and a new damper installed, oversize dowels should be used.

If necessary to remove the fan drive pulley and vibration damper assembly, it should be removed as a unit. Two capscrews, directly opposite, should be taken out and replaced with capscrews, the heads of which will extend sufficiently to permit attaching a claw or bar type puller. Do not attempt to drive this assembly off by striking with a hammer or prying with a bar.

When reassembling, be sure that starting crank jaw nut as well as the dowels and capscrews holding the vibration damper, are tight. This is very important.

GRD 233, HD 232: This damper unit is attached to the rear of the fan drive pulley by six capscrews. Be sure the nuts and lockwashers on the capscrews are tight.

If necessary to remove the fan drive pulley and vibration damper assembly, first remove the starting jaw nut, then insert two long capscrews in the holes in pulley and use a puller to remove the assembly.

By unscrewing the nuts from the six capscrews the pulley and vibration damper can be disassembled.

A locating dowel in the fan drive pulley insures correct reassembly in relation to the ignition timing notch which is on the outer rim of the vibration damper. It is important that the pulley and vibration damper be assembled correctly in order that the ignition timing notch will be in the proper position.

HD 232-A: The vibration damper used on the HD-232A engine is similar in construction to that used on the HD-232 engine, the main difference being in the assembly to the water pump drive pulley.

This unit is assembled to the front of the water pump drive pulley by means of three capscrews and three fan shaft driving studs.

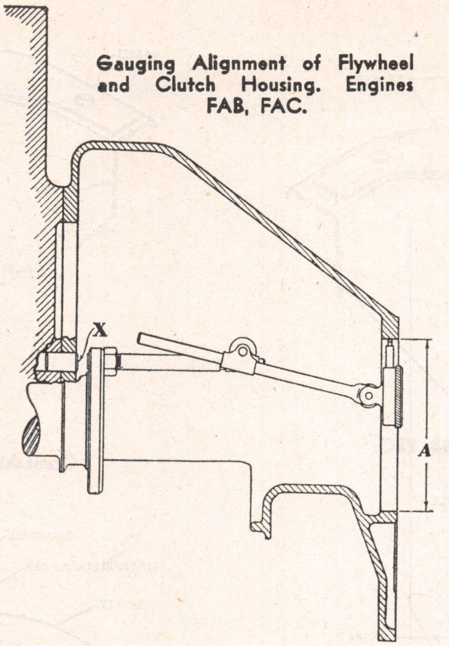
Removal from the pulley is accomplished by loosening the fan drive shaft spider capscrew and removing the driving stud nuts. Tap the spider to move it forward sufficiently to permit removal of the driving studs. Take out the three capscrews and remove the vibration damper from the water pump drive pulley.

When reassembling, be sure to use new lockwashers under the driving studs and capscrews and also see that the driving stud nuts are secured with cotter pins. Tighten the fan drive shaft spider capscrew, first making sure that the key has been replaced.

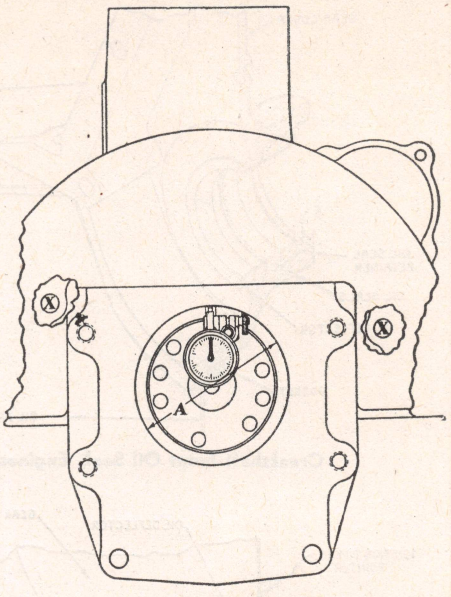
FLYWHEEL & CLUTCH HOUSING ALIGNMENT

1936-46: Proper alignment of flywheel and clutch housing is of extreme importance. The following procedure should be employed to check the alignment and make adjustments, using a suitable gauge as illustrated.

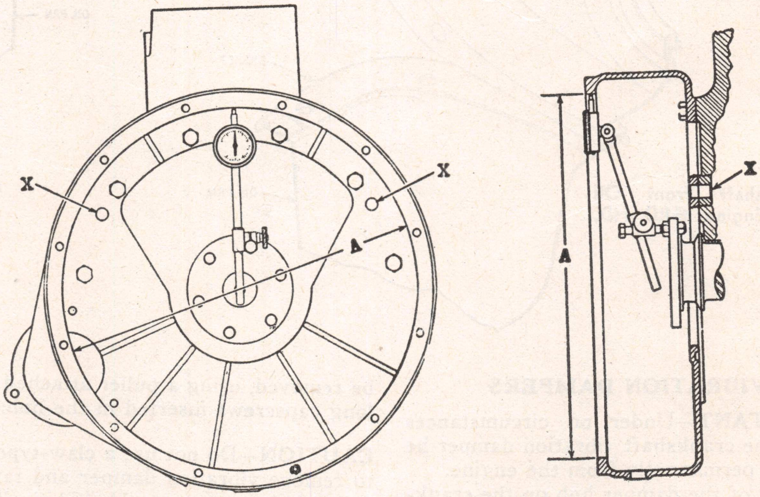
1. Remove floor boards, disconnect pedals and propeller shaft.
2. Support engine to allow removal of transmission and clutch.
3. FAB, FAC, GRD, HD: Remove transmission and throw-out shaft, bearing and clutch. FBB, FBC: Remove transmission and clutch housing, as one unit, from flywheel housing. Remove clutch.
4. Attach indicator as shown and check bore "A." Flywheel and clutch housing is doweled to crankcase at "X" and, when correctly aligned, runout of bore "A" should not exceed .005" total indicator reading.
5. If reading indicates misalignment beyond recommended limits, remove dowel pins and loosen housing attaching bolts sufficiently to permit movement by tapping lightly with a hammer.
6. Set indicator in position showing maximum runout, and tap housing slightly to shift its position until indicator reading is ½ of maximum reading. Recheck runout by rotating crank. The resultant reading should approach .000" or at most, less than .005" runout.
7. Tighten attaching bolts and reindicate. Re-ream dowel holes, using an oversize reamer that will produce a .001" to .002" drive fit of an oversize dowel.
8. Install oversize dowels and reindicate. If these are not available, they can be made from a piece of drill rod the desired size.



Gauging Alignment of Flywheel and Clutch Housing. Engines FAB, FAC.



Showing Gauge Attached for Checking Alignment of Flywheel and Clutch Housing. Engines FAB, FAC.



Gauging Alignment of Flywheel and Clutch Housing. Engines FBB, FBC.

FLYWHEEL MOUNTING

FAB, FAC: When assembling a flywheel to the crankshaft, check the crankshaft flange to ascertain if it is smooth and undamaged. Maximum runout should not exceed .002". If the flange is excessively rough or has abnormal runout, trouble may be experienced with the flywheel mounting bolts working loose. Be sure to use drilled capscrews to attach the flywheel to the crankshaft flange, and secure the capscrews with a lockwire.

GRD: The flywheel is assembled to the crankshaft with four bolts and two body-fit dowel bolts.

All holes in the flange of new crankshafts or flywheels are straight, therefore it is necessary to ream the two large holes that are directly opposite each other, in order to permit the installation of the body-fit dowels.

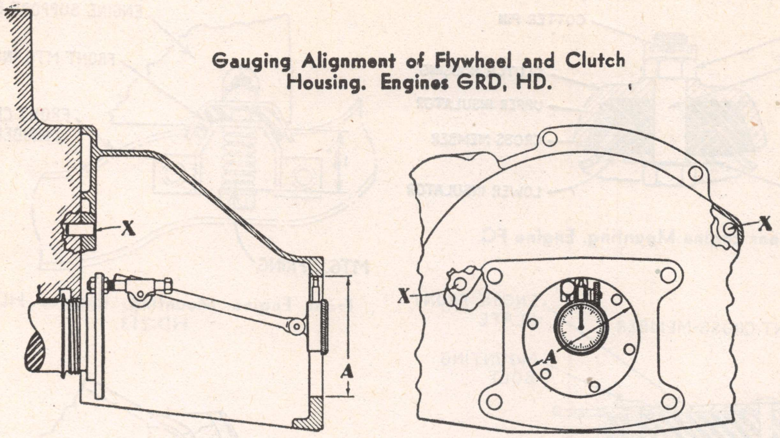
The two holes to be reamed should match on flywheel and crankshaft flange. Be sure nuts on dowel bolts as well as on the other four are drawn up tight.

HD: The flywheel is assembled to the crankshaft with four capscrews and two tapered dowels.

All holes in the flange of new crankshafts or flywheels are straight, therefore it is necessary to taper-ream the two large holes that are directly opposite each other in order to permit the installation of the tapered dowels.

The two holes to be reamed should match on flywheel and crankshaft flange. Be sure nuts on tapered dowels as well as on the capscrews are drawn up tight.

Pack hole in end of crankshaft with heavy cup grease.



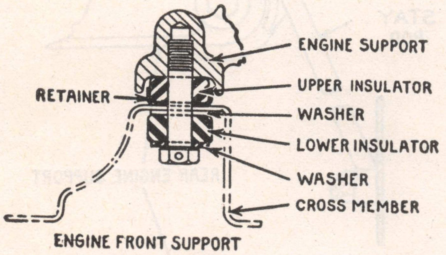
Gauging Alignment of Flywheel and Clutch Housing. Engines GRD, HD.

ENGINE MOUNTINGS

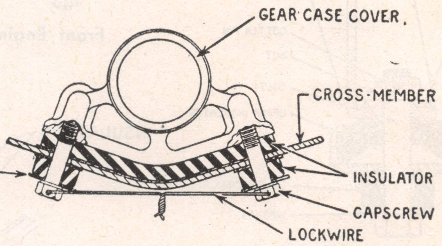
FAB, FAC, FC: Front and rear engine mountings are illustrated. Assemble as shown and tighten nut one complete turn. Check mounting screws occasionally to be sure the mountings are not loose and that the capscrews and mounting nuts are secured with cotter pins.

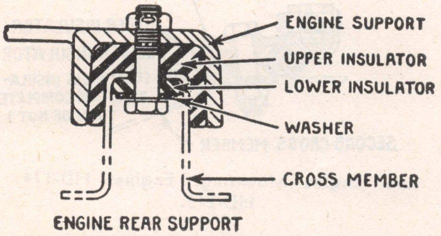
FBB, FBC: Engine mountings for early production and later production FBB and FBC engines are illustrated.

Check front mounting attaching screws occasionally to determine if they are tight and springs are under tension. Be sure engine support capscrews are securely locked with lockwire and cross member support capscrews are properly secured with cotter pins.

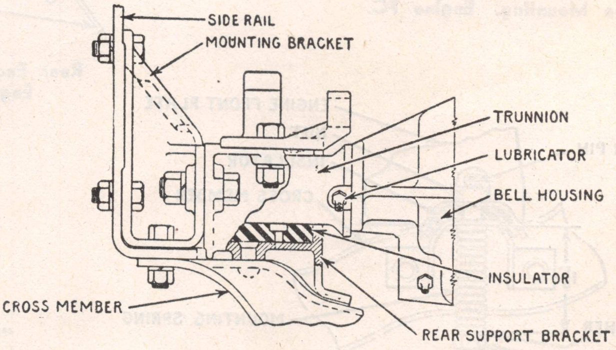

ENGINE SUPPORT
RETAINER
UPPER INSULATOR
WASHER
LOWER INSULATOR
WASHER
CROSS MEMBER
ENGINE FRONT SUPPORT

Front Engine Mounting. Engines FAB, FAC.

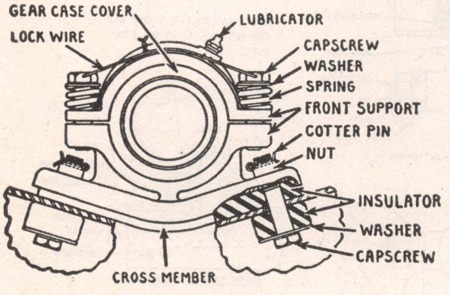

GEAR CASE COVER
CROSS-MEMBER
WASHER
INSULATOR
CAPSCREW
LOCKWIRE


ENGINE SUPPORT
UPPER INSULATOR
LOWER INSULATOR
WASHER
CROSS MEMBER
ENGINE REAR SUPPORT

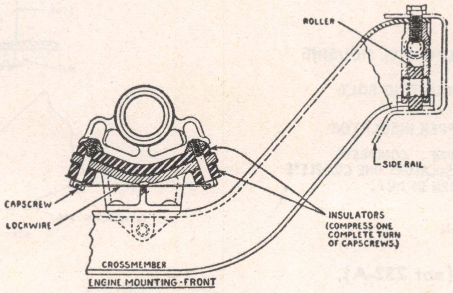
Rear Engine Mounting. Engines FAB, FAC.


SIDE RAIL
MOUNTING BRACKET
TRUNNION
LUBRICATOR
BELL HOUSING
INSULATOR
CROSS MEMBER
REAR SUPPORT BRACKET

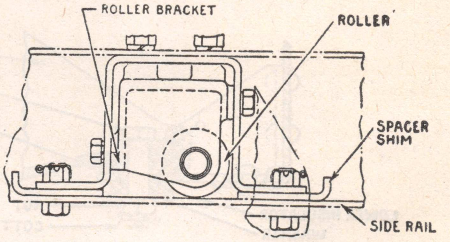
Engine Mountings (late production). Engines FBB and All FBC.


GEAR CASE COVER
LOCK WIRE
LUBRICATOR
CAPSCREW
WASHER
SPRING
FRONT SUPPORT
COTTER PIN
NUT
INSULATOR
WASHER
CAPSCREW
CROSS MEMBER

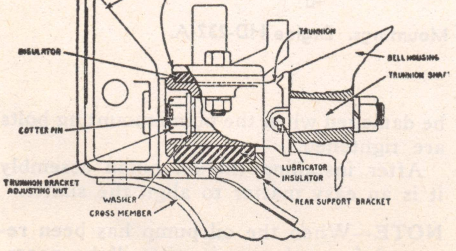
Front Engine Mounting (early production). Engine FBB.


ROLLER
SIDE RAIL
CAPSCREW
LOCKWIRE
INSULATORS (COMPRESS ONE COMPLETE TURN OF CAPSCREWS.)
CROSSMEMBER
ENGINE MOUNTING-FRONT

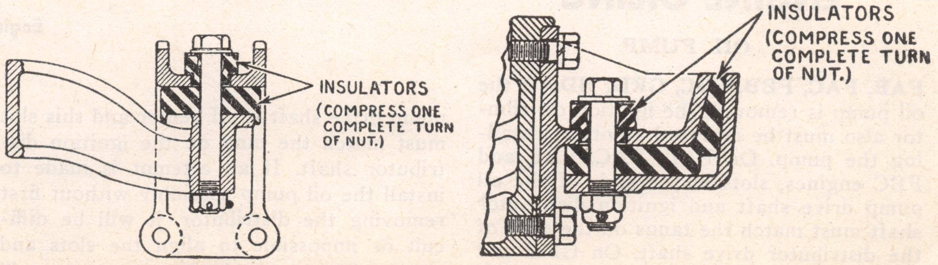
Front Engine Mounting, Forward-Control Trucks. Engine FBB.


ROLLER BRACKET
ROLLER
SPACER SHIM
SIDE RAIL

Roller Mounting, Forward-Control Trucks. Engine FBB.


SIDE RAIL
MOUNTING BRACKET
REAR SUPPORT CAP
TRUNNION
INSULATOR
BELL HOUSING
TRUNNION SHAFT
COTTER PIN
LUBRICATOR
INSULATOR
TRUNNION BRACKET ADJUSTING NUT
WASHER
REAR SUPPORT BRACKET
CROSS MEMBER

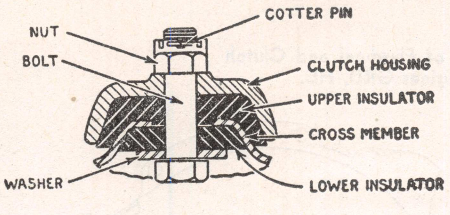
Rear Engine Mounting (early production). Engine FBB.


INSULATORS
(COMPRESS ONE COMPLETE TURN OF NUT.)
INSULATORS
(COMPRESS ONE COMPLETE TURN OF NUT.)

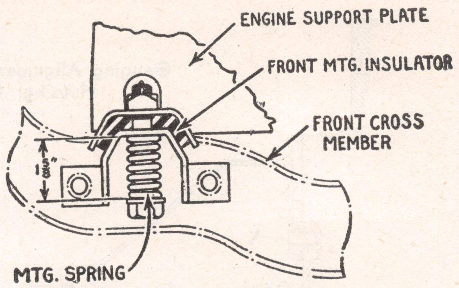
Cradle Mountings, Forward-Control Trucks. Engine FBB.

When reassembling rear mounting trunnion, tighten nut while rotating trunnion slowly. When tightening of trunnion shaft nut just stops trunnion, back nut off 1/6 turn or to next cotter pin hole. Trunnion should be free to move on trunnion shaft but not be loose.

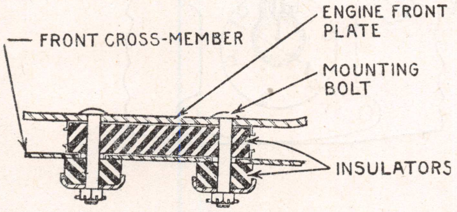
GRD, HD: Check mounting screws occasionally to be sure the mountings are not loose and that the capscrews are secured with cotter pins. Assemble as shown in illustrations, then tighten nut one complete turn.


COTTER PIN
NUT
BOLT
CLUTCH HOUSING
UPPER INSULATOR
CROSS MEMBER
WASHER
LOWER INSULATOR

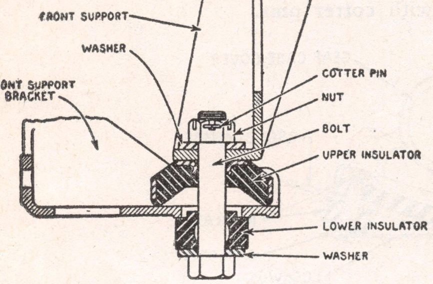
Rear Engine Mounting. Engine FC.


ENGINE SUPPORT PLATE
FRONT MTG. INSULATOR
FRONT CROSS MEMBER
MTG. SPRING

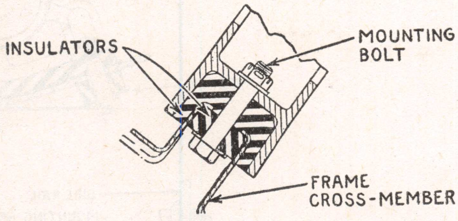
Front Engine Mounting. Engines HD-174. HD-213.


FRONT CROSS-MEMBER
ENGINE FRONT PLATE
MOUNTING BOLT
INSULATORS

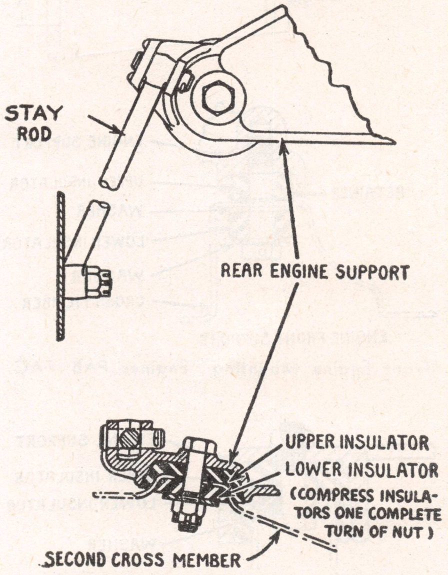
Front Engine Mounting. Engine GRD.


FRONT SUPPORT
WASHER
FRONT SUPPORT BRACKET
COTTER PIN
NUT
BOLT
UPPER INSULATOR
LOWER INSULATOR
WASHER

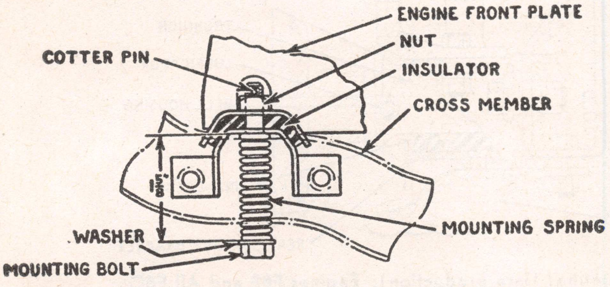
Front Engine Mounting. Engine FC.


INSULATORS
MOUNTING BOLT
FRAME CROSS-MEMBER

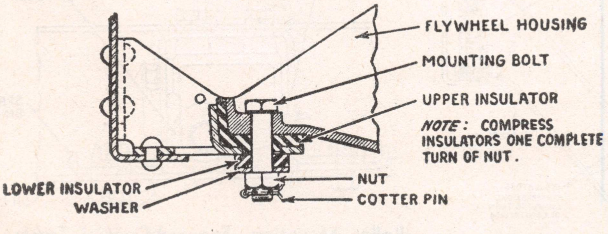
Rear Engine Mounting. Engine GRD.


STAY ROD
REAR ENGINE SUPPORT
UPPER INSULATOR
LOWER INSULATOR
(COMPRESS INSULATORS ONE COMPLETE TURN OF NUT)
SECOND CROSS MEMBER

Rear Engine Mounting. Engines HD-174 HD-213.

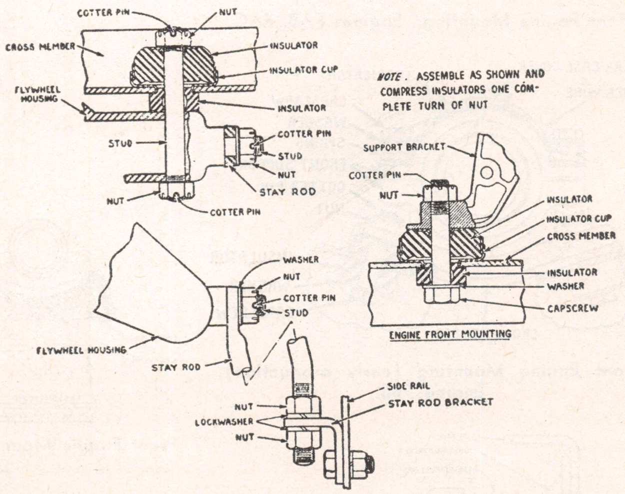

ENGINE FRONT PLATE
COTTER PIN
NUT
INSULATOR
CROSS MEMBER
WASHER
MOUNTING SPRING
MOUNTING BOLT

Front Engine Mounting. Engine HD-232 (not 232-A).


FLYWHEEL HOUSING
MOUNTING BOLT
UPPER INSULATOR
LOWER INSULATOR
WASHER
NUT
COTTER PIN

NOTE: COMPRESS INSULATORS ONE COMPLETE TURN OF NUT.

Rear Engine Mounting. Engine HD-232 (not 232-A).


COTTER PIN
NUT
CROSS MEMBER
INSULATOR
INSULATOR CUP
FLYWHEEL HOUSING
INSULATOR
STUD
COTTER PIN
STUD
NUT
STAY ROD
NUT
COTTER PIN
SUPPORT BRACKET
COTTER PIN
NUT
INSULATOR
INSULATOR CUP
CROSS MEMBER
INSULATOR
WASHER
CAPSCREW
ENGINE FRONT MOUNTING
WASHER
NUT
COTTER PIN
STUD
FLYWHEEL HOUSING
STAY ROD
SIDE RAIL
STAY ROD BRACKET
NUT
LOCKWASHER
NUT

NOTE. ASSEMBLE AS SHOWN AND COMPRESS INSULATORS ONE COMPLETE TURN OF NUT

Engine Mountings. Engine HD-232-A.

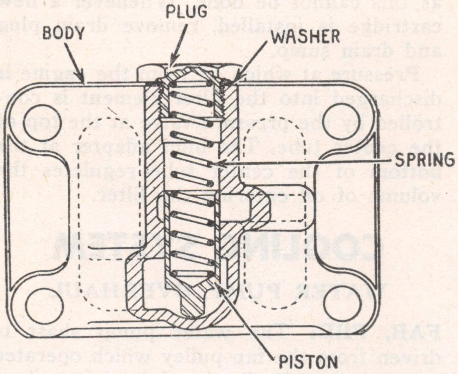
ENGINE OILING

OIL PUMP

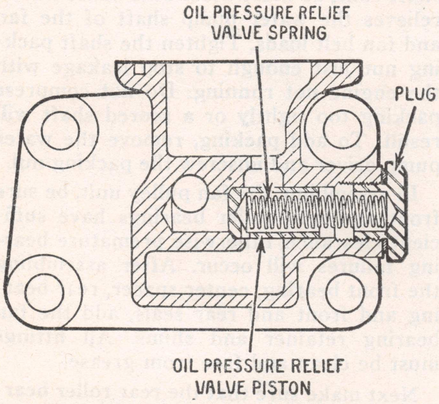
FAB, FAC, FBB, FBC, GRD, HD: If the oil pump is removed, the ignition distributor also must be removed before reinstalling the pump. On FAB, FAC, FBB and FBC engines, slots in the ends of the oil pump drive shaft and ignition distributor shaft must match the tangs on the ends of the distributor drive shaft. On GRD and HD engines, the slot in the end of the oil pump drive shaft is off center and this slot must match the tang on the ignition distributor shaft. If an attempt is made to install the oil pump assembly without first removing the distributor, it will be difficult or impossible to align the slots and tangs with the result that the pump will be damaged when the pump mounting bolts are tightened.

After installing the oil pump assembly it is an easy matter to align the shafts.

NOTE—When the oil pump has been removed from the engine it will be necessary to retime the ignition.


PLUG
BODY
WASHER
SPRING
PISTON

Oil Pressure Regulator. Engines FAB, FAC.


OIL PRESSURE RELIEF VALVE SPRING
PLUG
OIL PRESSURE RELIEF VALVE PISTON

Connecting-Rod Bolts

Oil Pressure Control. Engines FBB, FBC.

OIL PRESSURE REGULATOR

FAB, FAC: Oil presure is controlled by the pressure valve spring located in the oil pressure regulator as illustrated. Free length of spring should be 2½".

FBB, FBC: Oil pressure is controlled by the pressure valve spring located in the oil filter base as illustrated. Free length of spring should be 3".

FC, GRD, HD: Oil pressure is controlled by the pressure valve spring located in the oil pressure regulator. Free length of spring should be 1⅜".

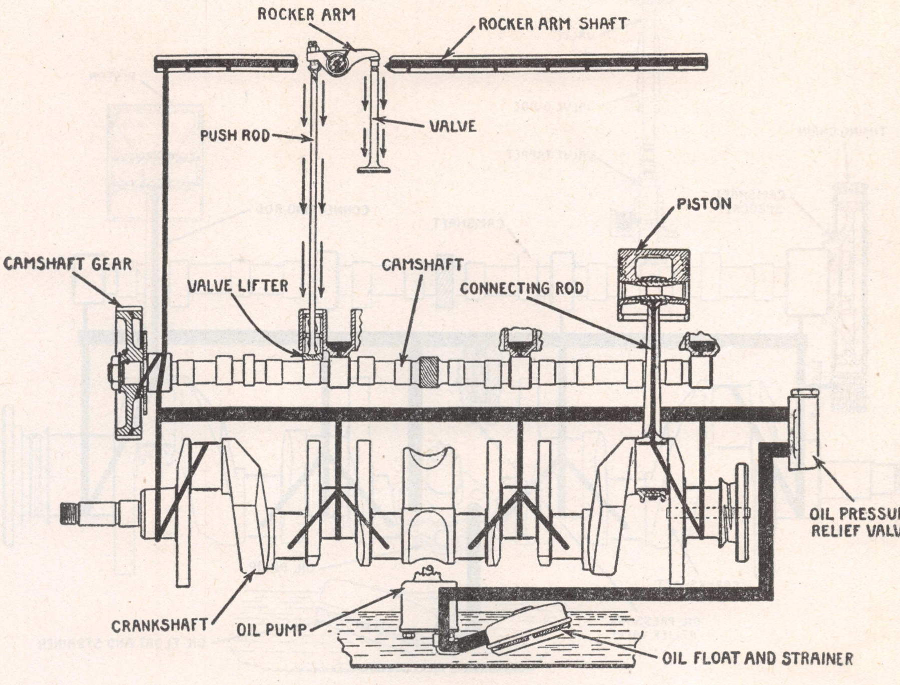
CRANKSHAFT OIL WICK

FAB, FBB: Be sure the crankshaft oil wick is properly installed when required. Do not use a screwdriver or similar tool to force wick into the hole as this will cut the felt and cause oil leakage. Wind a piece of wire around one end of wick, dip in light oil, start wick squarely and pull through, leaving 1/16" to ⅛" projecting on the connecting rod journal side. Cut off surplus on the flywheel side.

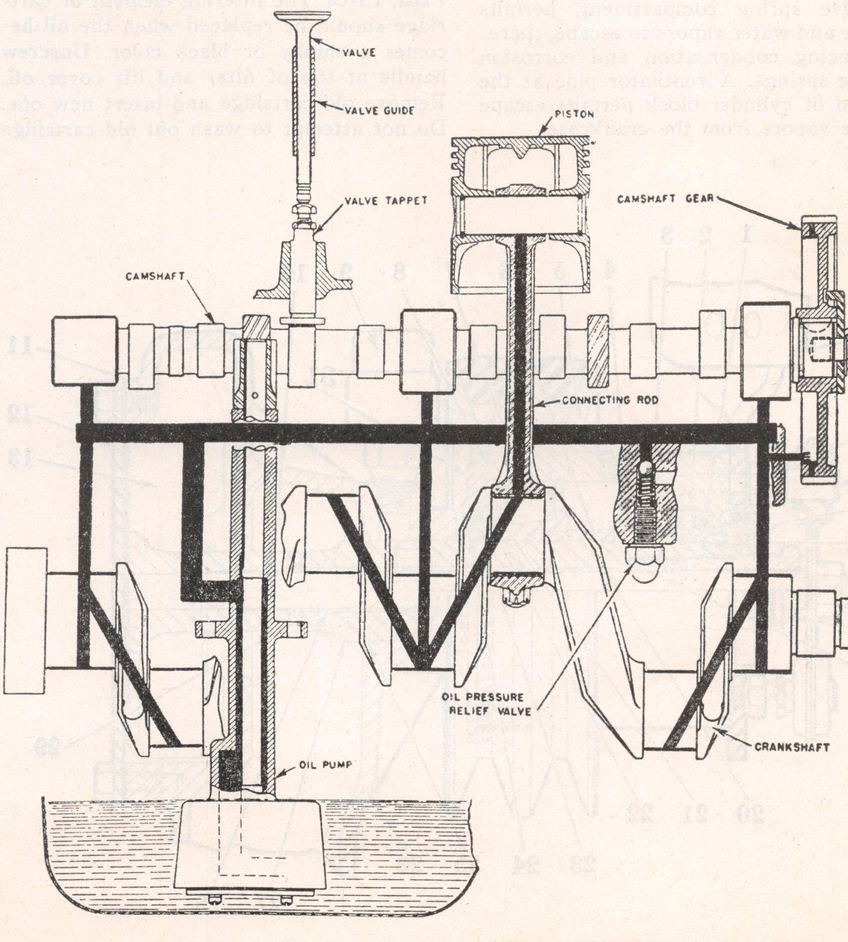
NOTE—The oil wick has been eliminated from late production engines and the hole omitted from the crankshaft.

CRANKCASE VENTILATOR

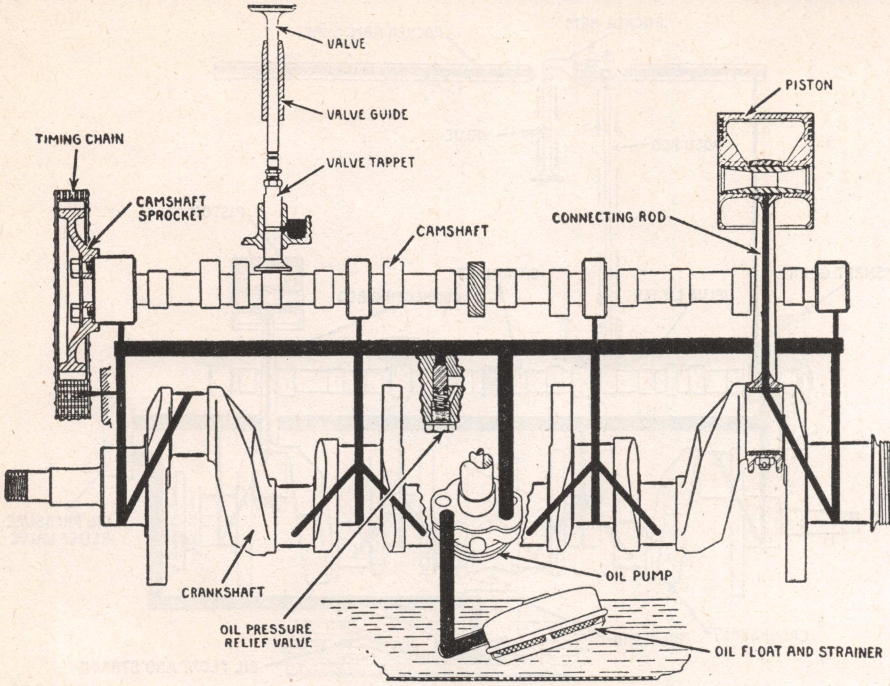
GRD, HD: Cup-type breathers, filled with crimped copper wire to prevent dirt enter-


ROCKER ARM
ROCKER ARM SHAFT
PUSH ROD
VALVE
PISTON
CAMSHAFT GEAR
CAMSHAFT
VALVE LIFTER
CONNECTING ROD
OIL PRESSURE RELIEF VALVE
CRANKSHAFT
OIL PUMP
OIL FLOAT AND STRAINER

Engine Oiling System. Engines FAB, FAC.


VALVE
VALVE GUIDE
PISTON
VALVE TAPPET
CAMSHAFT GEAR
CAMSHAFT
CONNECTING ROD
OIL PRESSURE RELIEF VALVE
CRANKSHAFT
OIL PUMP

Engine Oiling System. Engine FC-132.



Engine Oiling System. Engines GRD, HD.

ing, are installed in the cylinder head. An opening, through the head and block, into the valve spring compartment, permits gasoline and water vapors to escape, thereby reducing condensation and corrosion of valve springs. A ventilator pipe at the rear end of cylinder block permits escape of these vapors from the crankcase.

OIL FILTER

FBB, FBC: The filtering element or cartridge should be replaced when the oil becomes a smoky or black color. Unscrew handle at top of filter and lift cover off. Remove old cartridge and insert new one. Do not attempt to wash out old cartridge as this cannot be done. Whenever a new cartridge is installed, remove drain plug and drain sump.

Pressure at which oil from the engine is discharged into the filter element is controlled by the pressure valve at the top of the center tube. The inlet adapter at the bottom of the center tube regulates the volume of oil entering the filter.

COOLING SYSTEM

WATER PUMP, OVERHAUL

FAB, FBB: The water pump shaft is driven from the fan pulley which operates on two tapered roller bearings mounted on a sleeve through which the water pump shaft runs, as illustrated. This construction relieves the water pump shaft of the fan and fan belt loads. Tighten the shaft packing nut just enough to stop leakage with the engine not running. Do not compress packing too tightly or a scored shaft will result. To add packing, remove the water pump driver and unscrew the packing nut.

In assembling the fan pulley unit, be sure front and rear roller bearings have sufficient clearance, otherwise premature bearing failures will occur. After assembling the front bearing, center spacer, rear bearing and front and rear seals, add the fan bearing retainer and shims. All fittings must be clean and free from grease.

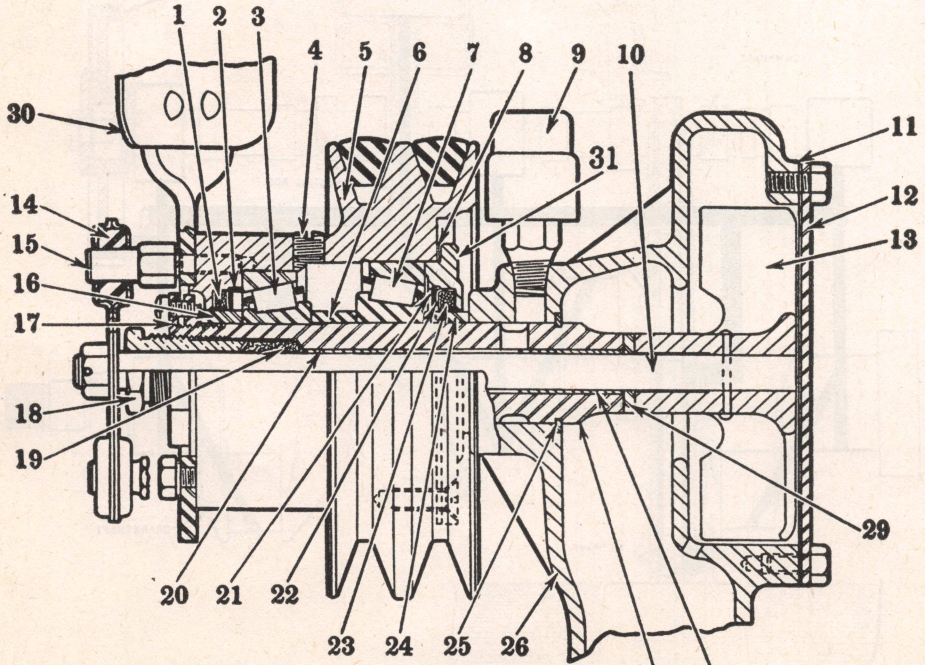
Next make sure that the rear roller bearing cup is against the fan bearing retainer. Tap the fan pulley assembly against a work bench or wood block to jar the bearing cup down against the retainer. Check the clearance between the center spacer and bearing cones by feel. If the center spacer is tight, install another shim between the bearing retainer and pulley and if the clearance is excessive, remove shims as required. Each time a shim is added or removed, tap the pulley assembly against a block of wood so that the bearing cup will be forced against the retainer, before testing clearance.

When bearings are correctly positioned, complete the assembly of the fan pulley and water pump. Remove the pipe plug and pack bearings with grease.

If water pump body plate is removed, dip threads of mounting screws in white lead before reassembling, to prevent water leakage.

FAC, FBC: Construction of the FAC engine water pump is illustrated. The FBC engine water pump is similar but is driven with two V-belts.

FC: The FC engine water pump, as illustrated, does not require packing. The water seal is a thrust washer held under spring tension against the thrust surface of the rear bushing. To disassemble (1) remove pump assembly from engine and take off the fan pulley and hub. (2) Remove shims and slip impeller shaft assembly out of water pump body. (3) Special water pump bushing tools are essential when removing or installing bushings. Insert expansion sleeve in the front bushing, then place ex-



Water Pump. Engine FBB. FAB Water Pump is Similar But Has Single V-Belt.

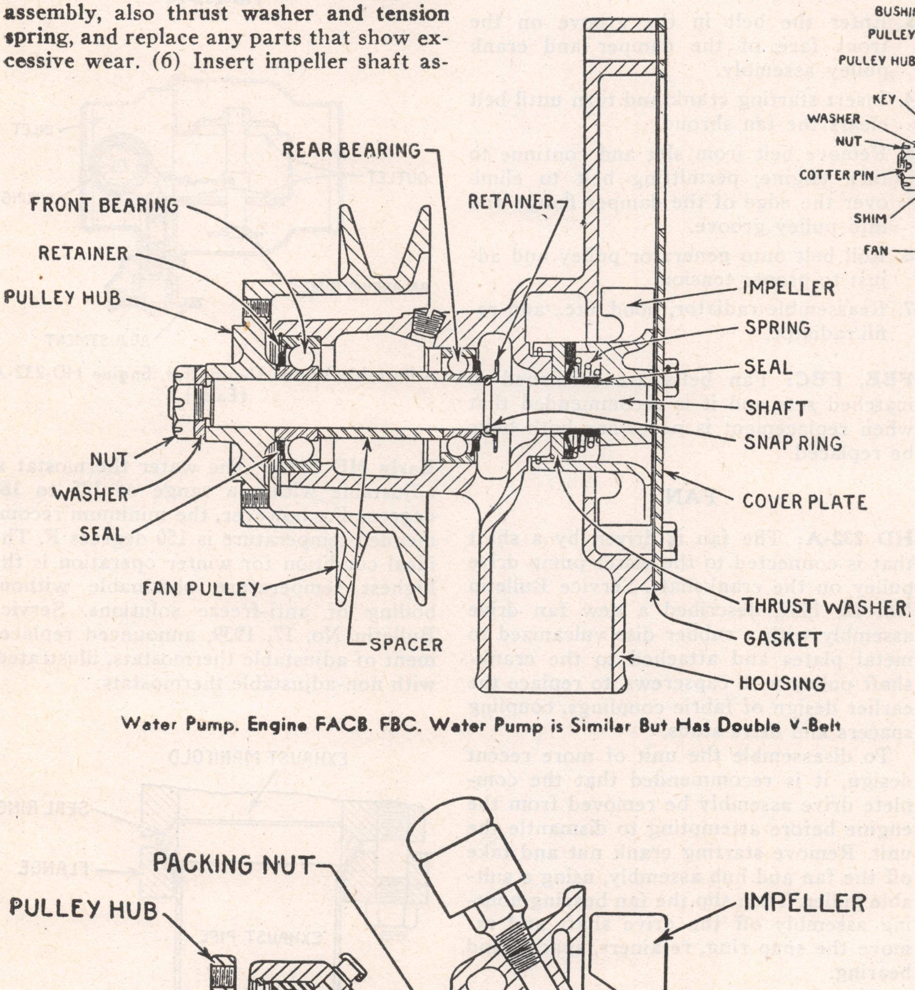
pansion sleeve punch through rear bushing into the expansion sleeve and (4) press out front bushing, using an arbor press. (5) Remove rear bushing similarly.

To assemble, (1) soak porous front and rear bushings in SAE-10 light engine oil. (2) Insert bushing arbor pilot sleeve in front bushing bore in body, then place the convex washer on the bushing arbor. (3) Place the rear bushing, having concave thrust surface, on the arbor and with arbor piloted in pilot sleeve, press into place using an arbor press. (4) To install the front bushing, assemble flat washer to the arbor, then place the bushing having flat thrust surface on the arbor and press in, using the rear bushing as a pilot for the arbor. (5) Check water pump shaft and impeller assembly, also thrust washer and tension spring, and replace any parts that show excessive wear. (6) Insert impeller shaft assembly and install shims to give from .005" to .020" clearance between bushing and fan hub. This clearance must be maintained. (7) Add pulley and hub assembly, making sure that the hub key has been replaced.

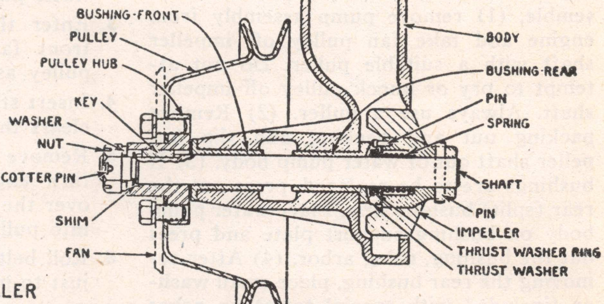
IMPORTANT—Do not drill or groove the front or rear bushings. They are porous and will absorb lubricant from the reservoir in the water pump body.

GRD: The GRD engine water pump is illustrated. Special tools are available to facilitate servicing. To disassemble (1) remove pump assembly from engine and take off fan pulley with a suitable puller. Do not attempt to pry or knock pulley off impeller shaft. Always use a puller. (2) Remove packing nut and packing and slip impeller shaft out of water pump body. (3) Remove bearing retainer snap ring, bearing retainer, bearing, spacer washer, and rear bearing seal. (4) Place adapter pilot in front bearing bore of housing and use tool to press out rear split bushing. (5) Check impeller shaft for excessive wear, examine thrust washer and replace parts that show wear.

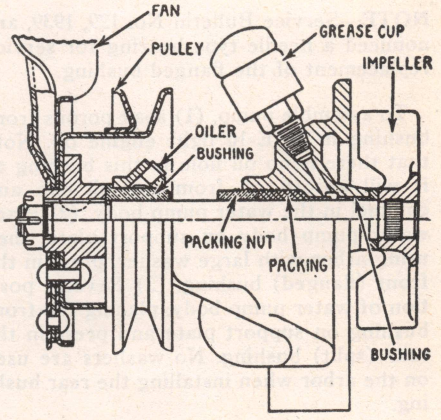
To assemble, (1) place housing on arbor


REAR BEARING
FRONT BEARING
RETAINER
RETAINER
PULLEY HUB
IMPELLER
SPRING
SEAL
SHAFT
SNAP RING
NUT
WASHER
SEAL
COVER PLATE
FAN PULLEY
THRUST WASHER,
GASKET
SPACER
HOUSING

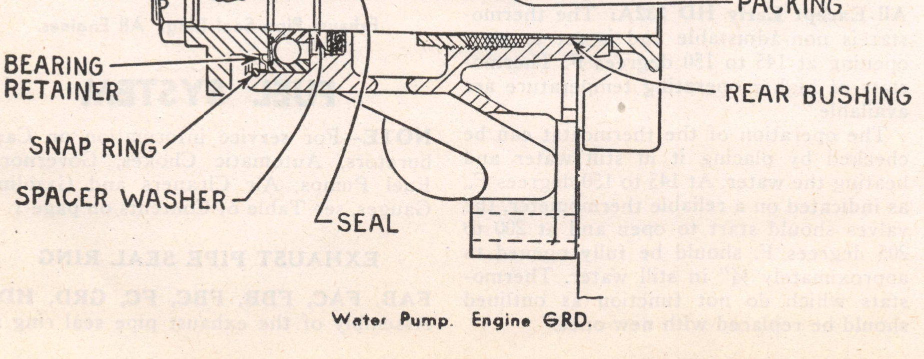
Water Pump. Engine FACB. FBC. Water Pump is Similar But Has Double V-Belt


BUSHING-FRONT
PULLEY
PULLEY HUB
KEY
WASHER
NUT
COTTER PIN
SHIM
FAN
BODY
BUSHING-REAR
PIN
SPRING
SHAFT
PIN
IMPELLER
THRUST WASHER RING
THRUST WASHER

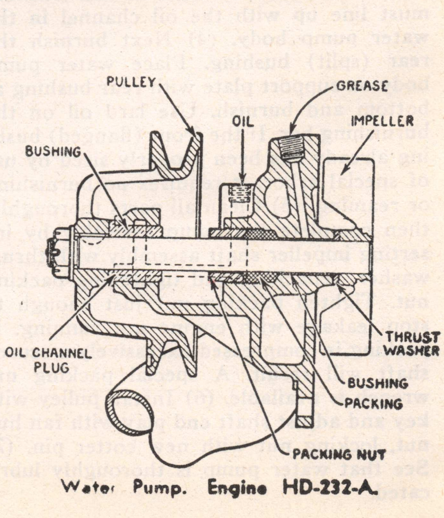
Water Pump. Engine FC.


FAN
GREASE CUP
PULLEY
IMPELLER
OILER
BUSHING
PACKING NUT
PACKING
BUSHING

Water Pump. Engines HD except HD 232-A


PACKING NUT
IMPELLER
PULLEY HUB
PACKING
BEARING RETAINER
REAR BUSHING
SNAP RING
SPACER WASHER
SEAL

Water Pump. Engine GRD.


PULLEY
GREASE
OIL
IMPELLER
BUSHING
OIL CHANNEL PLUG
THRUST WASHER
BUSHING
PACKING
PACKING NUT

Water Pump. Engine HD-232-A.

press with adapter pilot in front bearing bore. (2) Using arbor and small washer, install rear (split) bushing. Oil hole must line up with oil hole in housing. (3) Burnish rear bushing with Burnishing Bar. Use lard oil during burnishing. (4) Install impeller shaft with thrust washer, packing and packing gland nut. (5) Install bearing seal, spacer, bearing, bearing retainer and snap ring. (6) Install pulley with key and lock nut with new cotter pin. (7) Be sure the water pump is thoroughly lubricated.

HD: Water pumps used on HD engines are illustrated. The HD 232-A engine pump differs from the pump used on other HD engines. Special tools are available to facilitate servicing these pumps. To disassemble, (1) remove pump assembly from engine and take fan pulley off impeller shaft with a suitable puller. Do not attempt to pry or knock pulley off impeller shaft. Always use a puller. (2) Remove packing nut and packing and slip impeller shaft out of water pump body. (3) If bushings are to be replaced, press out the rear (split) bushing first. Place water pump body on bushing support plate and press out the bushing, using arbor. (4) After removing the rear bushing, place small washer (included with special tools) on arbor and press out front (flanged) bushing. (5) Check impeller shaft for wear and examine thrust washer and replace parts that show wear.

NOTE—Service Bulletin No. 129, 1939, announced a needle-type bearing for service replacement of the flanged bushing.

To assemble pump, (1) soak porous front bushing in SAE-10 light engine oil. Note that there is no oil hole in this bushing as it will absorb oil from the oil cup and channel in the water pump body. (2) Place water pump body on support plate, then using arbor with large washer, press in the front (flanged) bushing. (3) Reverse position of water pump body, placing the front bushing on support plate and press in the rear (split) bushing. No washers are used on the arbor when installing the rear bushing.

CAUTION—The oil hole in this bushing must line up with the oil channel in the water pump body. (4) Next burnish the rear (split) bushing. Place water pump body on support plate with rear bushing at bottom and burnish. Use lard oil on the burnishing bar. If the front (flanged) bushing already has been properly sized by use of special arbor, it requires no burnishing or reaming. (5) Clean all parts thoroughly, then complete the pump assembly by inserting impeller shaft assembly with thrust washer, repacking and tightening packing nut. Tighten packing nut just enough to stop leakage with engine not running. If packing is compressed excessively a scored shaft will result. A special packing nut wrench is available. (6) Install pulley with key and adjust shaft end play with fan hub nut, locking nut with new cotter pin. (7) See that water pump is thoroughly lubricated.

FAN BELT

1936-46: Proper tension on fan belt is obtained when belt can be depressed approximately ½" between water pump pulley and generator pulley.

FAB: Owing to limited clearance between fan shroud and vibration damper, it is necessary to install fan belt as follows:

1. Drain radiator upper tank, remove head assembly and loosen radiator stay rods, upper hose connection and mounting nuts.
2. Tilt radiator assembly forward sufficiently to permit slipping the belt over the fan assembly and past the end of the water pump shaft.
3. Enter the belt in the groove on the front face of the damper and crank pulley assembly.
4. Insert starting crank and turn until belt clears the fan shroud.
5. Remove belt from slot and continue to turn engine, permitting belt to climb over the edge of the damper flange and into pulley groove.
6. Roll belt onto generator pulley and adjust to proper tension.
7. Reassemble radiator, hood, etc., and refill radiator.

FBB, FBC: Fan belts are furnished in matched sets and it is recommended that when replacement is necessary both belts be replaced.

FAN

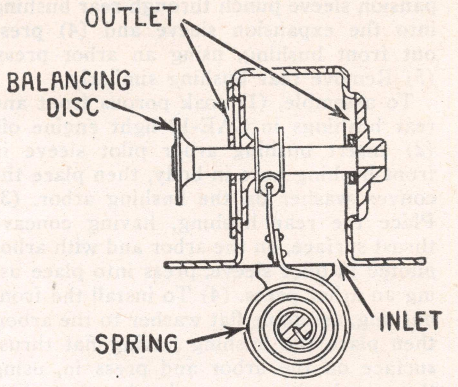
HD 232-A: The fan is driven by a shaft that is connected to the water pump drive pulley on the crankshaft. Service Bulletin No. 12, 1939, described a new fan drive assembly with a rubber disc vulcanized to metal plates and attached to the crankshaft pulley with capscrews, to replace the earlier design of fabric couplings, coupling spacers and drive studs.

To disassemble the unit of more recent design, it is recommended that the complete drive assembly be removed from the engine before attempting to dismantle the unit. Remove starting crank nut and take off the fan and hub assembly, using a suitable puller. Then slip the fan bearing housing assembly off the drive shaft and remove the snap ring, retainers, spacer, and bearing.

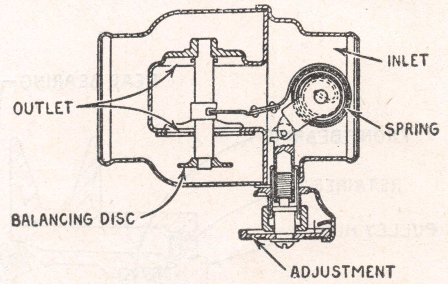
WATER THERMOSTAT

All Except Early HD 232A: The thermostat is non-adjustable and is set to start opening at 145 to 150 degrees F. Thermostats of higher operating temperature are available.

The operation of the thermostat can be checked by placing it in still water and heating the water. At 145 to 150 degrees F., as indicated on a reliable thermometer, the valves should start to open and at 200 to 205 degrees F. should be fully opened to approximately ¼" in still water. Thermostats which do not function as outlined should be replaced with new ones.

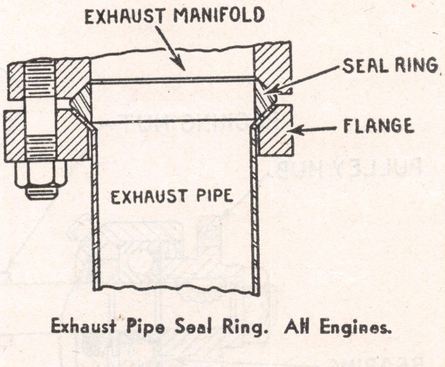


Engine Water Thermostat. All Engines Except HD-232-A.



Adjustable Water Thermostat. Engine HD-232-A (Early).

Early HD 232A: The water thermostat is adjustable within a range of 125 to 180 degrees F.; however, the minimum recommended temperature is 150 degrees F. The ideal condition for winter operation is the highest temperature obtainable without boiling of anti-freeze solutions. Service Bulletin No. 17, 1939, announced replacement of adjustable thermostats, illustrated, with non-adjustable thermostats.



Exhaust Pipe Seal Ring. All Engines.

FUEL SYSTEM

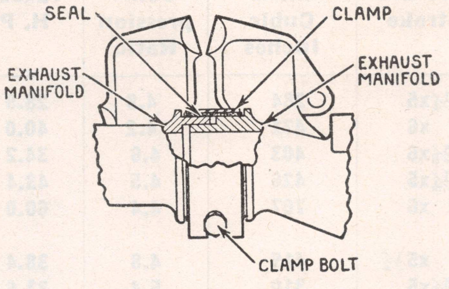
NOTE—For service information on Carburetors, Automatic Chokes, Governors, Fuel Pumps, Air Cleaners and Gasoline Gauges, see Table of Contents on page 1.

EXHAUST PIPE SEAL RING

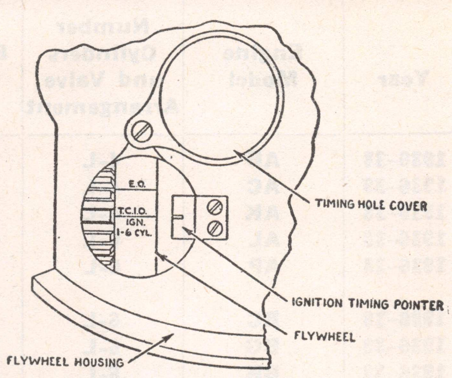
FAB, FAC, FBB, FBC, FC, GRD, HD: Assembly of the exhaust pipe seal ring is illustrated. Be sure that the seal ring seats squarely against the exhaust manifold, exhaust pipe and flange, and tighten stud nuts evenly in order to prevent distortion of the exhaust pipe and possible breakage of the exhaust pipe flange.

EXHAUST MANIFOLD SEALS

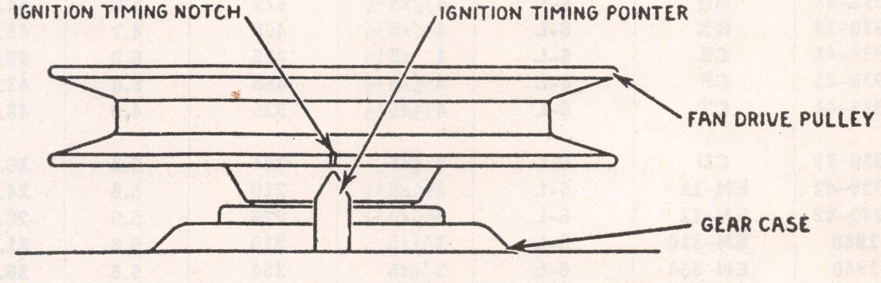
FBB, FBC: The two clamp type seals where the front and rear manifold sections join the center section must be kept tight. Check seal material under the clamps and replace if necessary. Pull clamp bolts tight to compress seal and insure a gas-tight fit. See illustration.



Exhaust Manifold Seal. Engines FBB, FBC.



Ignition Timing Mark on Flywheel. Engine HD-232-A.



Ignition Timing Mark. All Engines Except FC and HD-232-A.

ELECTRIC SYSTEM

NOTE—For service information on Distributors, Magnetos, Generators, Generator Regulators, Starting Motors and Starter Regulators, see Table of Contents on page 1.

IGNITION TIMING

1936-46: With the breaker gap set to the clearance given in the TUNE UP CHART, crank the engine to bring No. 1 piston up on its compression stroke and stop when the "IGN" mark on the vibration damper (flywheel on FC and HD-232-A) is in line with the indicator.

Locate No. 1 spark plug wire on the distributor cap, place the cap in position on the distributor and mark the housing opposite No. 1 terminal so that its relative position will be known when the cap is removed.

With the octane selector set midway between advance and retard, loosen the distributor body clamp and rotate the distributor until the points close. Then rotate the distributor in the opposite direction until the points just begin to open. Tighten the clamp bolt.

NOTE—For best results, use a Neon timing light or a conventional test lamp to check the timing. Advance or retard the octane selector to compensate for the grade of fuel being used. For best performance and fuel economy, this setting should be one which will provide smooth engine performance with a slight "ping" on wide-open throttle at comparatively low vehicle speed.

NOTE—On all engines except FC-132, whenever the oil pump has been removed from the engine, it will be necessary to retime the ignition.

NOTE—For International engines developed since 1942, see page 915.

ENGINES GASOLINE MACK

Year	Engine Model	Number Cylinders and Valve Arrangement	Bore and Stroke	Displacement Cubic Inches	Compression Ratio	Taxable H. P.	Brake H. P. at R. P. M.	Maximum Torque at R. P. M. Pounds Feet	Oil Capacity Quarts①
1936-38	AB	4-L	4¼x5	284	4.8	28.9	65@2100	192@1000	10
1936-38	AC	4-L	5 x6	471	4.2	40.0	77@1800	320@ 800	12
1936-38	AK	4-L	4⅝x6	403	4.6	34.2	70@1800	262@ 900	12
1936-38	AL	6-L	4¼x5	426	4.5	43.4	87@2200	265@ 900	18
1936-38	AP	6-L	5 x6	707	4.4	60.0	138@1900	468@ 800	20
1936-38	BC	6-L	4 x5½	415	4.8	38.4	102@2400	254@1200	14
1936-39	BG	6-L	3⅝x5	310	5.4	31.6	96@2800	210@1000	10
1936-38	BK	6-L	4½x5½	526	5.0	48.6	125@2300	347@1200	18
1936-38	BL	6-L	3¼x5	249	5.0	25.4	60@2600	146@1300	10
1936-38	BM	6-L	3¾x5½	364	5.0	33.7	96@2400	242@1200	14
1936-38	BQ	6-L	4¾x5¾	611	5.0	54.2	135@2200	420@600	18
1936-38	BX	6-L	4¼x5½	468	4.7	43.4	108@2400	303@1000	14
1936-41	CE	6-L	4 x5½	415	5.0	38.4	108@2400	270@1000	16
1936-41	CF	6-L	4¼x5½	468	5.0	43.4	117@2400	317@1000	16
1936-41	CT	6-L	4½x5½	525	4.9	48.6	120@2400	360@ 600	16
1936-39	CU	6-L	3⅞x5	354	5.3	36.0	103@2600	250@1000	10
1939-42	EN-11	6-L	3 3/16x4⅜	210	5.8	24.4	68@3000	145@1100	5½-5
1940-42	EN-12	6-L	3 5/16x4⅜	226	5.9	26.3	72@3000	166@1200	5½-5
1940	EN-310	6-L	3⅝x5	310	5.6	31.6	100@2950	213@1200	11-9
1940	EN-354	6-L	3⅞x5	354	5.5	36.0	115@2850	254@1100	11-9
1940	EN-405	6-I	4 x5⅜	405	5.8	38.4	122@2650	308@1100	17-13
1941-42	EN-431	6-I	4⅛x5⅜	431	5.7	40.8	124@2650	325@1100	19-15
1941-42	EN-457	6-I	4¼x5⅜	457	5.5	43.3	136@2600	348@1100	17-13
1941-46	EN-471	6-I	4 5/16x5⅜	471	5.6	44.6	133@2550	330@1000	19-15
1942	EN-253	6-L	3½x4⅜	253	5.8	29.4	77@2800	175@1200	7½-6½
1942-46	EN-271	6-L	3⅝x4⅜	271	6.0	31.6	82@2800	193@1200	7½-6½
1942-46	EN-290	6-L	3¾x4⅜	290	6.0	33.8	92@2800	200@1200	7½-6½
1939-42	EO	6-I	4⅜x5¾	519	5.4	45.9	154@2350	378@1000	19-15
1939-42	EP	6-I	4¾x5¾	611	5.4	54.1	175@2250	494@1000	19-15
1939-46	EY	6-I	5 x6	707	5.0	60.0	171@2200	520@ 600	19-15
1939-41	FK	6-L	3¾x4⅜	290	6.0	33.8	94@3000	200@1200	7½-6½
1939-41	FM	6-L	3⅝x4⅜	271	6.0	31.6	87@3000	193@1200	7½-6½
1939-41	FO	6-L	3½x4⅜	253	5.8	29.4	78@3000	175@1200	7½-6½

IMPORTANT—All Mack specifications are to be considered general and are to be used as a guide when specific data are not available. If in doubt regarding any item in the vehicle being serviced, consult the manufacturer, giving the chassis and engine numbers.

① Larger number includes filter capacity; smaller number, without filter.

TUNE UP CHART

Year	Engine Model	Firing Order	Spark Plug Gap	Breaker Gap	Cam Angle, Degrees	Timing Mark Location	Spark Timing, Degrees	Tappet Clearance For Running, Cold Int.	Tappet Clearance For Running, Cold Exh.	Tappet Clearance For Timing, Intake	Battery Terminal Grounded
1936-38	AB	1342	.025	.014	--	Flywheel	10ATDC	.008	.015	.008	Negative
1936-38	AC	1342	.025	.014	--	Flywheel	10ATDC	.008	.015	.008	Negative
1936-38	AK	1342	.025	.014	--	Flywheel	10ATDC	.008	.015	.008	Negative
1936-38	AL	153624	.025	.018-.024	35	Flywheel	TDC	.008	.015	.008	Positive
1936-38	AP	153624	.025	.018-.024	35	Flywheel	TDC	.008	.015	.008	Positive
1936-38	BC	153624	.025	.018-.024	35	Flywheel	7BTDC	.008	.015	.008	Positive
1936-39	BG	153624	.025	.018-.024	35	Flywheel	7BTDC	.008	.015	.008	Positive

MACK GASOLINE ENGINES

TUNE UP CHART

Year	Engine Model	Firing Order	Spark Plug Gap	Breaker Gap	Cam Angle, Degrees	Timing Mark Location	Spark Timing, Degrees	Tappet Clearance			Battery Terminal Grounded
								For Running ②		For Timing, Intake	
								Int.	Exh.		
1936-38	BK	153624	.025	.018-.024	35	Flywheel	7BTDC	.008	.015	.008	Positive
1936-38	BL	153624	.025	.018-.024	35	Flywheel	7BTDC	.008	.015	.008	Positive
1936-38	BM	153624	.025	.018-.024	35	Flywheel	15BTDC	.008	.015	.008	Positive
1936-38	BQ	153624	.025	.018-.024	35	Flywheel	TDC	.008	.015	.008	Positive
1936-38	BX	153624	.025	.018-.024	35	Flywheel	7BTDC	.008	.015	.008	Positive
1936-41	CE	153624	.025	.018-.024	35	Flywheel	15BTDC	.008	.025	.008	Positive
1936-41	CF	153624	.025	.018-.024	35	Flywheel	15BTDC	.008	.025	.008	Positive
1936-41	CT	153624	.025	.018-.024	35	Flywheel	7BTDC	.008	.025	.008	Positive
1936-39	CU	153624	.025	.018-.024	35	Flywheel	7BTDC	.008①	.025	.008	Positive
1939-42	EN-11	153624	.025	.018-.024	35	Vib. Damp.	1BTDC	.014	.014	.014	Positive
1940-42	EN-12	153624	.025	.018-.024	35	Vib. Damp.	5BTDC	.014	.014	.014	Positive
1940	EN-310	153624	.025	.018-.024	35	Vib. Damp.	7BTDC	.008	.025	.008	Positive
1940	EN-354	153624	.025	.018-.024	35	Vib. Damp.	7BTDC	.008	.025	.008	Positive
1940	EN-405	153624	.025	.018-.024	35	Vib. Damp.	22BTDC	.009	.015	.009	Positive
1941-42	EN-431	153624	.025	.018-.024	35	Vib. Damp.	22BTDC	.009	.015	.009	Positive
1941-42	EN-457	153624	.025	.018-.024	35	Vib. Damp.	29BTDC	.009	.015	.009	Positive
1941-46	EN-471	153624	.025	.018-.024	35	Vib. Damp.	22BTDC	.009	.015	.009	Positive
1942	EN-253	153624	.025	.018-.024	35	Vib. Damp.	TDC	.006	.023	.016	Positive
1942-46	EN-271	153624	.025	.018-.024	35	Vib. Damp.	3BTDC	.006	.023	.016	Positive
1942-46	EN-290	153624	.025	.018-.024	35	Vib. Damp.	7BTDC	.006	.023	.016	Positive
1939-42	EO	153624	.025	.018-.024	35	Vib. Damp.	21BTDC	.009	.015	.009	Positive
1939-42	EP	153624	.025	.018-.024	35	Vib. Damp.	21BTDC	.009	.015	.009	Positive
1939-46	EY	153624	.025	.018-.024	35	Vib. Damp.	18BTDC	.009	.015	.009	Positive
1939-41	FK	153624	.025	.018-.024	35	Vib. Damp.	7BTDC	.016	.023	.016	Positive
1939-41	FM	153624	.025	.018-.024	35	Vib. Damp.	3BTDC	.016	.023	.016	Positive
1939-41	FO	153624	.025	.018-.024	35	Vib. Damp.	TDC	.016	.023	.016	Positive

① Clearance for new type valve. If old type is in use, adjust to .015″. ② Set cold.

VALVE SYSTEM

Year	Engine Model	Stem Clearance		Tappet Guide Clearance	Tappet Clearance				Valve Spring Pressure Test		②Valve Seat Angle Degrees
					Running⑨		Timing				
		Intake	Exhaust		In-take	Ex-haust	In-take	Ex-haust	Free Length, Inches	③ Pounds at Inches, Length	
1936-38	AB	.002-.004	.002-.004	.0005-.0015	.008	.015	.008	.015	④	④	Flat
1936-38	AC	.002-.004	.002-.004	.0005-.0015	.008	.015	.008	.015	⑤	⑤	Flat
1936-38	AK	.002-.004	.002-.004	.0005-.0015	.008	.015	.008	.015	3½	65-70@2 15/16	Flat
1936-38	AL	.002-.004	.002-.004	.0005-.0015	.008	.015	.008	.015	3½	65-70@2 15/16	Flat
1936-38	AP	.002-.004	.002-.004	.0005-.0015	.008	.015	.008	.015	3½	65-70@2 15/16	Flat
1936-38	BC	.002-.004	.002-.004	.0005-.0015	.008	.015	.008	.015	⑥	⑥	Flat
1936-39	BG	.002-.004	.002-.004	.0005-.0015	.008	.015	.008	.015	3 5/16	44-49@2¾	Flat
1936-38	BK	.002-.004	.002-.004	.0005-.0015	.008	.015	.008	.015	3½	65-70@2 15/16	Flat
1936-38	BL	.002-.004	.002-.004	.0005-.0015	.008	.015	.008	.015	3½	65-70@2 15/16	Flat
1936-38	BM	.002-.004	.002-.004	.0005-.0015	.008	.015	.008	.015	3½	65-70@2 15/16	Flat

VALVE SYSTEM

Year	Engine Model	Stem Clearance		Tappet Guide Clearance	Tappet Clearance				Valve Spring Pressure Test		② Valve Seat Angle Degrees
		Intake	Exhaust		Running ⑨		Timing		Free Length, Inches	③ Pounds at Inches, Length	
					In-take	Ex-haust	In-take	Ex-haust			
1936–38	BQ	.002–.004	.002–.004	.0005–.0015	.008	.015	.008	.015	3 1/2	65–70@2 15/16	Flat
1936–38	BX	.002–.004	.002–.004	.0005–.0015	.008	.015	.008	.015	⑥	⑥	Flat
1936–41	CE	.002–.004	.002–.004	.0005–.0015	.008	.025①	.008	.025①	⑥	⑥	Flat
1936–41	CF	.002–.004	.002–.004	.0005–.0015	.008	.025①	.008	.025①	⑥	④	Flat
1936–41	CT	.002–.004	.002–.004	.0005–.0015	.008	.025①	.008	.025①	⑥	⑥	Flat
1936–39	CU	.002–.004	.002–.004	.0005–.0015	.008	.025①	.008	.025①	3 5/16	44–49@2 3/4	Flat
1939–42	EN-11	.001–.0025	.0035–.0045	.0005–.0018	.014	.014	.014	.014	1 15/16	43–47@1 21/32	⑦
1940–42	EN-12	.001–.0025	.0035–.0045	.0005–.0018	.014	.014	.014	.014	1 15/16	43–47@1 21/32	⑦
1940	EN-310	.002–.003	.003–.004	.0005–.0015	.007– .009	.024– .026	.009	.026	3 5/16	44–49@2 3/4	30
1940	EN-354	.002–.003	.003–.004	.0005–.0015	.007– .009	.024– .026	.009	.026	3 5/16	44–49@2 3/4	30
1940	EN-405	.0015– .003	.0035– .005	.0005– .0015	.006– .008H	.022– .024H	.010	.016	⑧	⑧	30
1941–42	EN-431	.0015– .003	.0035– .005	.0005– .0015	.006– .008H	.022– .024H	.010	.016	⑧	⑧	30
1941–42	EN-457	.0015– .003	.0035– .005	.0005– .0015	.006– .008H	.022– .024H	.010	0.16	⑧	⑧	30
1941–46	EN-471	.0015– .003	.0035– .005	.0005– .0015	.006– .008H	.022– .024H	.010	.016	⑧	⑧	30
1942	EN-253	.001–.0025	.0035 .0045	.0015 .0025	.015– .017	.022– .024	.017	.024	2 5/16	45–51@1 7/8	⑦
1942–46	EN-271	.001– .0025	.0035– .0045	.0015– .0025	.015– .017	.022– .024	.017	.024	2 5/16	45–51@1 7/8	⑦
1942–46	EN-290	.001– .0025	.0035– .0045	.0015– .0025	.015– .017	.022– .024	.017	.024	2 5/16	45–51@1 7/8	⑦
1939–42	EO	.0015– .003	.0035– .005	.0005– .0015	.006– .008H	.022– .024H	.010	.016	⑧	⑧	30
1939–42	EP	.0015– .003	.0035– .005	.0005– .0015	.006– .008H	.022– .024H	.010	.016	⑧	⑧	30
1939–46	EY	.0015– .003	.0035– .005	.0005– .0015	.006– .008H	.022– .024H	.010	.016	⑧	⑧	30
1939–41	FK	.001– .0025	.0035– .0045	.0015– .0025	.015– .017	.022– .024	.017	.024	2 5/16	45–51@1 7/8	⑦
1939–41	FM	.001– .0025	.0035– .0045	.0015– .0025	.015– .017	.022– .024	.017	.024	2 5/16	45–51@1 7/8	⑦
1939–41	FO	.001– .0025	.0035– .0045	.0015– .0025	.015– .017	.022– .024	.017	.024	2 5/16	45–51@1 7/8	⑦

① Clearance for new type valve. If old type is in use, adjust to .015″.

② Some engines specified as having flat seats may be found to have 30-degree seats.

③ Smaller figure is the minimum serviceable pressure; larger figure is minimum new spring pressure.

④ Spring No. 1AB1284: free length 3 11/16″, spring pressure 58–63 at 3 1/8″. Spring No. 1AB1574: free length 3 11/16″, spring pressure 86–93 at 2 15/16″. Inner spring No. 1AB1713: free length 2 3/8″, spring pressure 33–37 at 2″. Outer spring No. 1AB1714: free length 2 19/32″, spring pressure 40–45 at 2 1/4″.

⑤ Spring No. 1AB1574: free length 3 11/16″, spring pressure 86–93 at 2 15/16″. Spring No. 1AC16: free length 5 7/8″, spring pressure 73–80 at 4 13/64″. Spring No. 1AC1293: free length 4 7/8″, spring pressure 65–71 at 4″.

⑥ Spring No. 1BC 1479: free length 4 1/8″, spring pressure 85–93 at 3 1/32″. Spring No. 1BC1509: free length 4 1/32″, spring pressure 120–130 at 3 1/32″.

⑦ Intake 30, exhaust 45.

⑧ Inner spring: free length 2 15/16″, spring pressure 44–48 at 2 9/32″. Outer spring: free length 3 1/2″, spring pressure 56–61 at 2 1/2″.

⑨ Set cold.

PISTON AND RING CLEARANCES

Year	Engine Model	Piston Skirt, Inches		Fitting Pistons with Shim and Spring Scale		Ring End Gap, Inch ③		Ring and Groove, Inch	
		Top	Bottom	Shim Thickness ①	Pounds Pull on Scale ②	Compression	Oil	Compression	Oil
1936–38	AB	.004	.004	.004	.005	.017–.021	.017–.021	.002–.003	.002–.003
1936–38	AC	.004	.004	.004	.005	.017–.021	.017–.021	.002–.003	.002–.003
1936–38	AK	.004	.004	.004	.005	.017–.021	.017–.021	.002–.003	.002–.003
1936–38	AL	.004	.004	.004	.005	.017–.021	.017–.021	.002–.003	.002–.003
1936–38	AP	.004	.004	.004	.005	.017–.021	.017–.021	.002–.003	.002–.003
1936–38	BC	.0035	.0035	.0035	.0045	.017–.021	.017–.021	.002–.003	.002–.003
1936–39	BG	.003	.003	.003	.004	.012–.016	.012–.016	.001–.003	.001–.003
1936–38	BK	.004	.004	.004	.005	.017–.021	.017–.021	.002–.003	.002–.003
1936–38	BL	.002	.002	.002	.003	.010–.015	.010–.015	.001–.002	.001–.002
1936–38	BM	.003	.003	.003	.004	.017–.021	.017–.021	.001–.003	.001–.003
1936–38	BQ	.004	.004	.004	.005	.017–.021	.017–.021	.002–.003	.002–.003
1936–38	BX	.004	.004	.004	.005	.017–.021	.017–.021	.002–.003	.002–.003
1936–41	CE	.0035	.0035	.0035	.0045	.017–.021	.017–.021	.002–.003	.002–.003
1936–41	CF	.004	.004	.004	.005	.017–.021	.017–.021	.002–.003	.002–.003
1936–41	CT	.004	.004	.004	.005	.017–.021	.017–.021	.002–.003	.002–.003
1936–39	CU	.003	.003	.003	.004	.012–.016	.012–.016	.001–.003	.001–.003
1939–42	EN-11	.002	.002	.002	.003	.010–.015	.010–.015	.001–.002	.001–.002
1940–42	EN-12	.002	.002	.002	.003	.010–.015	.010–.015	.001–.002	.001–.002
1940	EN-310	.003	.003	.003	.004	.012–.016	.012–.016	.001–.003	.001–.003
1940	EN-354	.003	.003	.003	.004	.012–.016	.012–.016	.001–.003	.001–.003
1940	EN-405	.0038–.0041	.0038–.0041	.004	.005	.017–.021	.017–.021	.002–.003	.002–.003
1941–42	EN-431	.0038–.0041	.0038–.0041	.004	.005	.017–.021	.017–.021	.002–.003	.002–.003
1941–42	EN-457	.0038–.0041	.0038–.0041	.004	.005	.017–.021	.017–.021	.002–.003	.002–.003
1941–46	EN-471	.0038–.0041	.0038–.0041	.004	.005	.017–.021	.017–.021	.002–.003	.002–.003
1942	EN-253	.003	.003	.003	.004	.010–.015	.017–.021	.001–.002	.001–.002
1942–46	EN-271	.003	.003	.003	.004	.010–.015	.017–.021	.001–.002	.001–.002
1942–46	EN-290	.003	.003	.003	.004	.010–.015	.017–.021	.001–.002	.001–.002
1939–42	EO	.0038	.0038	.0038	.0048	.017–.021	.017–.021	.002–.003	.002–.003
1939–42	EP	.0038	.0038	.0038	.0048	.017–.021	.017–.021	.002–.003	.002–.003
1939–46	EY	.004	.004	.004	.005	.017–.021	.017–.021	.002–.003	.002–.003
1939–41	FK	.003	.003	.003	.004	.010–.015	.010–.015	.001–.002	.001–.002
1939–41	FM	.003	.003	.003	.004	.010–.015	.010–.015	.001–.002	.001–.002
1939–41	FO	.003	.003	.003	.004	.010–.015	.010–.015	.001–.002	.001–.002

① Piston should pass on shim thickness shown.

② Piston should lock on shim thickness shown.

③ End gaps are for cylinder bores without taper. Set rings in tapered bores with not less than the maximum dimension shown.

ENGINE BEARING SPECIFICATIONS

Year	Engine Model	Camshaft		Connecting Rod			Mains				
		Journal Diameter	Clearance	Journal Diameter ①	Clearance	Bearing Bolt Tension Lb. Ft.	Journal Diameter ①	Clearance	Bearing Bolt Tension Lb. Ft.	Thrust on No.	End-play
1936-38	AB	---	.002-.004	2.2475	.001-.003	60-65	⑥	.001-.003	135-145	2	.004-.006
1936-38	AC	---	.002-.004	2.3725	.001-.003	60-65	⑦	.001-.003	135-145	2	.004-.009
1936-38	AK	---	.002-.004	2.3725	.001-.003	60-65	⑦	.001-.003	135-145	2	.004-.006
1936-38	AL	---	.002-.004	2.9875	.0015-.003	60-65	⑧	.002-.004	135-145	3	.004-.006
1936-38	AP	---	.002-.004	2.9875	.0015-.003	60-65	⑧	.002-.004	135-145	3	.004-.006
1936-38	BC	---	.002-.004	2.4975	.0015-.003	65-70	2.6215	.001-.003	100-105	1	.004-.011
1936-39	BG	---	.002-.004	2.3725	.0015-.003	60-65	2.9975③	.001-.003	100-105	4	.004-.011
1936-38	BK	---	.002-.004	2.9875	.0015-.003	60-65	⑧	.002-.004	135-145	3	.004-.006
1936-38	BL	---	.002-.004	2.3725	.0015-.003	60-65	2.9975③	.001-.003	100-105	4	.004-.011
1936-38	BM	---	.002-.004	2.4975	.0015-.003	65-70	2.9975③	.0025-.004	100-105	1	.004-.011
1936-38	BQ	---	.002-.004	2.9875	.0015-.003	60-65	⑧	.002-.004	135-145	3	.004-.006
1936-38	BX	---	.002-.004	2.4975	.0015-.003	65-70	2.9975③	.0025-.004	100-105	1	.004-.011
1936-41	CE	---	.002-.004	2.4975	.0015-.003	65-70	2.9975③	.0025-.004	100-105	1	.004-.011
1936-41	CF	---	.002-.004	2.4975	.0015-.003	65-70	2.9975③	.0025-.004	100-105	1	.004-.011
1936-41	CT	---	.002-.004	2.4975	.0015-.003	65-70	2.9975③	.0025-.004	100-105	1	.004-.011
1936-39	CU	---	.002-.004	2.3725	.0015-.003	60-65	2.9975③	.001-.003	100-105	4	.004-.011
1939-42	EN-11	---	.002-.004	1.9370	.0015-.0025	35-40	2.2495	.0015-.0025	100-110	1	.004-.006
1940-42	EN-12	---	.002-.004	2.0620	.0015-.0025	35-40	2.3745	.0015-.0025	100-110	1	.004-.006
1940	EN-310	---	.0025 .0035	2.3725	.0015-.0025	60-65	2.9975③	.0015-.003⑤	100-105	4	.004-.011
1940	EN-354	---	.0025-.0035	2.3725	.0015-.0025	60-65	2.9975③	.0015-.003⑤	100-105	4	.004-.011
1940	EN-405	---	.0015-.003	2.7475	.0015-.003	100-105	3.4975④	.0015-.003⑤	100-105	4	.004-.011
1941-42	EN-431	---	.0015-.003	2.7475	.0015-.003	100-105	3.4975④	.0015-.003⑤	100-105	4	.004-.011
1941-42	EN-457	---	.0015-.003	2.7475	.0015-.003	100-105	3.4975④	.0015-.003⑤	100-105	4	.004-.011
1941-46	EN-471	---	.0015-.003	2.7475	.0015-.003	100-105	3.4975④	.0015-.003⑤	100-105	4	.004-.011
1942	EN-253	---	.002-.004	2.2485	.0015-.0025	70-75	2.6235	.0015-.0025	②	1	.004-.006
1942-46	EN-271	---	.002-.004	2.2485	.0015-.0025	70-75	2.6235	.0015-.0025	②	1	.004-.006
1942-46	EN-290	---	.002-.004	2.2485	.0015-.0025	70-75	2.6235	.0015-.0025	②	1	.004-.006
1939-42	EO	---	.0015-.003	2.9975	.0015-.003	145-150	3.4975④	.0015-.003⑤	100-105	4	.004-.011
1939-42	EP	---	.0015-.003	2.9975	.0015-.003	145-150	3.4975④	.0015-.003⑤	100-105	4	.004-.011
1939-46	EY	---	.0015-.003	2.9975	.0015-.003	145-150	3.4975④	.0015-.003⑤	100-105	4	.004-.011
1939-41	FK	---	.002-.004	2.2485	.0015-.0025	70-75	2.6235	.0015-.0025	②	1	.004-.006
1939-41	FM	---	.002-.004	2.2485	.0015-.0025	70-75	2.6235	.0015-.0025	②	1	.004-.006
1939-41	FO	---	.002-.004	2.2485	.0015-.0025	70-75	2.6235	.0015-.0025	②	1	.004-.006

① Plus or minus .0005".

② For ½" screws, 100 to 110; for 9/16" screws, 130 to 140.

③ For Nos. 4 and 7, 2.9965".

④ For Nos. 4 and 7, 3.4970".

⑤ For Nos. 4 and 7, .0025"-.004".

⑥ No. 1, 2.997"-2.998". No. 2, 2.981"-2.982". No. 3, 2.966"-2.967".

⑦ No. 1, 2.966"-2.967". No. 2, 2.950"-2.951". No. 3, 2.935"-2.936".

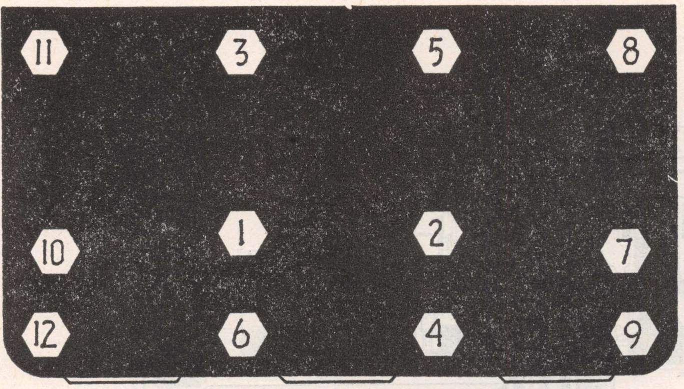
⑧ No. 1, 3.558"-3.559". No. 2, 3.527"-3.528". Nos. 3 and 4, 3.496"-4.397".

ENGINE

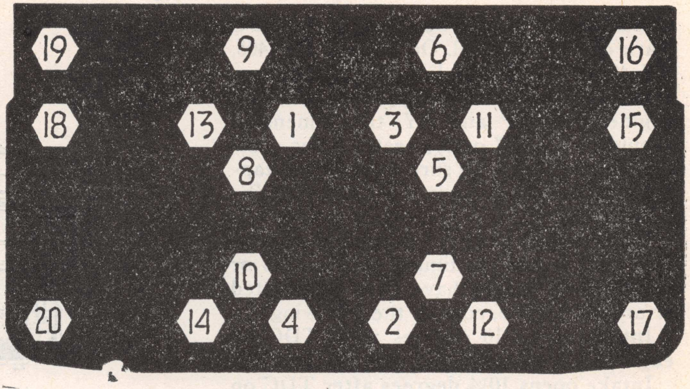
CYLINDER HEAD

1936-46: Cylinder heads on L-head engines should be tightened down by starting from the center nut of the middle row and working outward toward the sides and to the ends. See the diagrams for tightening sequence on overhead valve engines. Draw down the nuts evenly and repeat the operation until all are normally tight. After the engine has been run sufficiently long to bring all the parts to normal operating temperature, a final tightening should be made.

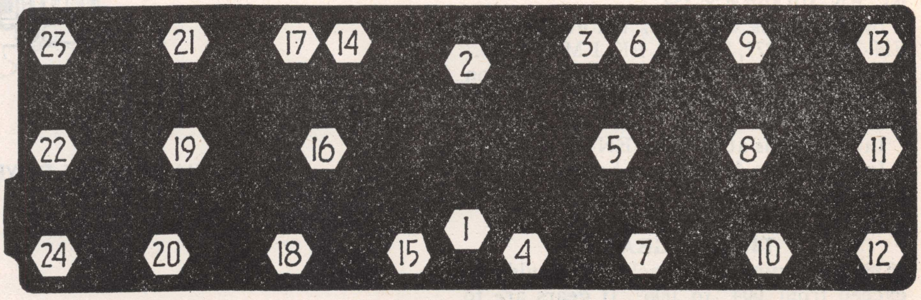
When using a torque wrench, the final tightening should be from 115 to 120 pounds feet on AB, AC, AK, BK and BQ; 100-105



HEAD TIGHTENING SEQUENCE. Engines EN-405, 431, 457 & 471.



HEAD TIGHTENING SEQUENCE. Engines EO, EP & EY.



L-HEAD ENGINES. Typical Cylinder Head Layout.

on CE, CF and CT; 85-90 on CU; 30-35 on EN-11 and EN-12; 70-75 on FK, FM, FO, EN-253, EN-271 and EN-290; 90-100 on EN-310, EN-354, and from 115 to 120 on overhead valve engines.

NOTE—On engines with two cylinder heads, whenever one head is removed, the stud nuts on the other head should be loosened to prevent the possibility of distortion. When using a torque wrench, be sure the nuts and studs are free from rust or dirt, otherwise a false reading will be obtained due to the increased friction. On overhead valve engines, be sure to check the valve lash after the final tightening.

When removing cylinder heads on overhead valve engines, while the engine remains in the chassis, do not remove the manifolds but it will be necessary to unscrew the studs from the block in order to facilitate handling.

ROCKER ARMS & PUSH RODS

EN-405, 431, 457, 451, EO, EP, EY: When disassembling rocker arm assemblies, place all parts on the bench in their proper relationship to assure correct assembly. Push rods are stamped "IN" for intake and "EX" for exhaust. To prevent the possibility of bending or twisting push rods, they should be removed before taking off the cylinder head, and replaced after the head is installed.

When installing valve springs, the spring end with the more tightly wound coils should face down or toward the cylinder head.

VALVE SEAT INSERTS

1936-46: Since these inserts are too hard to reface by the ordinary grinding methods, a high-speed grinding stone or a special lapping tool should be used to perform this operation. When using this equipment, be sure valve guides are clean and that the valve guide pilot is a snug fit in order to assure a concentric finish. Finished seats should be checked with a dial indicator and run-out should not exceed .0005".

NOTE—When necessary to replace inserts, it is advisable to use a special puller and driver which is available for the purpose. However, if this equipment is not procurable, the inserts may be removed and replaced in the following manner:

To remove an insert, use a drill which is smaller in diameter than the insert width and drill holes at opposite sides, but not all the way through. Cut through the undrilled portion of the insert with a sharp chisel and remove the two pieces.

To install an insert, pack in "dry ice" for at least fifteen minutes to allow the metal to contract, and heat the exhaust valve port area gradually, if necessary, to permit this material to expand. Then press the insert into the cylinder block or head, as the case may be, using extreme care to see that it is not cocked or misaligned. When installed, finish the seats with the grinding or lapping equipment already mentioned.

VALVE STEM GUIDES

1936-46: When necessary to replace guides on L-head engines with mushroom tappets and with the tappet guides pressed in the block, run the tappet adjusting screw all the way down and crank the engine to bring the tappet on the low point of the cam. Then use a suitable drift, preferably one having a pilot which is the same size as the valve stem, to drive out the guide. If the guide comes in contact with the tappet before it is all the way out, break off the lower part.

On L-head engines with removable tappet guide clusters, or with tappets not of the mushroom type, simply remove the tappet and guide assemblies, or lift out the tappets and drive out the valve stem guides.

On AB, AC, AK, AL, AP, BK and BQ engines, the guides have shoulders at the top which must be broken off before they can be driven out. This can be done by using a chisel, working through the valve ports.

NOTE—On all engines, it is good practice to remove and install one guide at a time. When installing an intake guide, measure the depth of an intake guide not yet removed in order to determine the correct depth of the guide being installed. Similarly, this procedure should be followed when replacing exhaust valve guides. When installed, the guides should be reamed to provide a clearance within the limits given in the VALVE SYSTEM table.

VALVE TAPPETS & GUIDES

1936-46: Tappets must be a free fit in their guides without excessive side play. On some of these engines, the tappet guides are removable bushings pressed in the block. When necessary to replace guides of this design, the camshaft will have to be removed and the old bushings pressed out and new ones installed. Then ream the bushings to provide a clearance within the limits given in the VALVE SYSTEM table.

If the engine being serviced has the "cluster" type tappet guides, install a new cluster and replace any tappets which are too loose a fit.

VALVE TIMING

1936-46: Valve timing is correct when the punch marks on the camshaft and crankshaft gears are meshed. When checking valve opening or closing in degrees of crankshaft travel, do so when the engine is at normal room temperature, and set the tappet clearance for timing as given in the VALVE SYSTEM table.

NOTE—On overhead valve engines, the valve timing may be checked by setting the No. 1 intake valve clearance to .025" (cold engine) and slipping a .010" feeler between the clearance gap. Turn the engine slowly until the feeler begins to drag. At this point, the timing indicator on the flywheel housing should be ahead of the TDC mark on the flywheel. On engines EN-405, EN-431, EN-457 and EN-471, this dimension should be 1 1/16" or 3¼ teeth, while on engines EO, EP and EY, this dimension should be 1 3/16" or 3½ teeth. After completing the check, be sure to reset the tappet clearance as given in the VALVE SYSTEM table.

If the engine has been entirely disassembled and, either the timing gear marks or the flywheel marks have been obliterated or are not legible, consult the following:

Intake opens 10 degrees after TDC on engines AB, AC, AK, AL, AP, BK and BQ.

Intake opens 10½ degrees after TDC on BC, BM, BX, CE, CF, CT and CU.

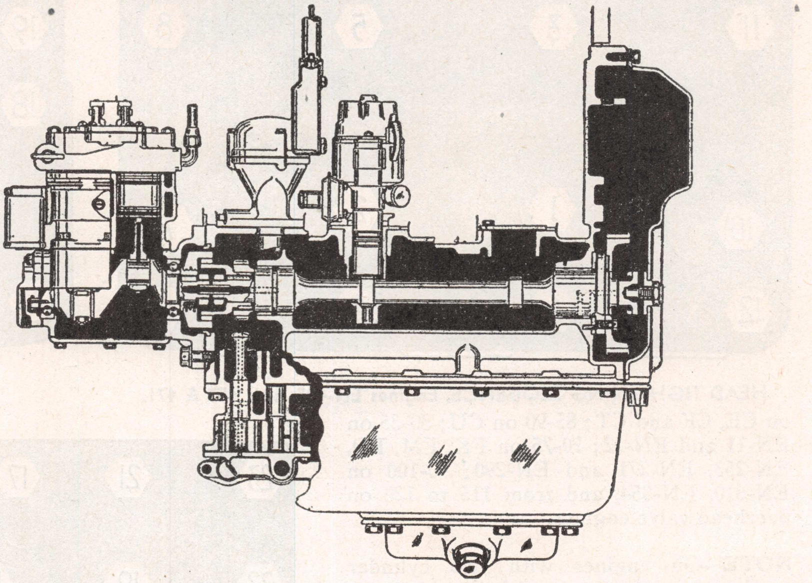
Intake opens 6 degrees after TDC on BG, BL, EN-310 and EN-354.

Intake opens 6 degrees before TDC on EN-253, EN-271, EN-290, FK, FM and FO.

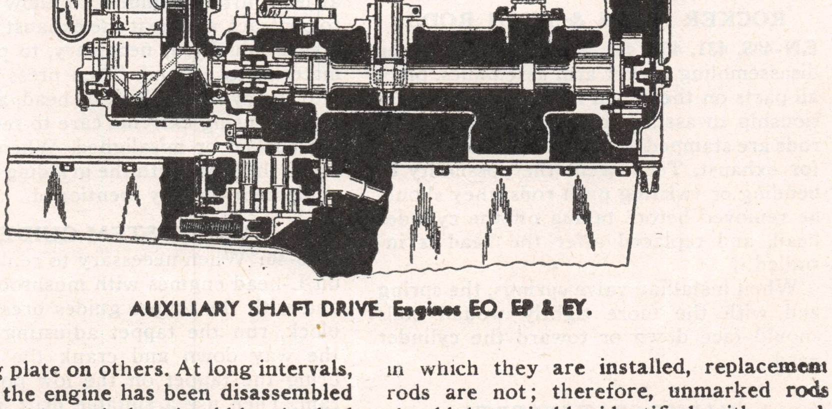
Intake opens 8 degrees before TDC on EN-405, EN-431, EN-457, EN-471, EO, EP and EY.

Intake opens at TDC on EN-11.

Intake opens 4½ degrees before TDC on EN-12.



AUXILIARY SHAFT DRIVE. Engines EN-405, 431, 457 & 471.



AUXILIARY SHAFT DRIVE. Engines EO, EP & EY.

TIMING GEARS

1936-46: Timing gear backlash should not exceed from .004" to .006". If gears are to be removed and the same gears replaced, make sure the timing marks are legible. The camshaft gear is fastened to the camshaft by bolts, and to prevent the possibility of installing the gear incorrectly, a dowel or pin is used in the camshaft flange which registers with a slot in the gear at one point only.

When installing a new crankshaft gear, it is advisable to heat the gear in boiling water to expand the metal, and coat the shaft with white lead to make assembly easier.

Before replacing the gear cover, be sure the valve timing is correct, which is when the punch marks on both gears are meshed.

CAMSHAFT & BEARINGS

1936-46: When necessary to renew camshaft bearings, they should be pressed in place and line-reamed to provide a clearance within the limits given in the ENGINE BEARING SPECIFICATIONS table.

NOTE—To assure proper camshaft fit on engines with crankcase separate from the cylinder block, camshaft bearings should be line-reamed **after** the cylinder block is bolted to the crankcase. Be sure the oil holes in the camshaft bearings are lined up with the oil holes in the crankcase, and that these holes are clean and open.

IMPORTANT—On "C" series engines having aluminum crankcases, it has been found that the camshaft bearings sometimes "float" due to the greater heat expansion of the aluminum. When installing camshaft bearings in these engines, drill and tap small holes in the crankcase at each bearing and insert screws in the tapped holes to prevent a recurrence of this condition.

Camshaft end play is controlled by an adjustable plug on some engines and by an adjusting plate on others. At long intervals, or when the engine has been disassembled for repairs, the end play should be checked and if in excess of about .010", it should be corrected.

AUXILIARY SHAFT & BEARINGS EN-405, 431, 457, 471, EO, EP, EY:

The auxiliary shaft bearings are similar to the camshaft bearings and fitted with .0015" to .003" clearance while the auxiliary shaft end play should be from .008" to .014".

PISTONS & RODS, REMOVE

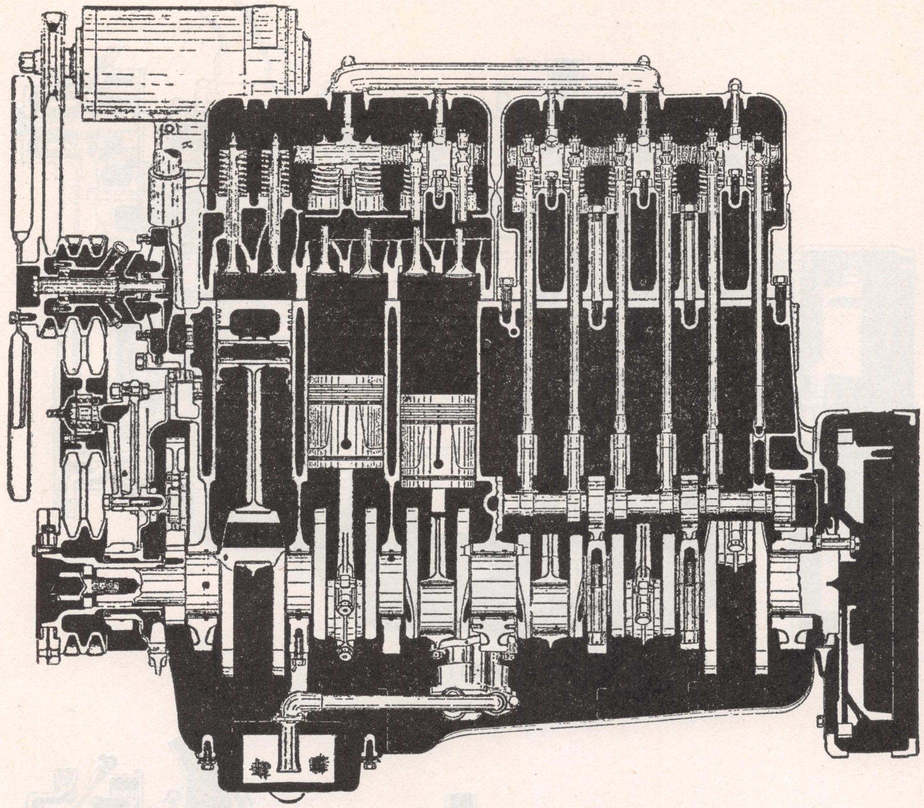
1936-46: Pistons and rods are removable from either the top or bottom on AB and AC engines while on all other engines, pistons are removed from the top only.

Although regular production rods are generally marked with the cylinder number in which they are installed, replacement rods are not; therefore, unmarked rods should be suitably identified with punch marks, as removed.

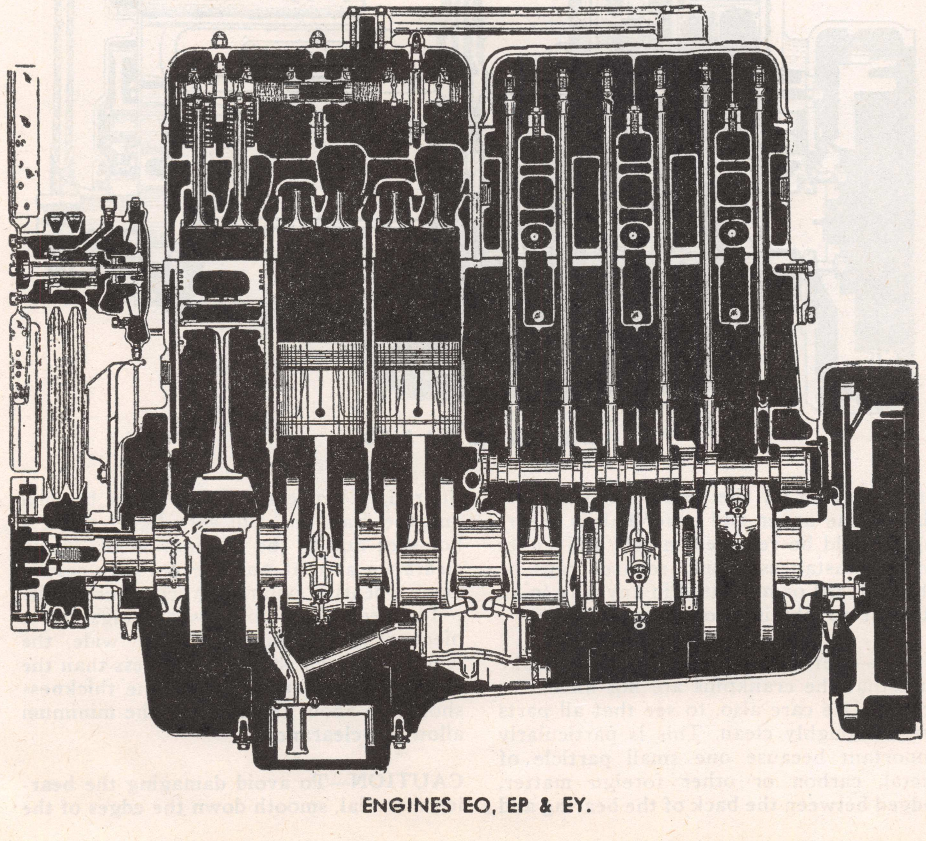
PISTON & ROD, ASSEMBLE

1936-46: Aluminum pistons should be assembled to the rods so that when inserted in the cylinder bores, the slotted side of the piston is facing opposite to the camshaft. Regular production aluminum pistons are usually marked with an arrow, and if so marked, they should be installed with the arrow toward the front of the engine.

NOTE—On overhead valve engines, the connecting rod caps are parted at an angle, and when installed, the oil squirt hole should be on the leading side, that is, the open side should be toward the camshaft on



ENGINES EN-405, 431, 457 & 471.



ENGINES EO, EP & EY.

engines EN-405, 431, 457 and 471, and away from the camshaft on EO, EP and EY engines.

PISTONS, RENEW

1936-46: A variation of 10 degrees between the temperature of the pistons and cylinder bores is sufficient to produce a difference of .0005". Therefore, both the pistons and cylinder bores should be at normal room temperature (about 70 degrees) when fitting pistons. This is particularly important because the clearances given in the PISTON & RING CLEARANCES table are minimum and pistons must not be fitted with less than specified.

Before any attempt is made to fit new pistons, cylinder bores should be carefully indicated and refinished. If bores do not require refinishing, be sure to remove the ridge at the top of each bore. If refinishing is required, it is good practice to do so in alternate cylinders due to the localized temperature build-up. Cylinder bores should not be out-of-round or tapered more than .0005".

Before fitting pistons, wipe the cylinder walls and pistons to remove all chips, dirt or other foreign matter. The feeler ribbon used to check piston fit should be about 12" long and ½" wide. Consult the PISTON & RING CLEARANCES table for the thickness of shim to use for the piston to pass on and lock on the feeler.

When fitting pistons, insert the piston in the bore upside down and in its running position. Place the feeler ribbon between the cylinder wall and the thrust side of the piston (opposite the slotted side on aluminum pistons) in a position at right angles to the piston pin hole.

After pistons have been fitted properly and are assembled to the rods, check the assembly for alignment on a suitable jig.

PISTON RINGS, RENEW

1936-46: NOTE—To prevent the possibility of bending or breaking the second ring land —thus ruining the piston—the ridge at the top of the cylinder bore should be cut away before removing the piston and rod assemblies. If the available ridge reamer has no provision to control the depth of the cut, it is good practice to bring the piston far enough up into the cylinder to allow the reamer to rest on top of the piston. This will serve to prevent cutting down into the ring travel area.

CAUTION—Never cut down into the ring travel area more than 1/32"—or more than half the depth of the top ring.

New rings should be fitted with end gaps and groove clearances as given in the PISTON & RING CLEARANCES table. Ring grooves must be clean and free from carbon, and must show no perceptible wear.

NOTE—Ring end gaps given in the PISTON & RING CLEARANCES table are for cylinder bores without taper. Fit rings in tapered bores with not less than the maximum dimension given. If rings other than standard are being installed, pay particular attention to the installation instructions which are usually included in the ring package. This applies to clearances, position in grooves, etc.

When rings are properly fitted to the pistons, be sure to stagger the ring gaps so they are spaced equal distances around the circumference of the piston. However, see that no gaps are over the piston pins.

PISTON PINS, RENEW

1936-46: The correct fit of piston pins in cast iron pistons should be one which requires a light push with the palm of the hand to insert the pin. For aluminum pistons, at normal room temperature, it should require a hard push with the palm of the hand to install the pin. However, to facilitate fitting pins in aluminum pistons, heat the piston in boiling water for a few minutes, after which, the pin should enter the piston easily.

In some engines, the pins are clamped in the upper end of the rod, and when installing pins of this type, turn the notch in the pin to line it up with the clamp screw hole in the rod, to prevent damage to the clamp screw threads as it is being installed.

In other engines, the pins "float" in both the rods and pistons, being retained by snap ring keepers in some cases or by aluminum plugs pressed into the ends of the pins.

To check the fit of pins after installation, hold the piston in both hands and, for aluminum pistons, the weight of the rod should not be sufficient to allow it to fall. When using the same method on cast iron pistons, the rod should drop easily by its own weight.

PISTON PIN BUSHINGS, RENEW

1936-46: New bushings should be pressed in place and reamed to provide a hand push fit of the pin with the parts at normal room temperature. If the bushing is in the rod, be sure the oil hole in the bushing lines up with the oil hole in the connecting rod.

CONNECTING ROD BEARINGS, RENEW

AB, AC, AK, AL, AP: Connecting rod bearings used in these engines are of the replaceable babbitt type having a thick steel shim on each side. When fitting bearings of this type, they must be scraped or reamed after assembly to obtain a bearing bore diameter of .001" greater than the diameter of the crankpin. The parting faces of the bearings must be filed and fitted so they project .002" above the contacting surface of the rod and cap.

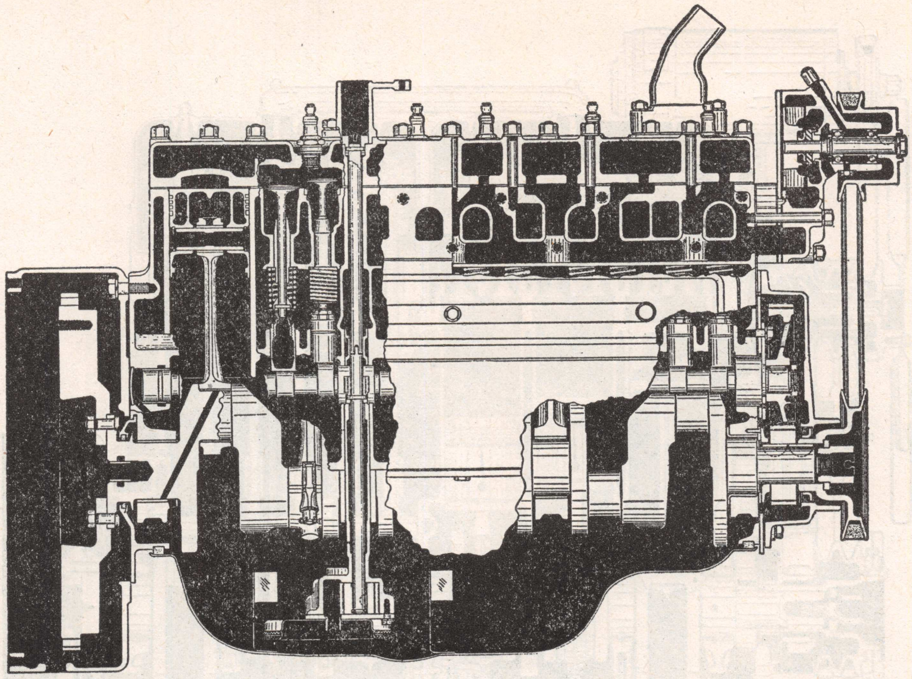
BC, BG, BK, BL, BM, BQ, BX, Early Production "C" Engines: These bearings are the spun type and are not replaceable. If bearings require adjustment, remove the same thickness of shims from each side until a metal-to-metal contact is established with the crankpin. The bearing may then be scraped to provide maximum bearing surface, and sufficient shims installed on both sides to provide a clearance within the limits given in the ENGINE BEARING SPECIFICATIONS table.

Late Production "C" Engines and All 1939-46: When bearings become worn, they can be replaced without removing the rod by simply taking off the bearing cap and replacing the upper and lower halves. Bearings should be replaced in sets and under no circumstances should rods or caps be filed, altered or mutilated in any way in an attempt to obtain proper bearing fit.

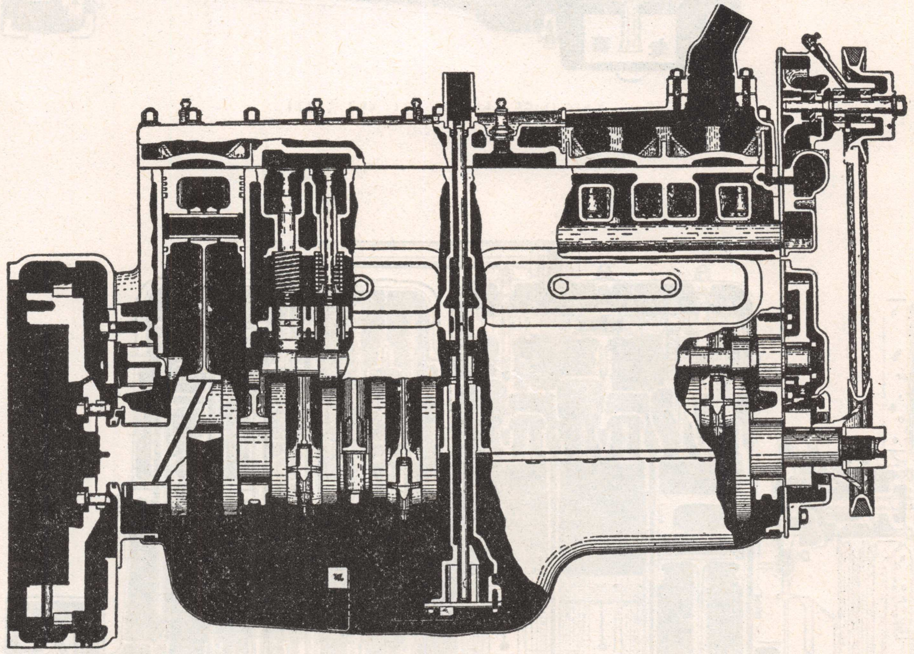
NOTE—Before replacing bearings, make sure that the crankpins are not nicked or scored. Use care also, to see that all parts are thoroughly clean. This is particularly important because one small particle of metal, carbon or other foreign matter, lodged between the back of the bearing and the rod, or between the face of the bearing and the crankpin, will very likely cause a hot spot due to the elimination of the oil clearance at that point, eventually resulting in a bearing failure or a scored crankpin.

To check the fit of new bearings, use a piece of brass shim stock 1/4" wide, the length of which should be 1/4" less than the length of the bearing, while the thickness should be about the same as the minimum allowable clearance.

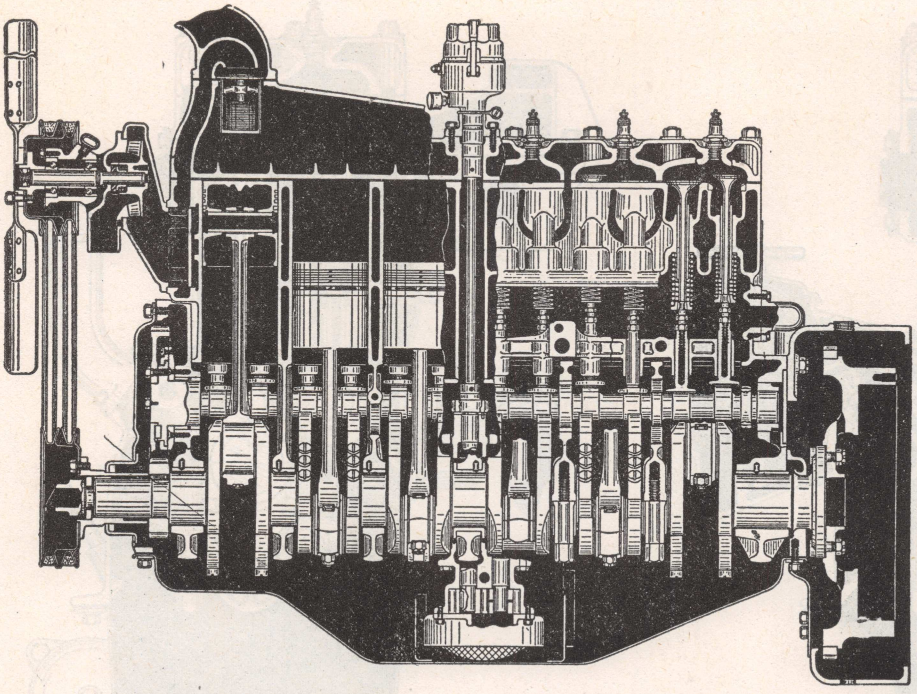
CAUTION—To avoid damaging the bearing material, smooth down the edges of the



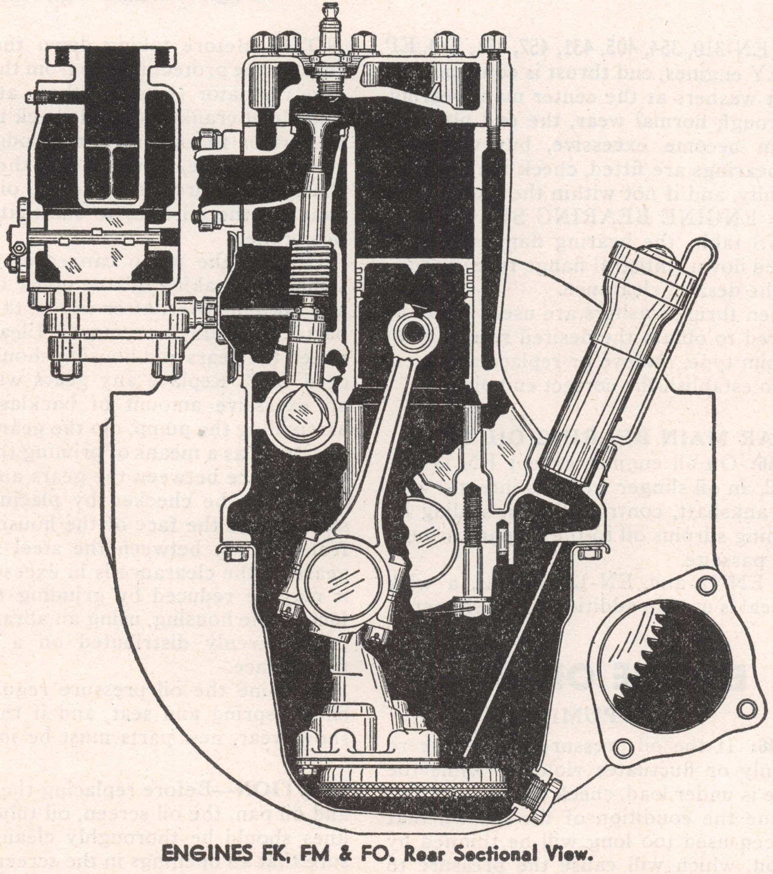
ENGINES EN-11 & EN-12.



ENGINES FK, FM & FO.



ENGINES EN-310 & EN-354.



ENGINES FK, FM & FO. Rear Sectional View.

shim stock on an oil stone so that no sharp edges remain. Install the shim between the bearing and the crankpin, in the center of the bearing, then tighten the cap bolts to the recommended torque tension. When fitted properly, it should not be possible to move the rod endwise by hand, but a light tap with a hammer should cause the rod to move endwise. Then remove the checking shim and install the cap again, tightening the cap bolts with the torque wrench, after which, the rod should move endwise by hand. If the rod is too loose with the checking shim in place, the crankpin should be turned down and undersize bearings fitted.

NOTE—It is good practice to check the connecting rod bore for roundness. A special tool with an indicator gauge is available for this operation, and before using this instrument, be sure that there are no nicks, burrs or dirt on the contacting surfaces to prevent a true reading. If the rod bore is out-of-round more than .002" or .003", the rod should be replaced.

MAIN BEARINGS, RENEW

1936-46: Two types of bearings have been used in these engines. One type employs a babbitt-lined removable bearing for the upper half, while in the lower half, the babbitt is poured directly in the bearing caps.

The other type is the precision insert shell bearings, which, when worn, can be replaced without removing the crankshaft.

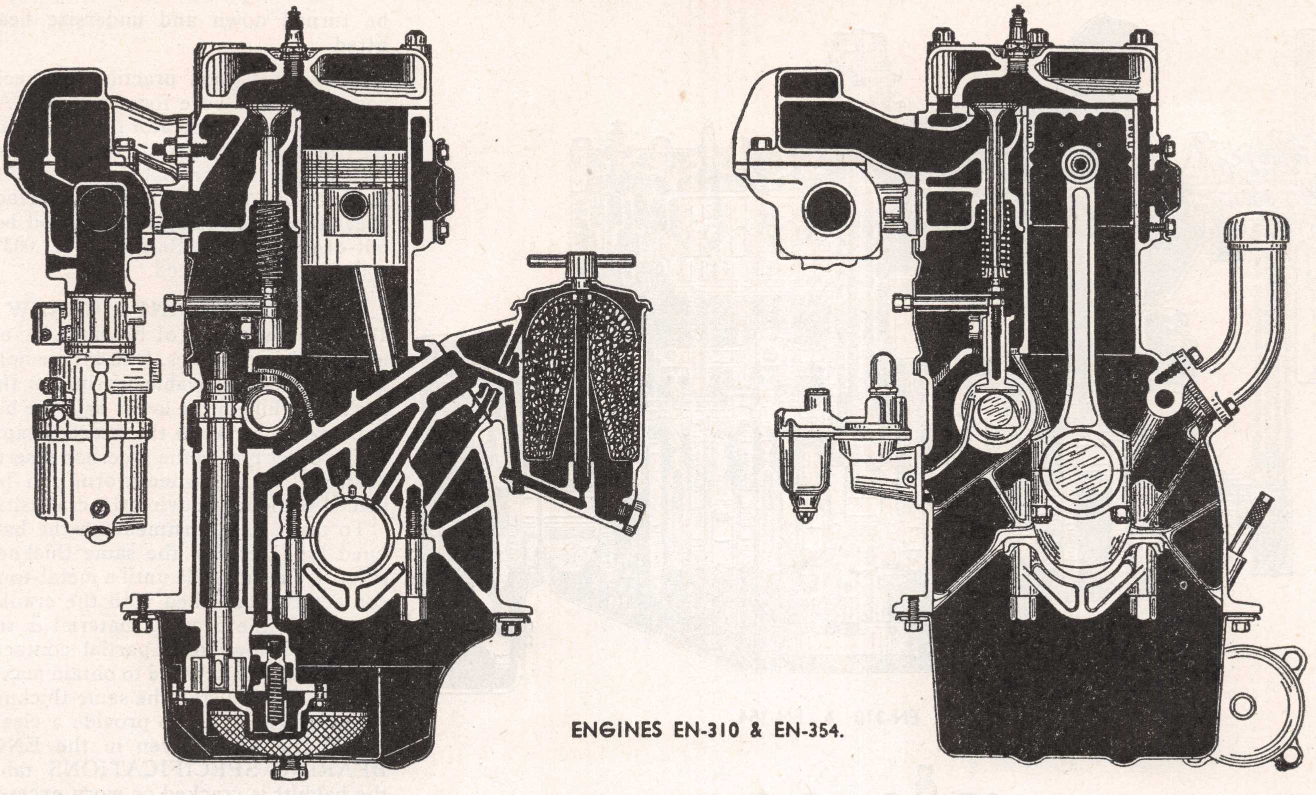
To make an adjustment on the babbitt-lined type, remove the same thickness of shims from each side until a metal-to-metal contact is established with the crankshaft journal. If the bearing material is scored, rough or shows only partial contact, the bearing may be scraped to obtain maximum contact. Then install the same thickness of shims on each side to provide a clearance within the limits given in the ENGINE BEARING SPECIFICATIONS table. If the babbitt is cracked or worn excessively, new bearings should be fitted and line-reamed to fit the crankshaft.

NOTE—Bearings of the precision insert type should be replaced in sets and under no circumstances should any attempt be made to file, alter or otherwise mutilate the bearing caps to obtain proper bearing fit. No shims are used.

Before replacing bearings, make sure that the crankshaft journals are not nicked or scored. Use care also, to see that all parts are thoroughly clean. This is particularly important because one small particle of metal, carbon, dirt or other foreign matter, lodged between the back of the bearing and the cap, or between the bearing face and the crankshaft journal, will very likely cause a hot spot due to the elimination of the oil clearance at that point, eventually resulting in a bearing failure or a scored journal.

When bearings become worn, they can be replaced without removing the crankshaft in the following manner: Remove the bearing cap and take out the worn lower shell. A suitable tool can be made to remove the upper shell by using a cotter pin with the rounded end flattened to form a T shape. Insert the T-shaped end of the pin in the oil passage hole in the crankshaft journal and, by rotating the crankshaft in the reverse direction, the T-shaped head will contact the bearing and force it out.

To install, place a new upper shell on the crankshaft journal with the locating notch in the correct position and rotate the shaft to turn the shell in place. Then install the lower shell in the cap and replace the cap, tightening the cap bolts to the recommended torque tension which will be found in the ENGINE BEARING SPECIFICATIONS table.



ENGINES EN-310 & EN-354.

To check the fit of new bearings, use a piece of brass shim stock ¼" wide, the length of which should be ¼" less than the length of the bearing, while the thickness should be about the same as the minimum allowable clearance.

CAUTION—To avoid damaging the bearing material, smooth down the edges of the shim stock to remove sharp edges or turned over corners. And before inserting it in place, coat the shim on both sides with a light film of engine oil.

Then lay the shim lengthwise in the center of the bearing and install the bearing cap to the crankshaft, tightening the cap bolts to the recommended torque tension which can be found in the ENGINE BEARING SPECIFICATIONS table. Test the fit of the bearing by rocking the flywheel through an arc of 2"—not more than 1" in either direction. The bearing may be considered fitted properly if the shaft is movable with a fairly heavy drag.

NOTE—Remove the shim and replace the cap, but do not tighten the cap bolts, as this bearing must be loose in order to check the fit of the other bearings. It is good practice to fit bearings by starting at the center—or one of the intermediates on a four bearing job—then the rear bearing, front bearing, and finally, the intermediates.

CRANKSHAFT END THRUST

1936-46: On "A," "B" and "C" engines, crankshaft end thrust is taken on the center main bearing on three-bearing shafts, and on the rear intermediate bearing on four-bearing shafts.

On EN-11, 12, 253, 271, 290, FK, FO and FM, end thrust is controlled by a 1/16" shim pack behind the crankshaft timing gear.

On EN-310, 354, 405, 431, 457, 471, EO, EP and EY engines, end thrust is controlled by thrust washers at the center main bearing.

Through normal wear, the end play will seldom become excessive, but whenever new bearings are fitted, check the end play carefully, and if not within the limits given in the ENGINE BEARING SPECIFICATIONS table, the bearing flanges may be dressed down (integral flange type) to provide the desired clearance.

When thrust washers are used, install as required to obtain the desired result. With the shim type, remove or replace as necessary to establish the correct end play.

REAR MAIN BEARING OIL SEAL

1936-46: On all engines except EN-11 and EN-12, an oil slinger which is integral with the crankshaft, controls the oil sealing by returning surplus oil to the oil pan through an oil passage.

On EN-11 and EN-12 engines, a wick type seal is used in addition to the slinger.

ENGINE OILING

OIL PUMP

1936-46: If the oil pressure drops to zero suddenly or fluctuates violently while the engine is under load, check the oil level and examine the condition of the oil. Oil that has been used too long will be thinned by dilution, which will cause the pressure to drop. If these conditions are not the cause, before taking down the oil pan and pump, check the oil gauge with another gauge known to be accurate. If the pressure continues to drop, remove and clean the oil pan thoroughly, and disassemble, clean and inspect the pump.

NOTE—Before taking down the oil pan, remove the protecting cap from the oil pressure regulator (engines where attached to outside of crankcase) and check to see that no dirt or foreign matter is lodged under the relief valve. If this is not the cause of the pressure drop, remove the oil pan and examine the oil lines to see that they are not broken.

Usually, the pump can easily be disassembled by taking off the upper drive gear and bottom cover, after which, the internal parts can readily be removed. Clearance between the gears and housing should not exceed .006". Replace any gears which have an excessive amount of backlash. When assembling the pump, dip the gears in fresh engine oil as a means of priming the pump.

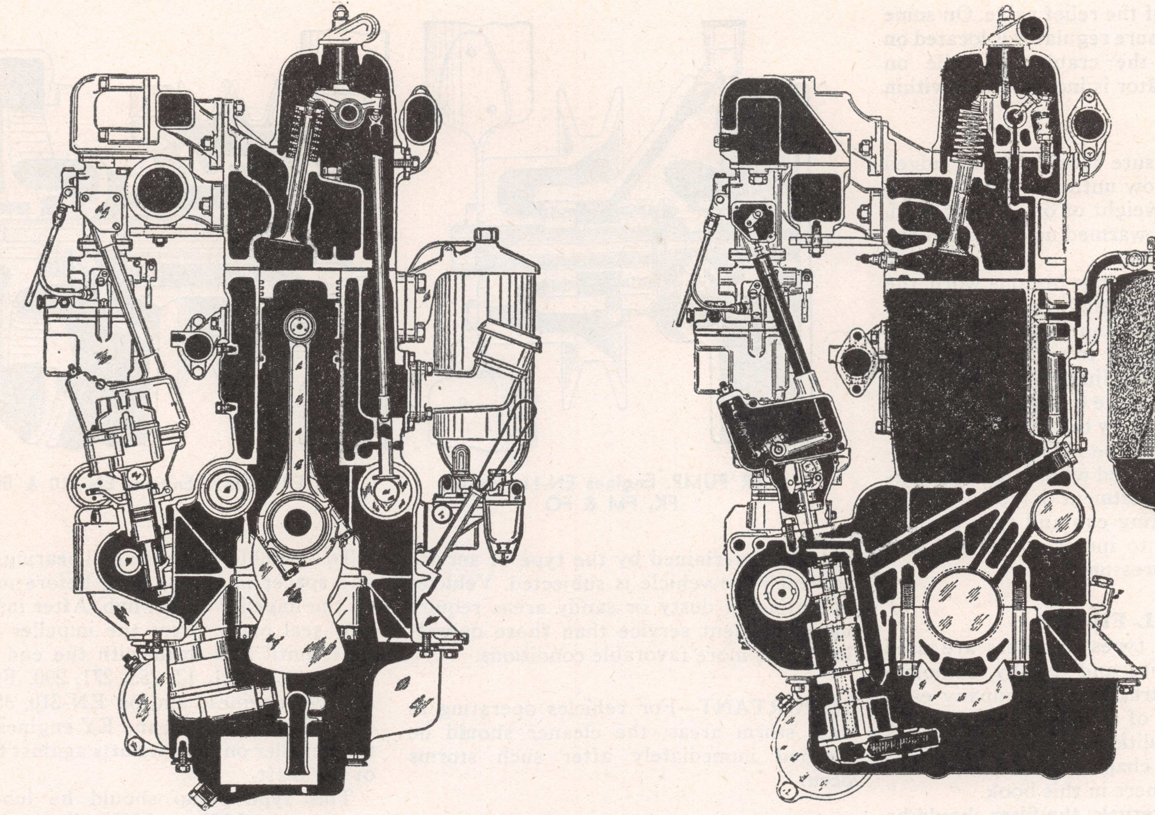
Clearance between the gears and bottom cover may be checked by placing a steel scale across the face of the housing, and a feeler ribbon between the steel scale and gears. If the clearance is in excess of .004", it may be reduced by grinding the lower face of the housing, using an abrasive compound evenly distributed on a perfectly flat surface.

Examine the oil pressure regulator ball check, spring and seat, and if these parts show wear, new parts must be installed.

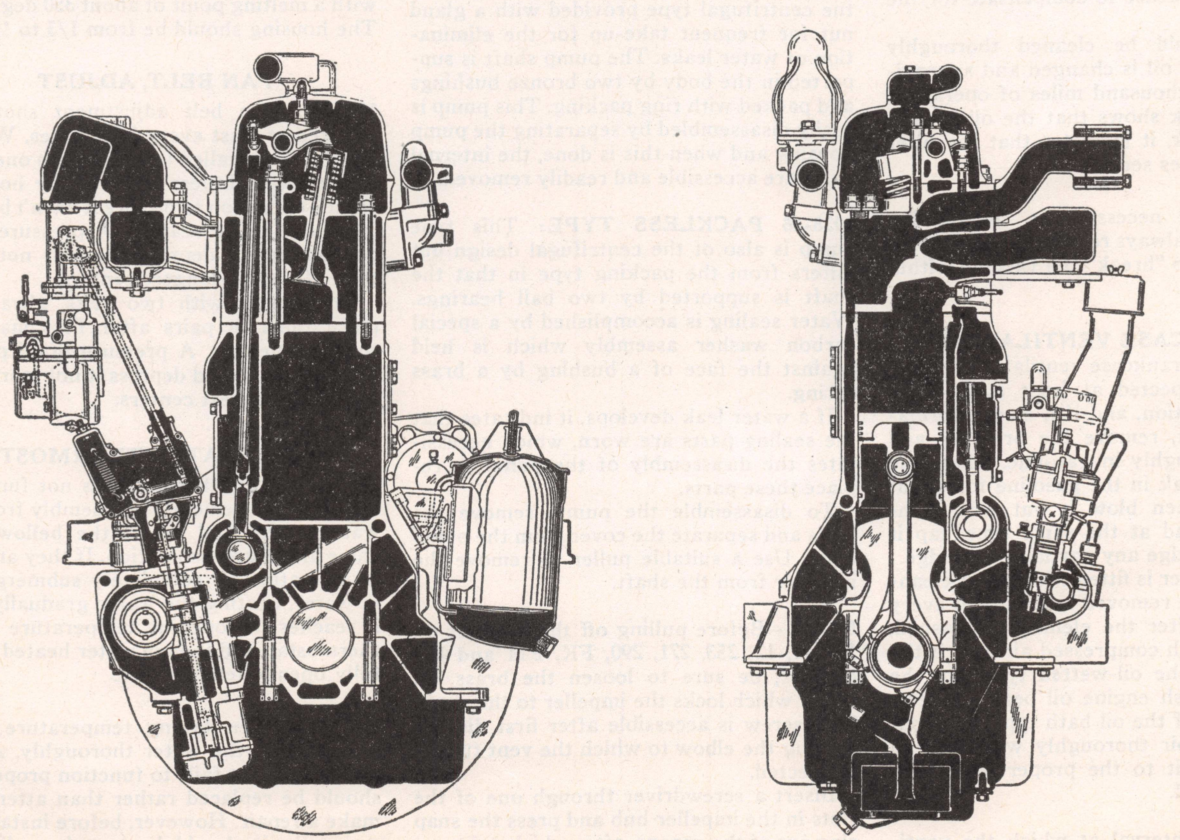
CAUTION—Before replacing the oil pump and oil pan, the oil screen, oil tubes and oil lines should be thoroughly cleaned, being sure that all openings in the screen are free and clean. If the screen is crushed, it is better to replace it rather than attempt to make a repair.

OIL PRESSURE REGULATOR

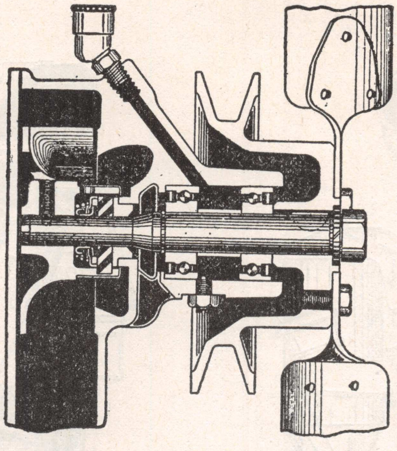
1936-46: Oil pressure is automatically controlled by a compression spring which con-



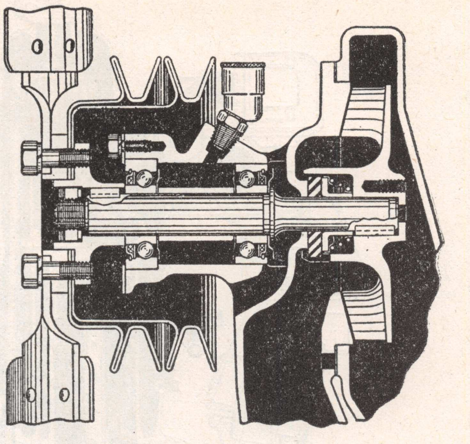
ENGINES EN-405, 431, 457 & 471.



ENGINES EO, EP & EY.



WATER PUMP. Engines EN-11, EN-12, FK, FM & FO



WATER PUMP. Engines EN-310 & EN-354

trols the action of the relief valve. On some engines, the pressure regulator is located on the outside of the crankcase while on others, the regulator is incorporated within the pump.

NOTE—Oil pressure should not be judged too high or too low until it is known whether the proper weight of oil is being used, and the engine is warmed up to normal operating temperature.

As the engine bearings become worn, the oil pressure will be slightly lower due to more oil escaping around the bearings. It is not advisable to try to correct this slight pressure loss by an adjustment of the pressure regulator, because the extra amount of oil being thrown off by the worn bearings is already over-oiling the cylinder walls.

On engines equipped with adjustable regulators, if an adjustment is required, remove the protecting cap and turn the adjusting screw **in** to increase pressure and **out** to decrease pressure.

OIL FILTER

1936-46: Several types of filters are used with these engines and usually, complete maintenance instructions accompany each filter in the form of a sticker pasted on the filter itself. If additional information is required, see the chapter devoted to OIL FILTERS elsewhere in this book.

At frequent intervals, the filter should be drained to get rid of any solid matter which may have settled in the filter sump. Whenever this is done, be sure to add sufficient oil to the crankcase to compensate for the oil drained.

Filters should be cleaned thoroughly every time the oil is changed and approximately every thousand miles of operation. If the dip stick shows that the oil is very dirty and thick, it indicates that the filter element requires service.

NOTE—When necessary to remove the filter element, always remove the drain plug first in order to "break" the vacuum within the filter.

CRANKCASE VENTILATOR

1936-46: The crankcase ventilator breather should be inspected at least every 2,000 miles of operation, and if a sludge formation is evident, remove the breather and clean it thoroughly in gasoline. Allow the breather to soak in the gasoline for about 30 minutes, then blow it out with compressed air, and at the same time, tap it lightly to dislodge any particles of sludge.

If the breather is fitted with an air cleaner, it should be removed and washed every 1,000 miles. After the element is washed, blow it dry with compressed air and, if the cleaner is of the oil-wetted type, dip the element in fresh engine oil before assembling. If it is of the oil bath type, wipe out the oil reservoir thoroughly with a clean cloth and fill it to the proper level with fresh engine oil.

NOTE—The interval at which the ventilator and air cleaner should be cleaned can only be determined by the type of service to which the vehicle is subjected. Vehicles operating in dusty or sandy areas require more frequent service than those operating under more favorable conditions.

IMPORTANT—For vehicles operating in dust storm areas, the cleaner should be cleaned immediately after such storms occur.

COOLING SYSTEM

WATER PUMP, OVERHAUL

1936-38 PACKING TYPE: This pump is of the centrifugal type provided with a gland nut for frequent take-up for the elimination of water leaks. The pump shaft is supported in the body by two bronze bushings and packed with ring packing. This pump is easily disassembled by separating the pump housing and when this is done, the internal parts are accessible and readily removed.

1938-46 PACKLESS TYPE: This type pump is also of the centrifugal design but differs from the packing type in that the shaft is supported by two ball bearings. Water sealing is accomplished by a special carbon washer assembly which is held against the face of a bushing by a brass spring.

If a water leak develops, it indicates that the sealing parts are worn, which necessitates the disassembly of the pump to replace these parts.

To disassemble the pump, remove the bolts and separate the cover from the pump body. Use a suitable puller to remove the impeller from the shaft.

NOTE—Before pulling off the impeller on EN-11, 12, 253, 271, 290, FK, FM and FO engines, be sure to loosen the brass set screw which locks the impeller to the shaft. This screw is accessible after first disconnecting the elbow to which the vent tube is connected.

Insert a screwdriver through one of the slots in the impeller hub and press the snap ring out of the groove, after which, take out the seal parts.

To assemble, place the ball bearings, shaft and spacer in the housing before pressing on the impeller or fan hub. After installing new seal parts, press the impeller on the shaft until it is **flush** with the end of the shaft on EN-11, 12, 253, 271, 290, FK, FM and FO engines; and on EN-310, 354, 405, 431, 457, 471, EO, EP and EY engines, press the impeller on until it **butts** against the end of the shaft.

This type pump should be lubricated after every 5,000 to 6,000 miles through a fitting provided for the purpose. Turn the cap down one-half turn. The lubricant used should be Ball and Roller Bearing Grease with a melting point of about 350 degrees F The housing should be from 1/3 to ½ full.

FAN BELT, ADJUST

1936-46: Fan belt adjustment should be checked at least every 1,500 miles. When a new belt is installed (engines with one belt), check the tightness after a few hours of engine operation to be sure it hasn't become loose due to its seating. A pressure of 10 pounds should depress the belt not more than ½" on its longest centers.

On engines with two belts, always replace them in pairs after first matching them for length. A pressure of 15 pounds on one belt should depress it not more than ½" on its longest centers.

ENGINE WATER THERMOSTAT

1936-46: If the thermostat is not functioning properly, remove the assembly from the water outlet and see if the bellows and valve are in good condition. If they are, test its operation by completely submerging it in water, heating the water gradually until it reaches the opening temperature of the thermostat, and then in water heated to the fully opened temperature.

NOTE—When taking temperature readings, agitate the water thoroughly. And if the thermostat fails to function properly, it should be replaced rather than attempt to make a repair. However, before installing a new unit, it should be tested as directed above.

On 1936-38 engines, the thermostat should start to open at approximately 150 degrees F. and be fully open at 170 degrees F. On EN-11, 12, 253, 271, 290, FK, FM and FO engines, the thermostat is calibrated to be wide open at 176 degrees and fully closed at 149 degrees F. On EN-310, 354, EO, EP and EY engines, the unit should be wide open at 160 and be fully closed at 135 degrees F. On EN-405, 431, 457 and 471, wide open at 175 and fully closed at 150 degrees F.

FUEL SYSTEM

NOTE—For service information on Carburetors, Automatic Chokes, Governors, Gasoline Gauges, Fuel Pumps and Air Cleaners, see the Table of Contents on page 1.

MANIFOLD HEAT CONTROL

1936-46: To regulate the amount of heat by-passed around the heat riser, the manifold is equipped with a valve mounted between the intake and exhaust manifold.

The heater valve (when adjustable) is set at the factory for a minimum of heat to the intake manifold. Under certain conditions, as when operating on short runs, or in cold climate, the setting of this valve should be changed so as to increase the heat directed to the manifold. This adjustment should be made very carefully because too little heat, under certain conditions, will tend to promote crankcase dilution; whereas too much heat will effect operating economy.

On engines equipped with a thermostatically-operated heater valve, the unit should be checked after every 6,000 miles to be sure that it is operating freely and not stuck. If the latter condition is evident, remove the heater valve and its shaft, and polish the shaft at the bushing points, using fine emery cloth.

ELECTRIC SYSTEM

NOTE—For service information on Distributors, Magnetos, Generators, Generator Controls, Starting Motors and Starting Switches, see the Table of Contents on page 1.

IGNITION TIMING

MAGNETO IGNITION: Bring No. 1 piston up on its compression stroke and stop when the TDC mark on the flywheel is in line with the pointer on the flywheel housing. Loosen the coupling connection between the magneto shaft and the engine shaft. Remove the breaker cover and the distributor cover. Move the advance arm to the retarded position—which is when the arm is moved as far as it will go in the direction of magneto rotation. Then turn the magneto in the direction of rotation until the points just begin to open, being sure the rotor is in line with the proper segment to distribute spark to No. 1 cylinder. With the magneto in this position, connect the coupling and replace the breaker and distributor covers.

BATTERY IGNITION: With the breaker gap adjusted to the clearance given in the TUNE UP CHART, crank the engine to bring No. 1 piston up on its compression stroke and stop when the ignition mark on the vibration damper (or flywheel) is in line with the indicator. In this position, the points should just begin to open with the distributor rotor in the No. 1 firing position.

If it becomes necessary to retime the ignition through disassembly of the distributor, locate No. 1 spark plug wire on the distributor cap, place the cap in position on the distributor, and mark the housing opposite No. 1 terminal so that its relative position will be known when the cap is removed.

Loosen the distributor base clamp bolt and rotate the distributor until the points close. Then rotate the distributor in the opposite direction until the points just begin to open, then tighten the clamp bolt.

NOTE—For best results, use a Neon timing light or a conventional test lamp to check the timing. For best performance and fuel economy, this setting should be one which will provide smooth engine performance with a slight "ping" on wide-open throttle at comparatively low vehicle speed

MACK JR.

Year	Engine Model	Number Cylinders and Valve Arrangement	Bore and Stroke	Displacement Cubic Inches	Compression Ratio	Taxable H. P.	Brake H. P. at R. P. M.	Maximum Torque at R. P. M. Pounds Feet	Oil Capacity Quarts ①
1937–38	MR-140	4-L	3 3/16x4 3/8	140	5.4	16.25	42@2800	90@1600	5
1936–38	MR-209	6-L	3 3/16x4 3/8	209	5.4	24.38	70@2800	145@1600	6
1936–38	MR-228	6-L	3 3/8x4 1/4	228	5.4	27.34	73@3000	150@1600	7
1936–38	MR-268	6-L	3 3/8x5	268	5.5	27.34	83@2800	178@1600	7

① Including oil filter.

TUNE UP CHART

Year	Engine Model	Firing Order	Spark Plug Gap	Breaker Gap	Cam Angle, Degrees	Timing Mark Location	Spark Timing, Degrees	Tappet Clearance For Running, Hot Int.	Tappet Clearance For Running, Hot Exh.	Tappet Clearance For Timing Intake	Battery Terminal Grounded ②
1937–38	MR-140	1342	.025	.020	①	Flywheel	6BTDC	.007	.012	.012	Negative
1936–38	MR-209	153624	.025	.020	①	Flywheel	2BTDC	.007	.012	.012	Negative
1936–38	MR-228	153624	.025	.020	①	Flywheel	8BTDC	.007	.012	.012	Negative
1936–38	MR-268	153624	.025	.020	①	Flywheel	8BTDC	.007	.012	.012	Negative

① See the Table of Contents on page 1 for "Distributor Specifications."

② Positive terminal grounded on 12-volt systems.

VALVE SYSTEM

Year	Engine Models	Stem Clearance Intake	Stem Clearance Exhaust	Tappet Guide Clearance	Tappet Clearance Running, Hot Intake	Tappet Clearance Running, Hot Exhaust	Tappet Clearance Timing Intake	Tappet Clearance Timing Exhaust	Valve Spring Pressure Test Free Length, Inches	Valve Spring Pressure Test Pounds at Inches, Length	Valve Seat Angle Degrees
1937–38	MR-140	.001–.0025	.002–.0035	.0005–.001	.007	.012	.012	.012	---	31–34@1 11/16	①
1936–38	MR-209	.001–.0025	.002–.0035	.0005–.001	.007	.012	.012	.012	---	37–40@1 21/32	①
1936–38	MR-228	.001–.0035	.002–.0045	.0005–.0015	.007	.012	.012	.012	2 9/16	48–52@2 3/8	45
1936–38	MR-268	.001–.0035	.002–.0045	.0005–.0015	.007	.012	.012	.012	2 9/16	48–52@2 3/8	45

① Intake 30 degrees: exhaust 45 degrees.

PISTON AND RING CLEARANCES

Year	Engine Model	Piston Skirt, Inches Top	Piston Skirt, Inches Bottom	Fitting Pistons with Shim and Spring Scale Shim Thickness	Fitting Pistons with Shim and Spring Scale Pounds Pull on Scale	Ring End Gap, Inch ① Compression	Ring End Gap, Inch ① Oil	Ring and Groove, Inch Compression	Ring and Groove, Inch Oil
1937–38	MR-140	.002	.002	.002	.003	.007–.015	.005–.015	.0015	.0015
1936–38	MR-209	.002	.002	.002	.003	.007–.015	.005–.015	.0015	.0015
1936–38	MR-228	.002	.002	.002	.003	.007–.015	.005–.015	.0015	.0015
1936–38	MR-268	.002	.002	.002	.003	.007–.015	.005–.015	.0015	.0015

① Fit rings in tapered bores with not less than maximum clearance given.

② Piston to pass on shim thickness shown.

③ Piston to lock on shim thickness shown.

ENGINE BEARING SPECIFICATIONS

Year	Engine Model	Camshaft		Connecting Rod			Mains				
		Journal Diameter	Clearance	Journal Diameter	Clearance	Bearing Bolt Tension Lb. Ft.	Journal Diameter	Clearance	Bearing Bolt Tension Lb. Ft.	Thrust on No.	End-play
1937–38	MR-140	①	.002–.0025	1.9365–1.9375	.0015–.0025	50–55	2.249–2.250	.0015–.0025	85–100	1	.003–.006
1936–38	MR-209	②	.002–.0025	1.9365–1.9375	.0015–.0025	50–55	2.249–2.250	.0015–.0025	85–100	1	.003–.006
1936–38	MR-228	③	.004–.006	2.187–2.188	.0015–.0025	70–75	2.624–2.625	.0015–.0025	65–75	7	.004–.007
1936–38	MR-268	③	.004–.006	2.187–2.188	.0015–.0025	70–75	2.624–2.625	.0015–.0025	65–75	7	.004–.007

① No. 1, 1⅞. No. 2, 1¾. No. 3, 1¼.
② No. 1, 1⅞. No. 2, $1\frac{13}{16}$. No. 3, 1¾. No. 4, 1¼.
③ No. 1, $2\frac{3}{16}$. No. 2, 2⅛. No. 3, $2\frac{1}{16}$. No. 4, 2½.

ENGINE

CYLINDER HEAD

1936-38 All: When installing a cylinder head, always use a new gasket. Make sure the gasket, cylinder head and cylinder block are clean and free from carbon and dirt. Tighten cylinder head nuts or capscrews in the sequence shown, drawing them down evenly, repeating the operation until they are tight. On engines with iron cylinder heads, make a final tightening after the engine has been run to bring it to operating temperature. On aluminum heads, the final tightening should be made after the engine has been run and cooled and while it is still cool.

When using a torque indicating wrench, the final tightening should be 60 pounds feet on 140 and 209 and from 62.5 to 64.5 on 228, 268 and 309.

VALVE SPRINGS

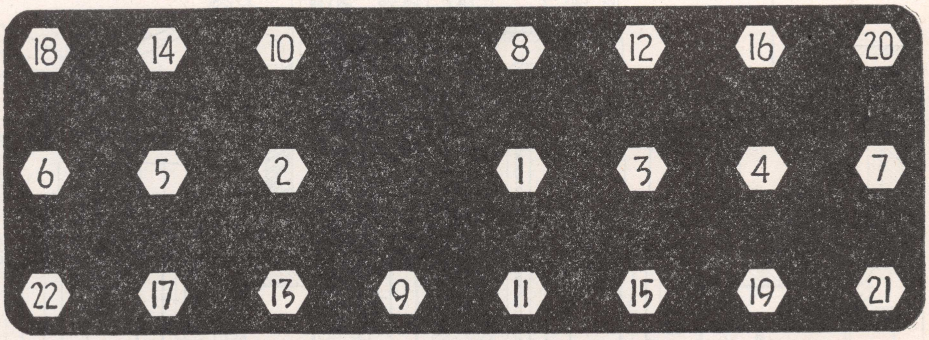
1936-38 All: Check valve springs whenever removed, and replace any that do not meet specifications given in the VALVE SYSTEM table.

EXHAUST VALVE SEAT INSERTS

1936-38: Since these inserts are too hard to reface by the ordinary grinding methods, a high-speed grinding stone or a special lapping tool should be used to perform this operation. When using this equipment, be sure valve guides are clean and that the valve guide pilot is a snug fit in order to assure a concentric finish. Finished seats should be checked with a dial indicator and run-out should not exceed .0005".

To remove an insert—if special equipment is not available—use a drill which is smaller in diameter than the insert width and drill two holes at opposite sides, but not all the way through. Cut through the undrilled portion of the insert with a sharp chisel and remove the two pieces.

To install an insert, pack in "dry ice" for at least fifteen minutes to allow the metal to contract, and heat the exhaust valve port area gradually, if necessary, to permit this material to expand. Then press the insert into the cylinder block, using extreme care to see that it is not cocked or misaligned, after which, peen securely. When installed, finish the seats with the grinding or lapping equipment already mentioned.



Cylinder head tightening diagram. All engines except S-140.

VALVE STEM GUIDES

1936-38: A special tool is available to remove and install valve stem guides. After new guides are installed, ream them to provide the valve stem clearance given in the VALVE SYSTEM table. When installing guides, see that each new guide is pressed in so that the top of the guide is the correct distance from the top of the cylinder block.

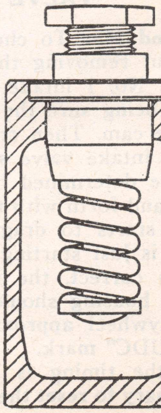
NOTE—On all engines, it is good practice to remove and install one guide at a time. When installing an intake guide, measure the depth of an intake guide not yet removed to determine the correct depth of the guide being installed. Similarly, when installing an exhaust guide, measure the depth of an exhaust guide not yet removed.

VALVE TAPPETS & GUIDES

140 and 209: On these engines, the valve tappet guides are integral with the cylinder block and the tappets are of the straight barrel type. When necessary to remove these tappets, simply take out the valves and springs and lift out the tappets.

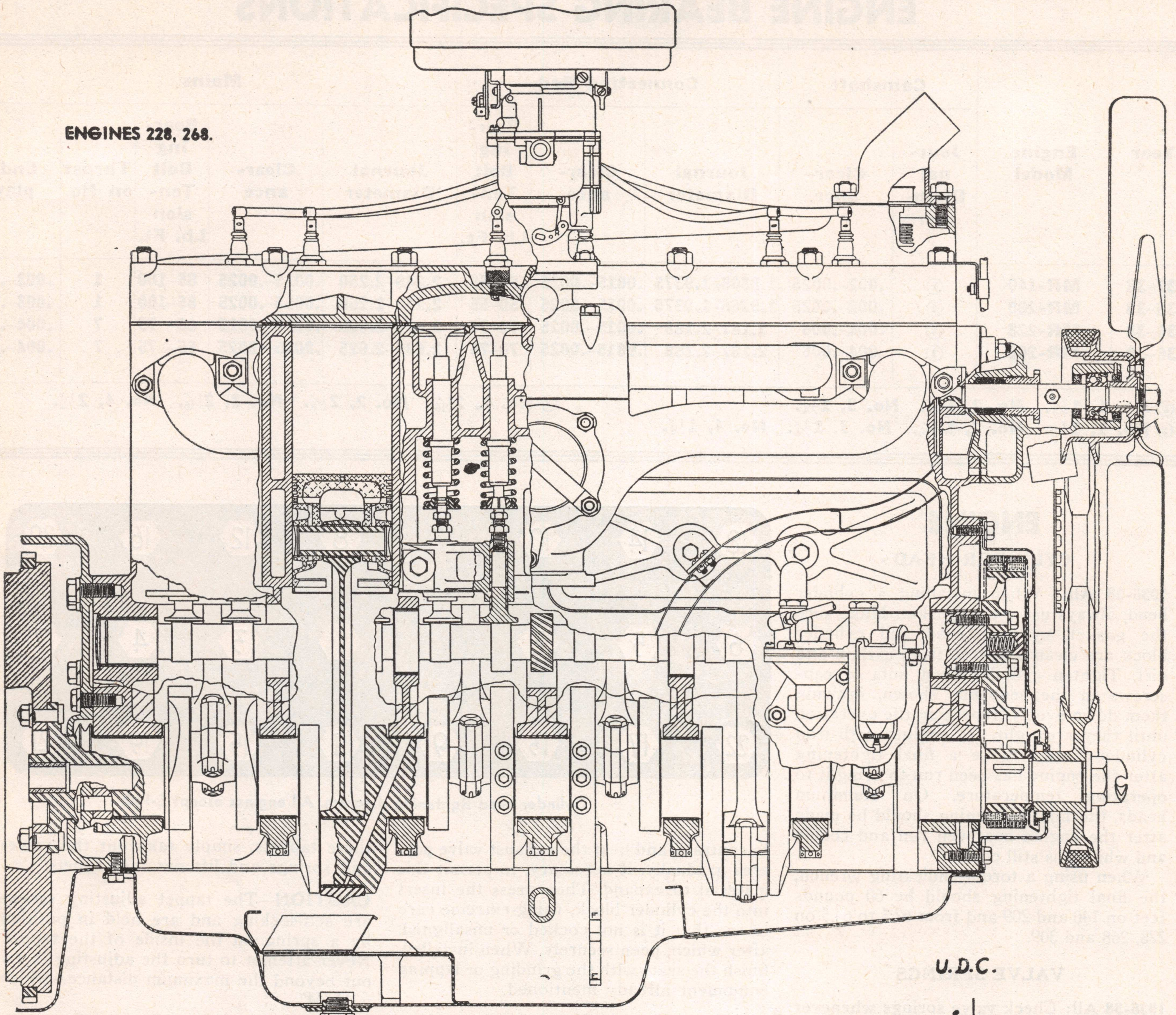
CAUTION—The tappet adjusting screws are self-locking and are held in position by a spring on the inside of the tappet. Never attempt to turn the adjusting screw out beyond the maximum distance—which is 11/64".

1936-38 Except 140 and 209: These engines have removable tappet guide assemblies and worn guides may be replaced. To remove the tappets, remove the right front wheel and fender inspection shield (if equipped) and take off the valve cover



VALVE TAPPET.
Engines 140 and 209.

ENGINES 228, 268.



plates. Crank the engine until the tappets in one of the banks are loose and remove the tappets and guide assembly. Repeat this operation with the other cluster.

VALVE TIMING

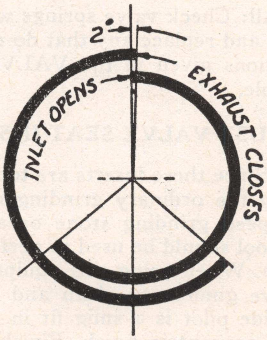
140 and 209: To check the valve timing without removing the timing case cover, adjust No. 1 intake valve to .012" clearance, being sure the lifter is on the base of the cam. Then crank the engine until No. 1 intake valve starts to open, which can be determined by rotating the lifter back and forth with the fingers. When the lifter starts to drag in its rotation, the valve is just starting to open. If the timing is correct, the indicator at the flywheel housing should point to a spot on the flywheel approximately 3/16" before the "UDC" mark.

If the timing is incorrect, it will be necessary to reset the position of the chain. The "O" marks on both the camshaft and crankshaft sprockets should be set so there are nine links (or ten pins) between the "O" marks with No. 1 piston on UDC and No. 1 intake valve just starting to open.

NOTE—The above information is stamped on the front engine support plate, above the chain.

228, 268, 309: Procedure for checking valve timing on these engines is the same as described for 140 and 209 engines. If the timing is correct, the indicator at the flywheel inspection hole will register with a point on the flywheel as indicated in the valve timing illustrations.

If the timing is incorrect, it will be necessary to reset the position of the chain. The "O" marks on the camshaft and crankshaft sprockets should be immediately opposite each other and on a straight line between the sprocket centers.

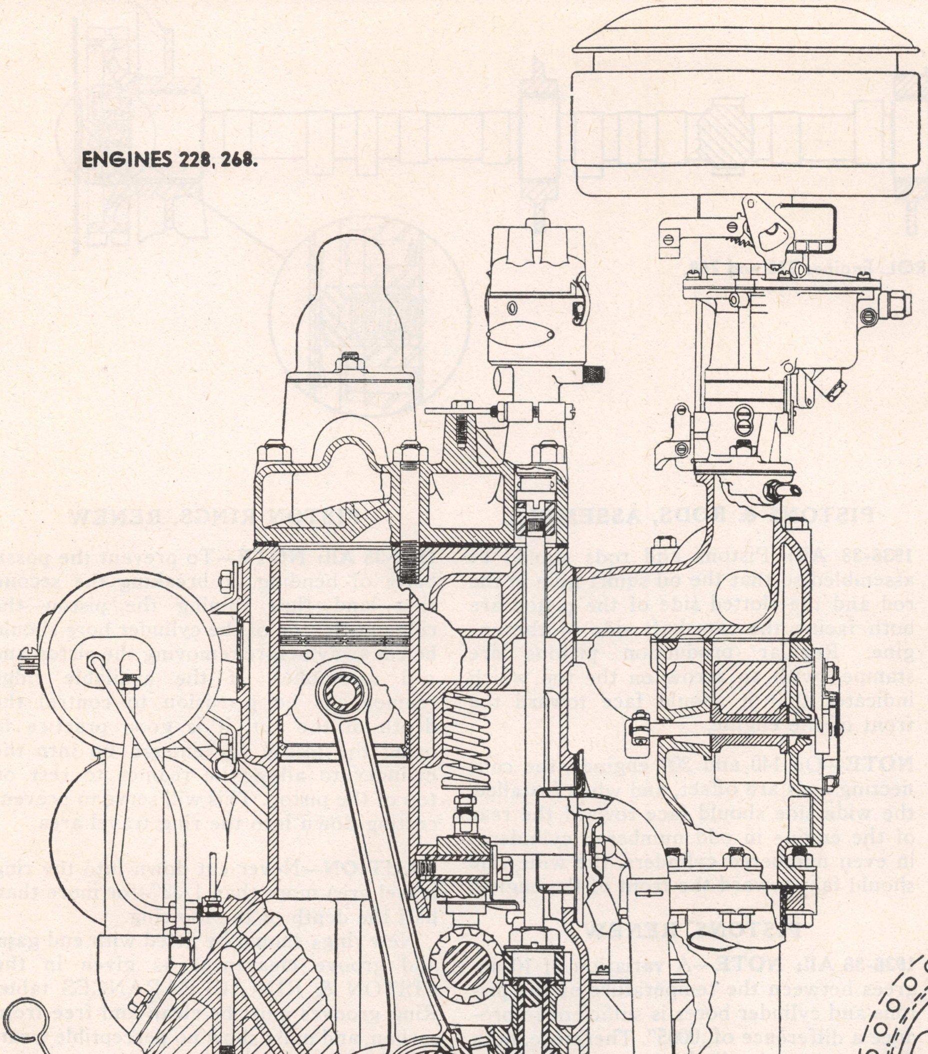


VALVE TIMING DIAGRAM.
Engine MR-268.

TIMING CHAIN & SPROCKETS

140 and 209: The crankshaft sprocket is keyed to the crankshaft and the camshaft sprocket is held to the camshaft by a special washer and nut. Lubrication of the chain and sprocket is provided from a small bleeding hole in front of the camshaft.

ENGINES 228, 268.

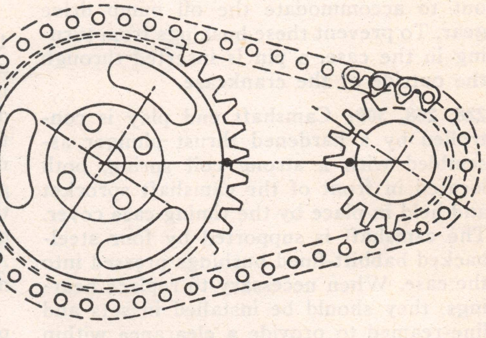


228, 268, 309: On these engines, the crankshaft sprocket is keyed to the crankshaft and the camshaft sprocket is held to the camshaft by four screws, one screw being much longer than the others and is of the dowel type—which is for timing purposes.

Lubrication of the chain and sprocket is from a small hole drilled in a pipe plug, which is screwed in the end of the main oil line and is located just behind the crankshaft sprocket. If a squeak or an unusual noise develops in the timing mechanism, remove the radiator and timing cover and inspect the oil bleed holes. If plugged, the hole should be cleaned out with a small wire. Before replacing the timing cover, check the flow of oil by starting the engine.

To install the chain and sprocket, rotate the crankshaft until No. 1 piston is on UDC or when the marks on the sprockets are immediately opposite each other and on a straight line between the sprocket centers. Adjust No. 1 intake valve to .012" clearance with the lifter on the base of the cam, and turn the camshaft clockwise until No. 1 intake valve just starts to open, as indicated when a slight drag is felt on the tappet. Place the chain on the camshaft sprocket and over the crankshaft sprocket, holding the camshaft sprocket so that when this sprocket is installed, the timing marks come in line as mentioned above.

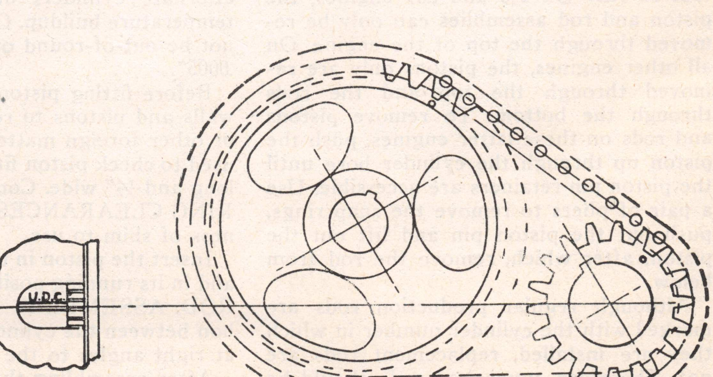
NOTE—Place the cam sprocket on the camshaft and start the dowel screw in the



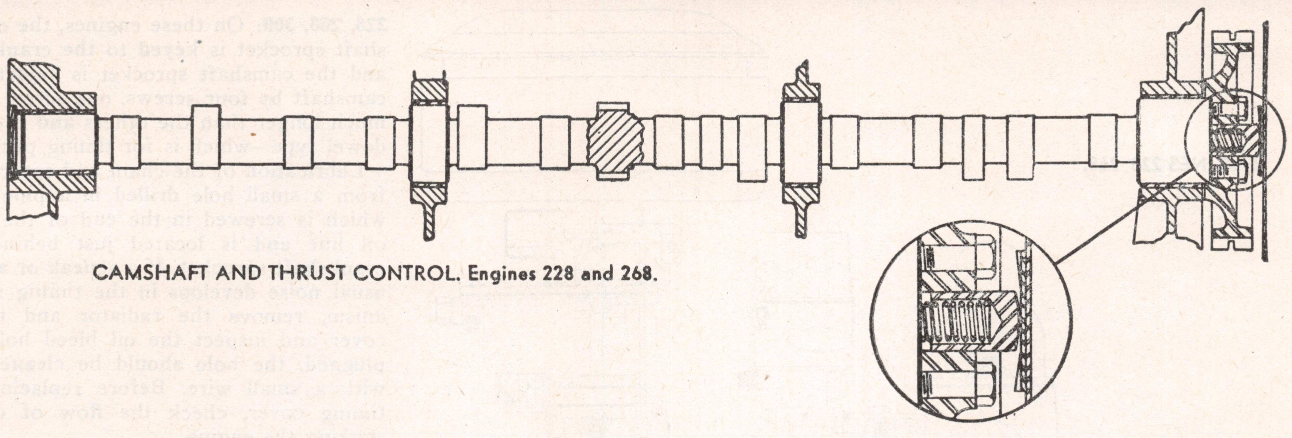
Timing chain position for valve timing. Engines 228 and 268.

NOTE—When installing the chain and sprockets, the "O" marks on the camshaft and crankshaft sprockets should be set so that there are nine links (or ten pins) between the marks with No. 1 piston on UDC and No. 1 intake valve just starting to open.

When the camshaft sprocket is replaced, be sure to lock the nut in place with the special lock. The oil slinger on the front end of the crankshaft must be installed with the flange pointing away from the crankshaft sprocket.



Timing chain position for valve timing. Engines 140 and 209.



CAMSHAFT AND THRUST CONTROL. Engines 228 and 268.

top left hole. Install the other screws and tighten the sprocket evenly on the camshaft. Before replacing the cover, recheck the timing.

CAMSHAFT & BEARINGS

140 and 209: Camshaft end play is controlled by a thrust plate just behind the camshaft sprocket. End play should be held to approximately .005" and can be checked by forcing the shaft back to the limit of its end play and inserting a feeler between the thrust plate and the front end of the shaft.

When necessary to replace bearings, they should be replaced in sets and line-reamed to provide a clearance within the limits given in the ENGINE BEARING SPECIFICATIONS table.

NOTE—On the 140 engine, No. 2 bushing, and No. 3 bushing on 209 engines, are cut out to accommodate the oil pump drive gear. To prevent these bushings from turning in the case, a pin is inserted through the outside of the crankcase.

228, 268, 309: Camshaft end play is controlled by a hardened thrust plunger assembled with a strong coil spring, both located in front of the camshaft sprocket and held in place by the timing case cover. The camshaft is supported by four steel-backed babbitt-lined bushings pressed into the case. When necessary to replace bearings, they should be installed in sets and line-reamed to provide a clearance within the limits given in the ENGINE BEARING SPECIFICATIONS table.

PISTONS & RODS, REMOVE

1936-38 All: On 140 and 209 engines, the piston and rod assemblies can only be removed through the top of the engine. On all other engines, the pistons only are removed through the top and the rods through the bottom. To remove pistons and rods on these latter engines, push the piston up through the cylinder bore until the piston pin retainers are accessible. Use a pair of pliers to remove the snap rings, push out the piston pin and lift out the piston, after which, remove the rod from below.

Although regular production rods are marked with the cylinder number in which they are installed, replacement rods are not. Therefore, unmarked rods should be suitably identified with punchmarks, as they are removed.

PISTONS & RODS, ASSEMBLE

1936-38 All: Pistons and rods should be assembled so that the oil squirt hole in the rod and the slotted side of the piston are both facing the camshaft side of the engine. Regular production pistons are stamped with an arrow on the top which indicates that it should face toward the front of the engine.

NOTE—On 140 and 209 engines, the connecting rods are offset, and when installed, the wide side should face toward the rear of the engine in odd numbered cylinders; in even numbered cylinders, the wide side should face toward the front of the engine.

PISTONS, RENEW

1936-38 All: NOTE—A variation of 10 degrees between the temperature of the pistons and cylinder bores is sufficient to produce a difference of .0005". Therefore, both the pistons and cylinder bores should be at normal room temperature (about 70 degrees) when fitting pistons. This is particularly important because the clearances given in the PISTON & RING CLEARANCES table are minimum and pistons must not be fitted with less than specified.

Before any attempt is made to fit new pistons, cylinder bores should be carefully indicated and refinished. If bores do not require refinishing, be sure to remove the ridge at the top of each bore. If refinishing is required, it is good practice to do so in alternate cylinders due to the localized temperature buildup. Cylinder bores should not be out-of-round or tapered more than .0005".

Before fitting pistons, wipe the cylinder walls and pistons to remove all chips, dirt or other foreign matter. The feeler ribbon used to check piston fit should be about 12" long and ½" wide. Consult the PISTON & RING CLEARANCES table for the thickness of shim to use.

Insert the piston in the bore upside down and in its running position (see PISTON & ROD, ASSEMBLE). Place the feeler ribbon between the cylinder wall in a position at right angles to the piston pin hole.

After assembling the piston to the connecting rod, check the assembly for alignment on a suitable jig.

PISTON RINGS, RENEW

1936-38 All: NOTE—To prevent the possibility of bending or breaking the second ring land—thus ruining the piston—the ridge at the top of the cylinder bore should be cut away before removing the piston and rod assemblies. If the available ridge reamer has no provision to control the depth of the cut, it is good practice to bring the piston far enough up into the cylinder to allow the reamer to rest on top of the piston. This will serve to prevent cutting down into the ring travel area.

CAUTION—Never cut down into the ring travel area more than 1/32"—or more than half the depth of the top ring.

New rings should be fitted with end gaps and groove clearances as given in the PISTON & RING CLEARANCES table. Ring grooves must be clean and free from carbon, and must show no perceptible wear.

NOTE—Ring end gaps given in the PISTON & RING CLEARANCES table are for cylinder bores without taper. If rings other than standard are being installed, pay particular attention to the installation instructions which are usually included in the ring package. This applies to clearances, position in grooves, etc.

When rings are properly fitted to the pistons, be sure to stagger the ring gaps so they are spaced equal distances around the circumference of the piston. However, see that no gaps are over the piston pins.

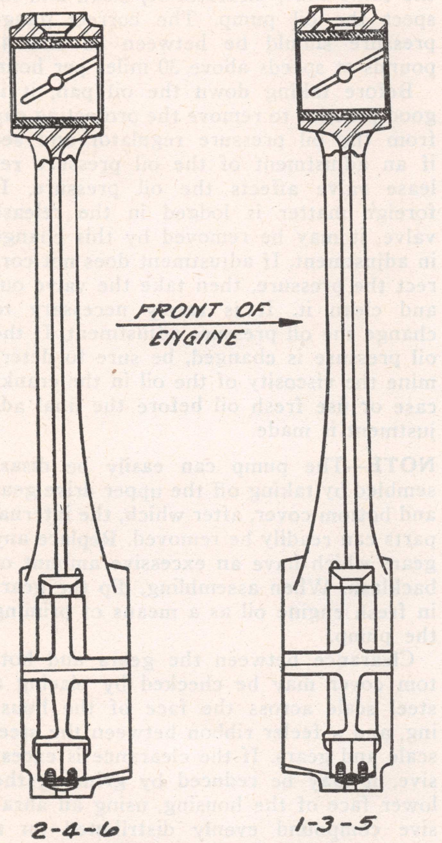
PISTON PINS, RENEW

1936-38 All: The correct fit of aluminum pistons, at normal room temperature, should require a light tap fit with a rubber mallet to install the pin. However, to facilitate fitting pins in aluminum pistons, heat the piston in boiling water for a few minutes, after which the pin should enter the piston easily.

These pins are of the full-floating type, being held in place by snap rings in the grooves of the piston bosses.

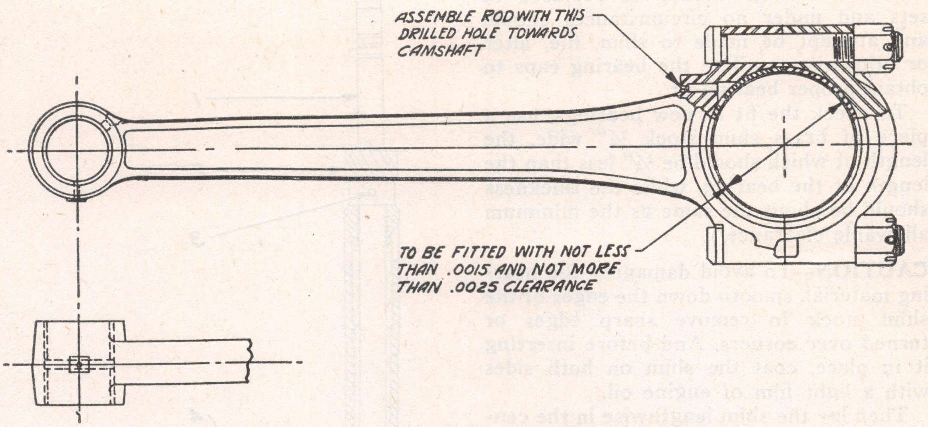
PISTON PIN BUSHINGS, RENEW

1936-38 All: New bushings should be pressed in place and reamed to provide a light push fit of the pin with the parts at

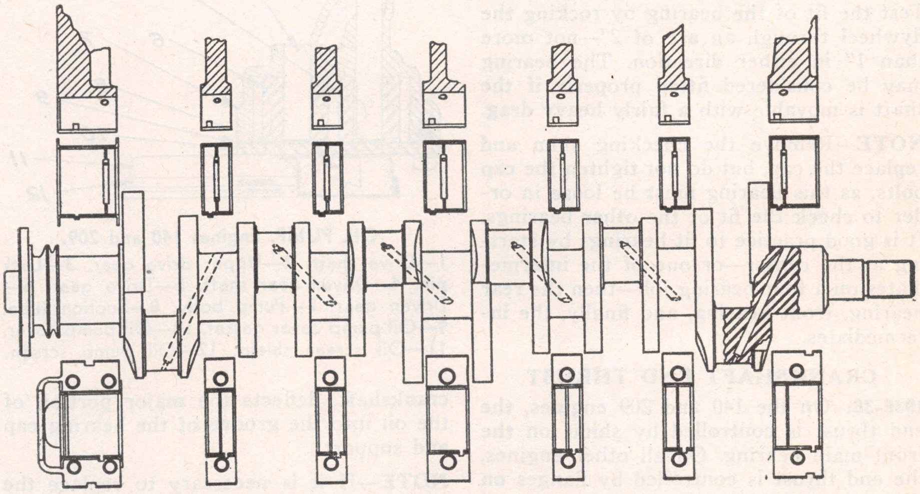


Connecting rod installation. Engines 140 and 209.

normal room temperature. When installed, be sure the oil hole in the bushing lines up with the hole in the connecting rod.


ASSEMBLE ROD WITH THIS DRILLED HOLE TOWARDS CAMSHAFT
TO BE FITTED WITH NOT LESS THAN .0015 AND NOT MORE THAN .0025 CLEARANCE

Connecting rod and bearing. All engines.



Crankshaft and main bearings. Engines 228 and 268.

CONNECTING ROD, BEARINGS, RENEW

1936-38 All: These bearings are of the precision insert type and when worn, they may be replaced by simply taking off the bearing cap and slip the old shells out and the new ones in. Bearings should be replaced in sets and under no circumstances should rods or caps be filed, altered or mutilated in any way in an attempt to obtain proper bearing fit.

NOTE—Before replacing bearings, make sure that the crankpins are not nicked or scored, and that all parts are thoroughly clean. This is particularly important because the presence of one small particle of metal, carbon or other foreign matter, lodged between the back of the bearing and the rod, or between the face of the bearing and the crankpin, will very likely cause a hot spot due to the elimination of the oil clearance at that point, eventually resulting in a bearing failure or a scored crankpin.

CAUTION—These bearings are designed for use without shims and under no circumstances should shims be used in an attempt to obtain a bearing fit, because the proper "crush" fit of the bearings in the connecting rod bores will not be obtained.

To check the fit of new bearings, use a piece of brass shim stock ¼" wide, the length of which should be ¼" less than the length of the bearing, while the thickness should be approximately the same as the minimum allowable clearance.

CAUTION—To avoid damaging the bearing material, smooth down the edges of the shim stock on an oil stone so that no sharp edges remain. Install the shim between the bearing and the crankpin, in the center of the bearing, then tighten the cap bolts to the recommended torque tension. When fitted properly, it should not be possible to move the rod endwise by hand, but a light tap with a hammer should cause the rod to move endwise. Then remove the checking shim and re-install the cap, tightening the cap bolts with a torque wrench, after which the rod should move endwise by hand. If the rod is too loose with the checking shim in place, the crankpin should be turned down and undersize bearings fitted.

MAIN BEARINGS, RENEW

1936-39 All: NOTE—Before replacing bearings, make sure that the crankshaft journals are not nicked or scored. Use care also, to see that all parts are thoroughly clean. This is particularly important because one small particle of metal, carbon, dirt or other foreign matter, lodged between the back of the bearing and the cap or saddle, or between the bearing face and the crankshaft journal, will very likely cause a hot spot due to the elimination of the oil clearance at that point, eventually resulting in a bearing failure or a scored journal.

When bearings become worn, they can be replaced without removing the crankshaft in the following manner: Remove the bearing cap and take out the worn lower shell. A suitable tool can be made to remove the upper shell by using a cotter pin with the rounded end flattened to form a T shape. Insert the long end of the pin in the oil passage hole in the crankshaft journal and, by rotating the crankshaft in the reverse direction, the T-shaped head will contact the bearing and force it out.

To install, place a new upper shell on the crankshaft journal with the locating notch in the correct position and rotate the shaft to turn the shell in place. Then install the lower shell in the cap and replace the cap, tightening the cap bolts to the recommended torque tension.

NOTE—Bearings should be replaced in sets and under no circumstances should any attempt be made to shim, file, alter or otherwise mutilate the bearing caps to obtain proper bearing fit.

To check the fit of new bearings, use a piece of brass shim stock ¼" wide, the length of which should be ¼" less than the length of the bearing, while the thickness should be about the same as the minimum allowable clearance.

CAUTION--To avoid damaging the bearing material, smooth down the edges of the shim stock to remove sharp edges or turned over corners. And before inserting it in place, coat the shim on both sides with a light film of engine oil.

Then lay the shim lengthwise in the center of the bearing and install the bearing cap to the crankshaft, tightening the cap bolts to the recommended torque tension. Test the fit of the bearing by rocking the flywheel through an arc of 2"—not more than 1" in either direction. The bearing may be considered fitted properly if the shaft is movable with a fairly heavy drag.

NOTE—Remove the checking shim and replace the cap, but do not tighten the cap bolts, as this bearing must be loose in order to check the fit of the other bearings. It is good practice to fit bearings by starting at the center—or one of the intermediates on a four bearing job—then the rear bearing, front bearing, and finally, the intermediates.

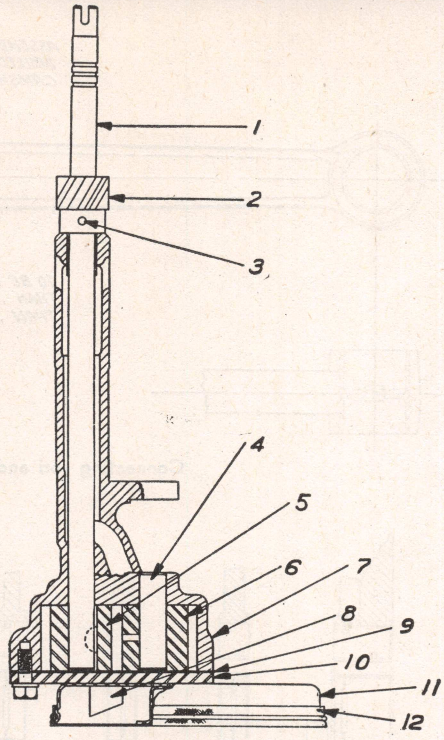
CRANKSHAFT END THRUST

1936-38: On the 140 and 209 engines, the end thrust is controlled by shims on the front main bearing. On all other engines, the end thrust is controlled by flanges on the rear main bearing. Through normal wear, the end play will seldom become excessive but whenever new bearings are fitted, the clearance should be carefully checked and, if required, the bearing flanges may be dressed down, or shims removed, as the case may be, to obtain the desired end play.

CRANKSHAFT OIL SEALS

140 and 209: Oil sealing at the front and rear main bearing is accomplished by die cast filler blocks sealed with cork. When installing the front oil seal filler block, tighten the four screws which fasten it to the front engine support plate before tightening the two screws at the crankcase, being careful to place the oil pan gaskets in their proper position under the filler block.

When installing the rear oil seal, always install both the upper and lower seals. The upper seal may be replaced without dismantling the engine. To do this, rotate the seal retainer out of its position, remove the old seal and install the new, being sure that both ends protrude an equal distance at both sides to assure uniform compression when the filler blocks are installed.



OIL PUMP. Engines 140 and 209.
1—Drive shaft. 2—Upper drive gear. 3—Lock pin. 4—Driven gear shaft. 5—Drive gear. 6—Driven gear. 7—Pump body. 8—Suction tube. 9—Oil pump cover gasket. 10—Oil pump cover. 11—Oil screen shield. 12—Oil pump screen.

228, 268, 309: The rear main bearing support is provided with packing which forms an oil seal at the outer end of the shaft. In addition, an oil slinger, integral with crankshaft, deflects the major portion of the oil into the groove of the bearing cap and support.

NOTE—If it is necessary to replace the packing in the upper half of the rear main bearing, the crankshaft must be removed from the engine and the packing installed in the same manner as described below for the lower half of the bearing.

To install, insert the packing in the groove of the bearing cap and use a smooth, rounded tool to work the packing from each end towards the center of the cap, to force, and shape the packing in the groove. Then cut off the overlapping ends of the packing **flush** with the surface of the cap.

NOTE—Make sure that the packing is not pulled out of the groove when cutting off the ends. A special seal compressor, or a round block of wood of the same diameter as the crankshaft flange may be used to hold the packing firmly in position.

ENGINE OILING

OIL PUMP

1936-38: If the oil pressure drops to zero suddenly or fluctuates violently while the engine is under load, check the oil level and examine the condition of the oil. If these conditions are not the cause, check the oil gauge by using another gauge known to be accurate, before attempting to tear down the engine. If the checking oil gauge shows a pressure drop, then remove and clean the oil pan thoroughly. At the same time, disassemble, clean and inspect the oil pump. The correct gauge pressure should be between 30 and 45 pounds at speeds above 30 miles per hour.

Before taking down the oil pan, it is good practice to remove the protecting cap from the oil pressure regulator and see if an adjustment of the oil pressure release valve affects the oil pressure. If foreign matter is lodged in the release valve, it may be removed by this change in adjustment. If adjustment does not correct the pressure, then take the valve out and clean it. It is rarely necessary to change the oil pressure adjustment. If the oil pressure is changed, be sure to determine the viscosity of the oil in the crankcase or use fresh oil before the final adjustment is made.

NOTE—The pump can easily be disassembled by taking off the upper drive gear and bottom cover, after which, the internal parts can readily be removed. Replace any gears which have an excessive amount of backlash. When assembling, dip the gears in fresh engine oil as a means of priming the pump.

Clearance between the gears and bottom cover may be checked by placing a steel scale across the face of the housing, and a feeler ribbon between the steel scale and gears. If the clearance is excessive, it may be reduced by grinding the lower face of the housing, using an abrasive compound evenly distributed on a perfectly flat surface.

Examine the oil pressure regulator ball check, spring and seat, and if these parts show wear, new parts must be installed.

CAUTION—Before replacing the oil pump and oil pan, the oil screen, oil tubes and oil lines should be thoroughly cleaned, being sure that all openings in the screen are free and clean. If the screen is crushed, it is better to replace it rather than attempt to make a repair.

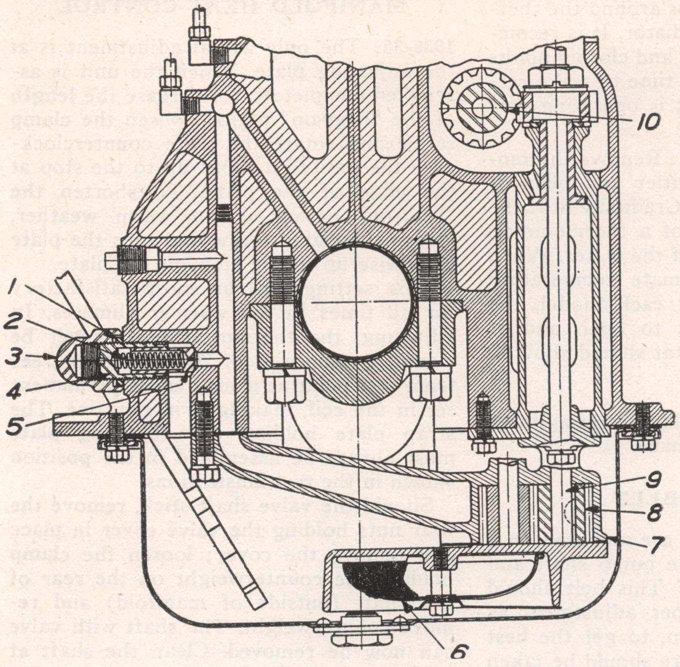
OIL FILTER

1936-38: Filters should be cleaned thoroughly every time the oil is changed. If the dip stick shows the oil to be very thick and dirty, it indicates that the filter requires service.

CRANKCASE VENTILATOR

1936-38: The crankcase ventilator breather should be inspected at least every 2,000 miles of operation, and if a sludge formation is evident, remove the breather and clean it thoroughly in gasoline. Allow the breather to soak in the gasoline for about 30 minutes, then blow it out with compressed air, and at the same time, tap it lightly to dislodge any particles of sludge.

If the breather is fitted with an air cleaner, it should be removed and washed every 1,000 miles. After the element is washed, blow it dry with compressed air and, if the cleaner is of the oil-wetted type, dip the element in fresh engine oil before assembling. If it is of the oil bath type, wipe out the oil reservoir thoroughly with a clean cloth and fill it to the proper level with fresh engine oil.



Oil pump and by-pass valve. Engines 228 and 268.

1—Lock nut. 2—Spring. 3—Acorn nut. 4—Adjuster sleeve. 5—Valve. 6—Oil pump screen. 7—Oil pump body. 8—Oil pump gear. 9—Drive shaft. 10—Drive gear.

NOTE—The interval at which the ventilator and air cleaner should be cleaned can only be determined by the type of service to which the vehicle is subjected. Vehicles operating in dusty or sandy areas require more frequent service than those operating under more favorable conditions.

IMPORTANT—For vehicles operating in dust storm areas, the cleaner should be cleaned immediately after such storms occur.

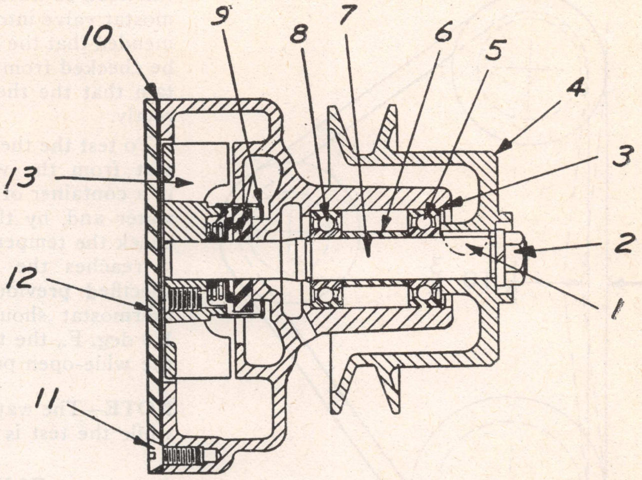
COOLING SYSTEM

WATER PUMP, OVERHAUL

140 and 209: The water pump is of the packless type. An assembled water seal of the flexible type provides protection against water leaks around the pump shaft. The pump shaft is mounted on two ball bearings that are packed with grease at time of assembly and need no further attention.

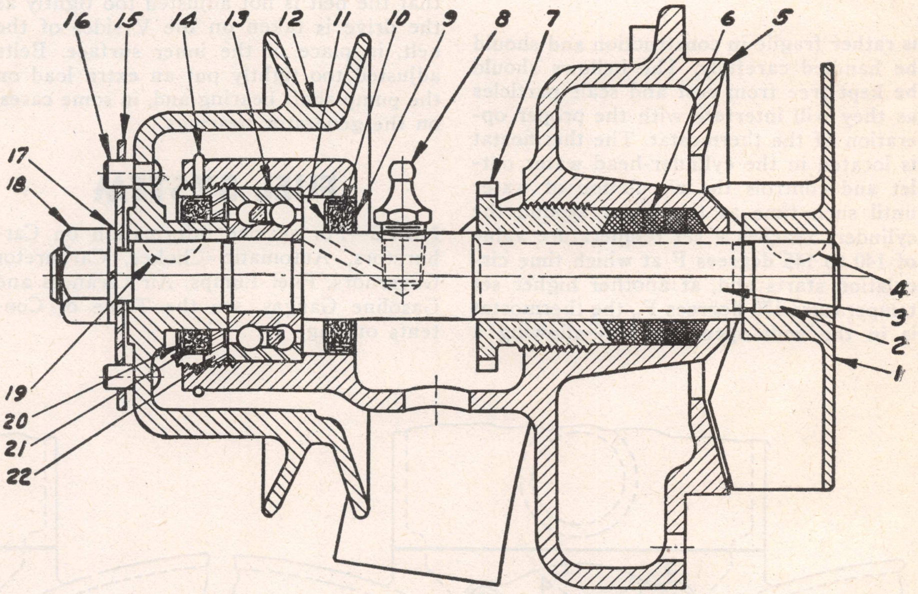
To disassemble water pump: Remove pump from front of cylinder block. Remove nut and press fan pulley off. Remove the screws and pump cover. Remove snap ring and remove the assembled shaft and impeller. Drive out the straight pin from the end of the shaft, and remove impeller. Press bearings and the spacer out through front end of housing. To reassemble, reverse the foregoing instructions.

NOTE—When assembling bearings into the housing, be sure to pack the space between the bearings with a good grade of lime soap grease. Never dip the bearings in gasoline to clean; use a cloth and wipe clean.



WATER PUMP. Engines 140 and 209.

1—Key. 2—Pulley retaining nut. 3—Snap ring. 4—Pulley. 5—Bearing. 6—Spacer. 7—Shaft. 8—Bearing. 9—Assembled seal. 10—Pump cover gasket. 11—Pump cover screws. 12—Pump cover. 13—Impeller.



WATER PUMP. Engines 228 and 268.

1—Impeller. 2—Shaft. 3—Sleeve. 4—Woodruff key. 5—Pump body and fan support. 6—Packing. 7—Gland nut. 8—Oiler. 9, 10 and 11—Felts. 12—Pulley. 13—Bearing. 14—Lock spring. 15—Washer. 16—Dowel. 17—Lock washer. 18—Nut. 19—Woodruff key. 20—Retainer. 21—Cork seal. 22—Bearing retainer.

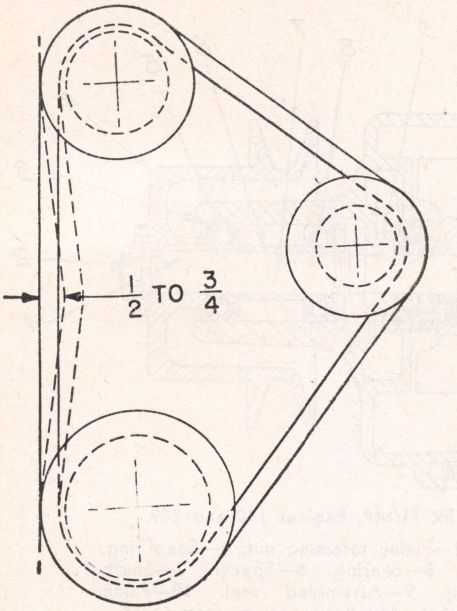
228, 268, 309: To disassemble water pump: Drain radiator and remove water pump from cylinder block. Remove nut from end of shaft that holds fan pulley in place. Press fan pulley from shaft. Remove the Woodruff keys and oiler. Remove impeller and shaft assembly and remove gland packing nut and oil packing. Remove locking spring from bearing adjusting collar. Remove adjusting collar and bearing; also remove oil seals.

To reassemble water pump: Insert impeller shaft through pump body and gland nut and install five new packing rings. Screw gland nut into body of pump and tighten down lightly. Insert rear oil seal retainers and felts and press ball bearing over shaft and into pump housing. Install outer oil retainers and felt, then screw bearing retainer nut in place and install lock ring. Install oiler. Press fan hub on shaft and replace nut and washer. Replace pump in cylinder block and connect.

CAUTION—Do not tighten gland nut too much or it will cause packing to score the shaft.

ENGINE WATER THERMOSTAT

1936-38: The thermostat used on all models



FAN BELT ADJUSTMENT. All engines.

is rather fragile in construction and should be handled carefully. The bellows should be kept free from rust and scale particles as they will interfere with the proper operation of the thermostat. The thermostat is located in the cylinder-head water outlet and controls the circulation of water until such time as the water around the cylinders reaches a set temperature value of 140 to 145 degrees F at which time circulation starts and, at another higher set temperature 170 degrees F., the thermostat is in the wide-open position—allowing a full head of water to pass around the thermostat valve into the radiator. It is recommended that the opening and closing points be checked from time to time to make certain that the thermostat is operating correctly.

To test the thermostat: Remove thermostat from the water outlet and place it in a container of water. Gradually heat the water and, by the use of a thermometer, check the temperature of the water. When it reaches the approximate temperature specified previously for each model, the thermostat should start to open and at 170 deg. F., the thermostat should show in the wide-open position.

NOTE—The water should be kept agitated while the test is being made.

FAN AND BELT

1936-38: The fan blades are mounted on a flange on the end of the pump shaft and are driven by a V-belt. This belt should always be kept in proper adjustment as shown in the illustration, to get the best results from the fan. Care should be taken that the belt is not adjusted too tightly as the drive is taken on the V sides of the belt, in place of the inner surface. Belts adjusted too tightly put an extra load on the pump shaft bearing and, in some cases, on the generator bearings.

FUEL SYSTEM

NOTE—For service information on Carburetors, Automatic Chokes, Carburetor Governors, Fuel Pumps, Air Cleaners and Gasoline Gauges, see the Table of Contents on page 1.

MANIFOLD HEAT CONTROL

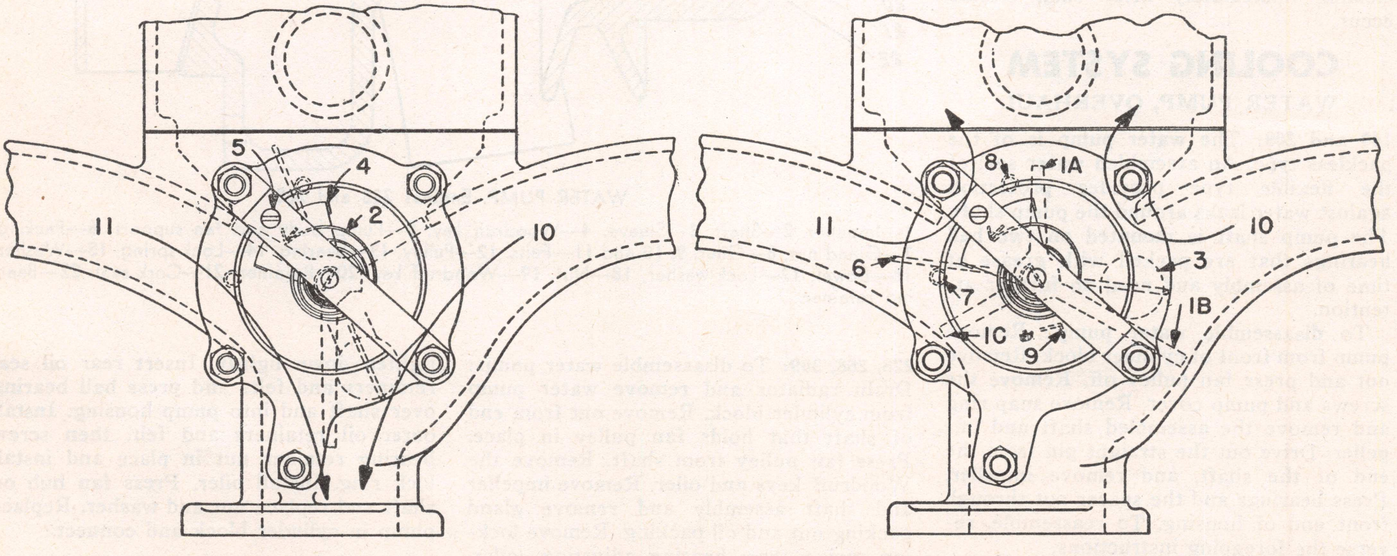
1936-38: The only actual adjustment is at the adjusting plate. When the unit is assembled completely, to increase the length of the "heat-on" period, loosen the clamp screw and rotate the plate counterclockwise the desired amount up to the stop at the edge of the plate. To shorten the "heat-on" period as for warm weather, loosen the clamp screw and turn the plate clockwise up to the stop on the plate.

This setting will be most satisfactory for all times in the warmer climates. In adjusting, the thermostat must never be wound up more than 200 to 220 degrees from rest point as it may cause permanent set in the coil, making it inoperative. The strap plate holding the adjusting plate must always be assembled in the position shown in the two illustrations.

Should the valve shaft stick, remove the four nuts holding the valve cover in place and remove the cover; loosen the clamp holding the counterweight on the rear of the shaft (outside of manifold) and remove counterweight. The shaft with valve can now be removed. Clean the shaft at the bushings with fine emery paper; also clean bushings before reinstalling. When reinstalling, place the valve and shaft in position with long vane hanging in practically a perpendicular position. Then attach the counterweight so that the wire is touching stop post. In attaching, rotate thermostat approximately 200 degrees counter-clockwise and hook on adjusting plate.

ELECTRIC SYSTEM

NOTE—For service information on Ignition Distributors, Magnetos, Generators.



HEAT OFF POSITION HEAT ON POSITION

MANIFOLD HEAT CONTROL. Engines 228 and 268.

1—Heat valve. 2—Thermostat. 3—Valve counterweight. 4—Adjusting plate. 5—Locking screw. 6—Stop wire. 7—Stop wire for "heat on." 8—Stop wire for "heat off." 9—Thermostat position unhooked. 10—Exhaust passage from forward cylinder. 11—Exhaust passage from rear cylinder.

Generator Regulators, Starting Motors and Starter Switches, see the Table of Contents on page 1.

IGNITION TIMING

1936-38: With the breaker gap set to the clearance given in the TUNE UP CHART, crank the engine to bring No. 1 piston up on its compression stroke and stop when the UDC mark on the flywheel is in line with the indicator.

Locate No. 1 spark plug wire on the distributor cap, place the cap in position on the distributor and mark the housing opposite No. 1 terminal so that its relative position will be known when the cap is removed.

With the octane selector set midway between advance and retard, loosen the distributor body clamp and rotate the distributor until the points close. Then rotate the distributor in the opposite direction until the points just begin to open. Tighten the clamp bolt.

NOTE—For best results, use a Neon timing light or a conventional test lamp to check the timing. Advance or retard the octane selector to compensate for the grade of fuel being used. For best performance and fuel economy, this setting should be one which will provide smooth engine performance with a slight "ping" on wide-open throttle at comparatively low vehicle speed.

Year	Engine Model	Number Cylinders and Valve Arrangement	Bore and Stroke	Displacement Cubic Inches	Compression Ratio	Taxable H. P.	Brake H. P. at R. P. M.	Maximum Torque at R. P. M. Pounds Feet	Oil Capacity Quarts ①
1937–38	S-140	4-L	3 3/16x4 3/8	140	5.4	16.25	42@2800	90@1600	5
1936–38	S-209	6-L	3 3/16x4 3/8	209	5.4	24.38	70@2800	145@1600	6
1936–38	S-228	6-L	3 3/8x4 1/2	228.1	5.4	27.34	73@3000	150@1600	7
1940–46	GC-228	6-L	3 3/8x4 1/4	228.1	6.2	27.34	83@3100	177@1000	8
1940–46	GC-245	6-L	3 1/2x4 1/4	245.3	6.2	29.40	89@3100	191@1000	8
1936–38	S-3-268	6-L	3 3/8x5	268	5.58	27.34	83@2800	178@1000	6
1936–38	S-3L-268	6-L	3 3/8x5	268	5.58	27.34	81@2800	160@1000	6
1940–46	GC-288	6-L	3 1/2x5	288.6	6.0	29.40	94@3000	221@1200	8
1936–38	S-5-309	6-L	3 5/8x5	309.6	5.44	31.50	88@2800	204@900	6
1940–46	GC-310	6-L	3 5/8x5	309.6	5.8	31.50	101@3000	241@900	8

① Including filter.

TUNE UP CHART

Year	Engine Model	Firing Order	Spark Plug Gap	Breaker Gap	Cam Angle, Degrees	Timing Mark Location	Spark Timing, Degrees	Tappet Clearance For Running, Hot Int.	Tappet Clearance For Running, Hot Exh.	Tappet Clearance For Timing Intake	Battery Terminal Grounded ①
1937–38	S-140	1342	.025	.020	②	Flywheel	6BTDC	.007	.012	.012	Negative
1936–38	S-209	153624	.025	.020	②	Flywheel	2BTDC	.007	.012	.012	Negative
1936–38	S-228	153624	.025	.020	②	Flywheel	8BTDC	.007	.012	.012	Negative
1940–46	GC-228	153624	.032	.020	②	Vib. Damp.	8BTDC	.008	.012	.012	Negative
1940–46	GC-245	153624	.032	.020	②	Vib. Damp.	8BTDC	.008	.012	.012	Negative
1936–38	S-3-268	153624	.025	.020	②	Flywheel	8BTDC	.007	.012	.012	Negative
1936–38	S-3L-268	153624	.025	.020	②	Flywheel	6BTDC	.007	.012	.012	Negative
1940–46	GC-288	153624	.032	.020	②	Vib. Damp.	8BTDC	.008	.012	.012	Negative
1936–38	S-5-309	153624	.025	.020	②	Flywheel	8BTDC	.007	.012	.012	Negative
1940–46	GC-310	153624	.032	.020	②	Vib. Damp.	8BTDC	.008	.012	.012	Negative

① Positive terminal grounded on 12-volt systems.

② See the Table of Contents on page 1 for "Distributor Specifications."

VALVE SYSTEM

Year	Engine Models	Stem Clearance Intake	Stem Clearance Exhaust	Tappet Guide Clearance	Tappet Clearance Running, Hot In-take	Tappet Clearance Running, Hot Ex-haust	Tappet Clearance Timing In-take	Tappet Clearance Timing Ex-haust	Valve Spring Pressure Test Free Length, Inches	Valve Spring Pressure Test Pounds at Inches, Length	Valve Seat Angle Degrees
1937–38	S-140	.001–.0025	.002–.0035	.0005–.001	.007	.012	.012	.012	---	31–34@1 11/16	①
1936–38	S-209	.001–.0025	.002–.0035	.0005–.001	.007	.012	.012	.012	---	37–40@1 21/32	①
1936–38	S-228	.001–.0035	.002–.0045	.0005–.0015	.007	.012	.012	.012	2 9/16	52@2 3/8	45
1940–46	GC-228	.0015–.003	.003–.0045	.0005–.0015	.008	.012	.012	.012	2 9/16	52@2 3/8	45
1940–46	GC-245	.0015–.003	.003–.0045	.0005–.0015	.008	.012	.012	.012	2 9/16	52@2 3/8	45
1936–38	S-3-268	.001–.0035	.002–.0045	.0005–.0015	.007	.012	.012	.012	2 9/16	52@2 3/8	45
1936–38	S-3L-268	.001–.0035	.002–.0045	.0005–.0015	.007	.012	.012	.012	2 9/16	52@2 3/8	45
1940–46	GC-288	.0015–.003	.003–.0045	.0005–.0015	.008	.012	.012	.012	2 9/16	52@2 3/8	45
1936–38	S-5-309	.001–.0035	.002–.0045	.0005–.0015	.007	.012	.012	.012	2 9/16	52@2 3/8	45
1940–46	GC-310	.0015–.003	.003–.0045	.0005–.0015	.008	.012	.012	.012	2 9/16	52@2 3/8	45

① Intake 30 degrees: exhaust 45 degrees.

NOTE—For Reo engines developed since 1942, see page 915.

PISTON AND RING CLEARANCES

Year	Engine Model	Piston Skirt, Inches		Fitting Pistons with Shim and Spring Scale		Ring End Gap, Inch ①		Ring and Groove, Inch	
		Top	Bottom	Shim Thickness ②	Pounds Pull on Scale ③	Compression	Oil	Compression	Oil
1937–38	S-140	.002	.002	.002	.003	.007–.015	.005–.015	.0015	.0015
1936–38	S-209	.002	.002	.002	.003	.007–.015	.005–.015	.0015	.0015
1936–38	S-228	.002	.002	.002	.003	.007–.015	.005–.015	.0015	.0015
1940–46	GC-228	.002	.002	.002	.003	.009–.014	.009–.014	.002	.002
1940–46	GC-245	.002	.002	.002	.003	.009–.014	.009–.014	.002	.002
1936–38	S-3-268	.002	.002	.002	.003	.007–.015	.005–.015	.0015	.0015
1936–38	S-3L-268	.002	.002	.002	.003	.007–.015	.005–.015	.0015	.0015
1940–46	GC-288	.002	.002	.002	.003	.009–.014	.009–.014	.002	.002
1936–38	S-5-309	.002	.002	.002	.003	.007–.015	.005–.015	.0015	.0015
1940–46	GC-310	.002	.002	.002	.003	.009–.014	.009–.014	.002	.002

① Fit rings in tapered bores with not less than maximum clearance given.

② Piston to pass on shim thickness shown.

③ Piston to lock on shim thickness shown.

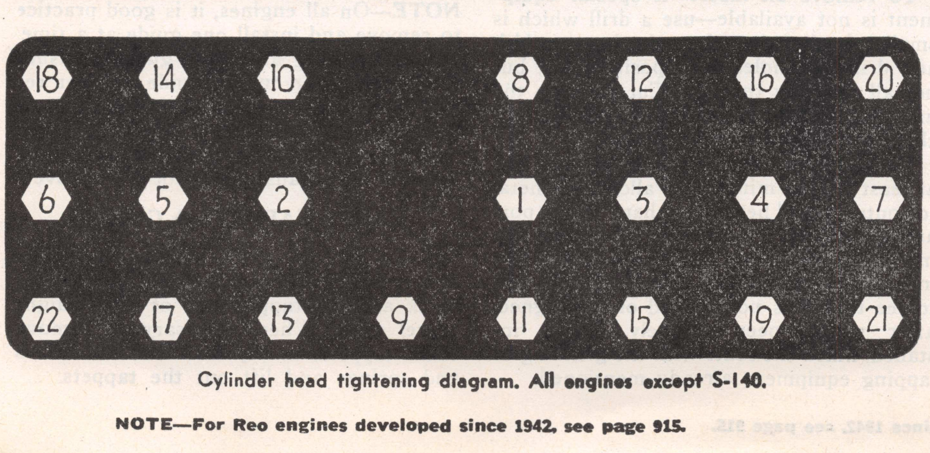
ENGINE BEARING SPECIFICATIONS

Year	Engine Model	Camshaft		Connecting Rod			Mains				
		Journal Diameter	Clearance	Journal Diameter	Clearance	Bearing Bolt Tension Lb. Ft.	Journal Diameter	Clearance	Bearing Bolt Tension Lb. Ft.	Thrust on No.	End-play
1937–38	S-140	②	.002–.0025	1.9365–1.9375	.0015–.0025	50–55	2.249–2.250	.0015–.0025	85–100	1	.003–.006
1936–38	S-209	③	.002–.0025	1.9365–1.9375	.0015–.0025	50–55	2.249–2.250	.0015–.0025	85–100	1	.003–.006
1936–38	S-228	①	.004–.006	2.187–2.188	.0015–.0025	70–75	2.624–2.625	.0015–.0025	65– 75	7	.004–.007
1940–46	GC-228	①	.004–.006	2.187–2.188	.0015–.0035	70–75	2.624–2.625	.0025–.004	67– 75	7	.003–.007
1940–46	GC-245	①	.004–.006	2.187–2.188	.0015–.0035	70–75	2.624–2.625	.0025–.004	67– 75	7	.003–.007
1936–38	S-3-268	①	.004–.006	2.187–2.188	.0015–.0025	70–75	2.624–2.625	.0015–.0025	65– 75	7	.004–.007
1936–38	S-3L-268	①	.004–.006	2.187–2.188	.0015–.0025	70–75	2.624–2.625	.0015–.0025	65– 75	7	.004–.007
1940–46	GC-288	①	.004–.006	2.187–2.188	.0015–.0035	70–75	2.624–2.625	.0025–.004	67– 75	7	.003–.007
1936–38	S-5-309	①	.004–.006	2.187–2.188	.0015–.0025	70–75	2.624–2.625	.0015–.0025	65– 75	7	.004–.007
1940–46	GC-310	①	.004–.006	2.187–2.188	.0015–.0035	70–75	2.624–2.625	.0025–.004	67– 75	7	.003–.007

① No. 1, $2\frac{3}{16}$. No. 2, $2\frac{1}{8}$. No. 3, $2\frac{1}{16}$. No. 4, $2\frac{1}{2}$.

② No. 1, $1\frac{7}{8}$. No. 2, $1\frac{3}{4}$. No. 3, $1\frac{1}{4}$.

③ No. 1, $1\frac{7}{8}$. No. 2, $1\frac{13}{16}$. No. 3, $1\frac{3}{4}$. No. 4, $1\frac{1}{4}$.



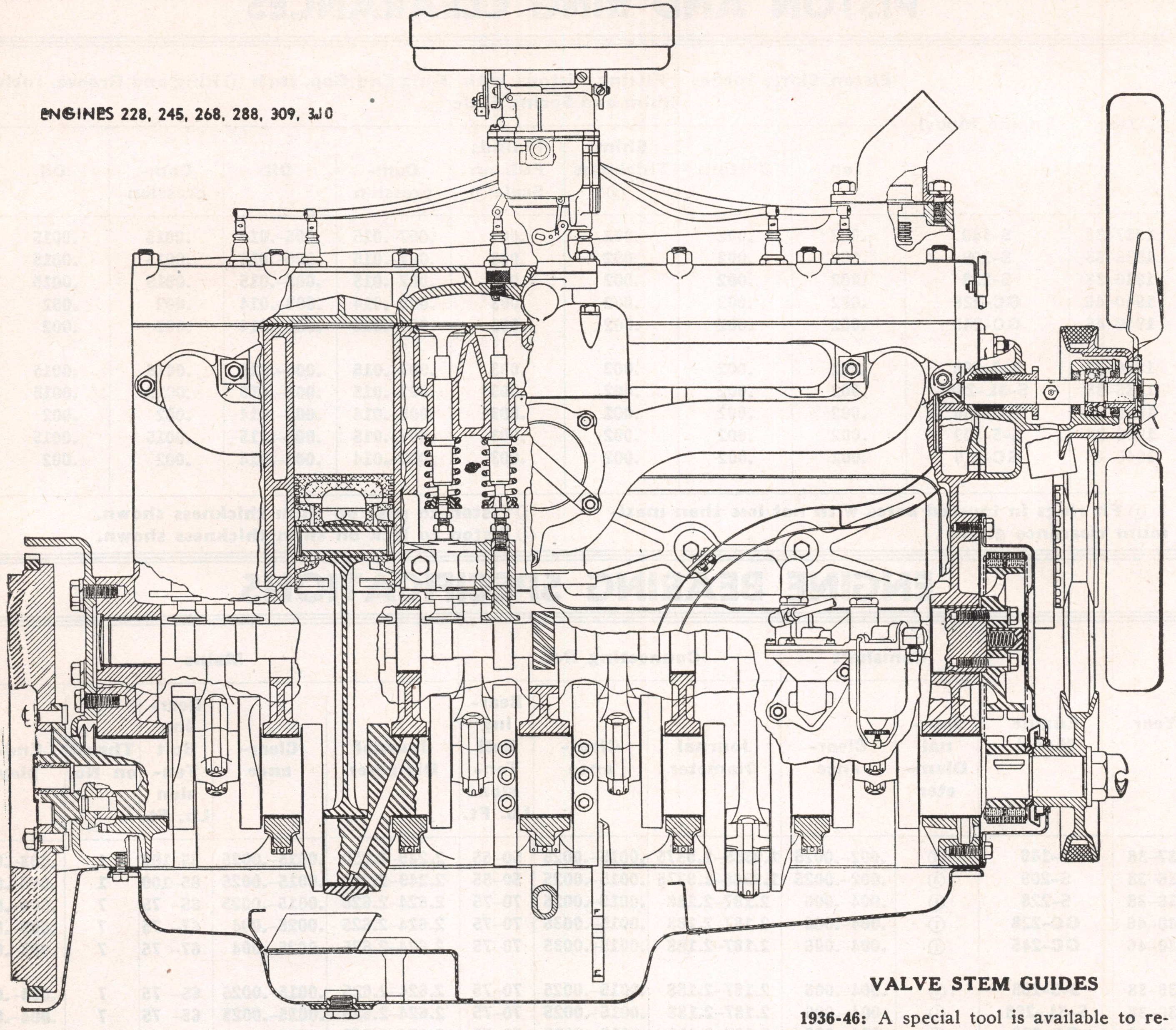
Cylinder head tightening diagram. All engines except S-140.

ENGINE

CYLINDER HEAD

1936-46 All. When installing a cylinder head, always use a new gasket. Make sure the gasket, cylinder head and cylinder block are clean and free from carbon and dirt. Tighten cylinder head nuts or capscrews in the sequence shown, drawing them down evenly, repeating the operation until they are tight. On engines with iron cylinder heads, make a final tightening after the engine has been run to bring it to operating temperature. On aluminum heads, the final tightening should be made

NOTE—For Reo engines developed since 1942, see page 915.



ENGINES 228, 245, 268, 288, 309, 310

after the engine has been run and cooled and while it is still cool.

When using a torque indicating wrench, the final tightening should be 60 pounds feet on S-140 and S-209; from 62.5 to 64.5 on S-228, S-268 and S-309, and from 83 to 100 on all GC engines.

VALVE SPRINGS

1936-46 All: Check valve springs whenever removed, and replace any that do not meet specifications given in the VALVE SYSTEM table.

EXHAUST VALVE SEAT INSERTS

1936-46: Since these inserts are too hard to reface by the ordinary grinding methods, a high-speed grinding stone or a special lapping tool should be used to perform this operation. When using this equipment, be sure valve guides are clean and that the valve guide pilot is a snug fit in order to assure a concentric finish. Finished seats should be checked with a dial indicator and run-out should not exceed .0005".

To remove an insert—if special equipment is not available—use a drill which is smaller in diameter than the insert width and drill two holes at opposite sides, but not all the way through. Cut through the undrilled portion of the insert with a sharp chisel and remove the two pieces.

To install an insert, pack in "dry ice" for at least fifteen minutes to allow the metal to contract, and heat the exhaust valve port area gradually, if necessary, to permit this material to expand. Then press the insert into the cylinder head, using extreme care to see that it is not cocked or misaligned, after which, peen securely. When installed, finish the seats with the grinding or lapping equipment already mentioned.

VALVE STEM GUIDES

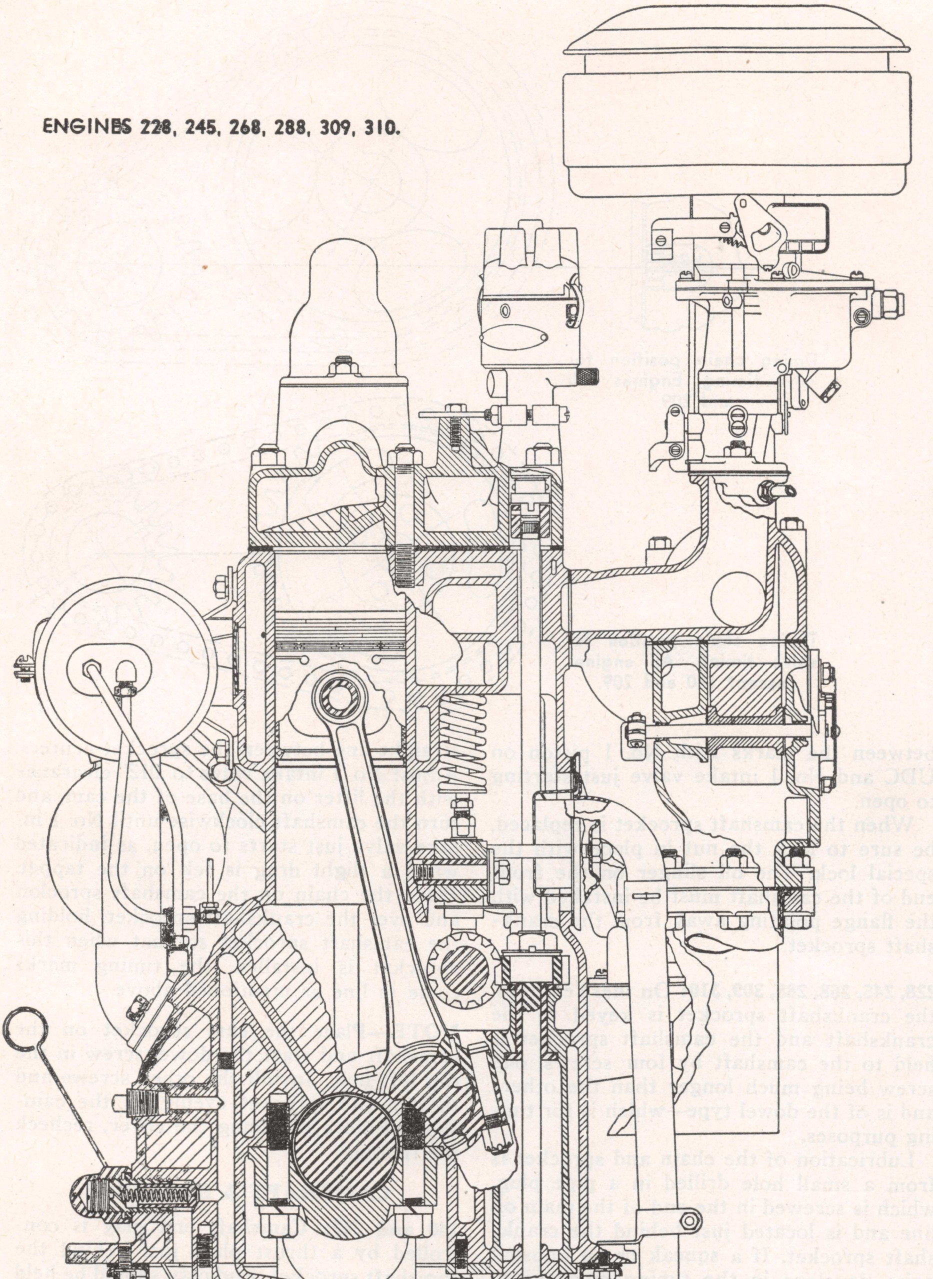
1936-46: A special tool is available to remove and install valve stem guides. After new guides are installed, ream them to provide the valve stem clearance given in the VALVE SYSTEM table. When installing guides, see that each new guide is pressed in so that the top of the guide is the correct distance from the top of the cylinder block.

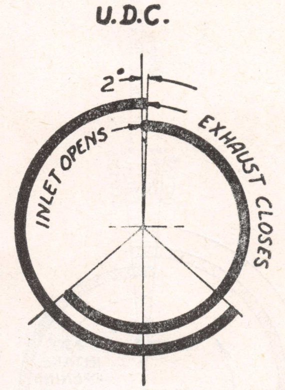
NOTE—On all engines, it is good practice to remove and install one guide at a time. When installing an intake guide, measure the depth of an intake guide not yet removed to determine the correct depth of the guide being installed. Similarly, when installing an exhaust guide, measure the depth of an exhaust guide not yet removed.

VALVE TAPPETS & GUIDES

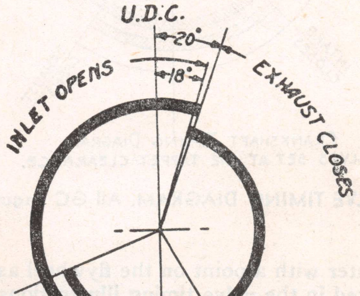
140 and 209: On these engines, the valve tappet guides are integral with the cylinder block and the tappets are of the straight barrel type. When necessary to remove these tappets, simply take out the valves and springs and lift out the tappets.

ENGINES 228, 245, 268, 288, 309, 310.

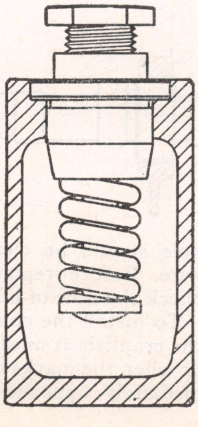




VALVE TIMING DIAGRAM. Engine S-3-268



VALVE TIMING DIAGRAM. Engine S-3L-268.



VALVE TAPPET.
Engines 140 and 209.

CAUTION—The tappet adjusting screws are self-locking and are held in position by a spring on the inside of the tappet. Never attempt to turn the adjusting screw out beyond the maximum distance—which is 11/64″

1936-46 Except 140 and 209: These engines have removable tappet guide assemblies and worn guides may be replaced. To remove the tappets, remove the right front wheel and fender inspection shield (if equipped) and take off the valve cover plates. Crank the engine until the tappets in one of the banks are loose and remove the tappets and guide assembly. Repeat this operation with the other cluster.

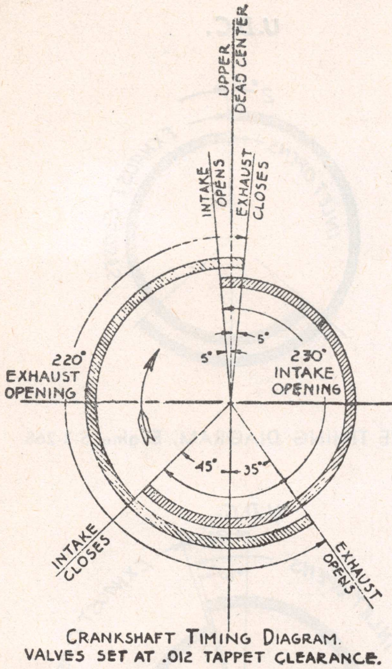
VALVE TIMING

140 and 209: To check the valve timing without removing the timing case cover, adjust No. 1 intake valve to .012″ clearance, being sure the lifter is on the base of the cam. Then crank the engine until No. 1 intake valve starts to open, which can be determined by rotating the lifter back and forth with the fingers. When the lifter starts to drag in its rotation, the valve is just starting to open. If the timing is correct, the indicator at the flywheel housing should point to a spot on the flywheel approximately 3/16″ before the "UDC" mark.

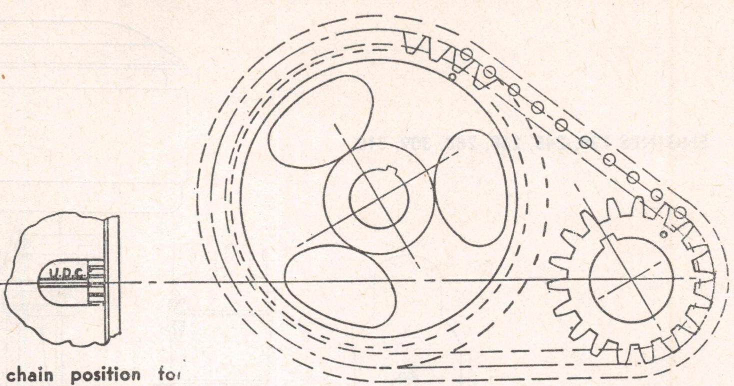
If the timing is incorrect, it will be necessary to reset the position of the chain. The "O" marks on both the camshaft and crankshaft sprockets should be set so there are nine links (or ten pins) between the "O" marks with No. 1 piston on UDC and No. 1 intake valve just starting to open.

NOTE—The above information is stamped on the front engine support plate, above the chain.

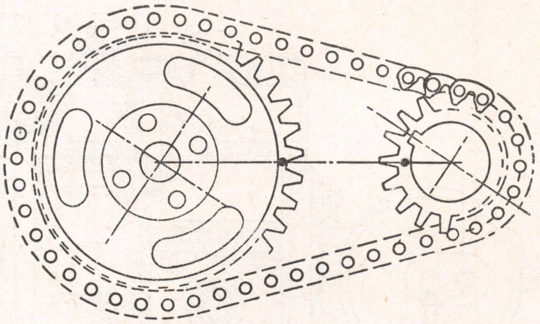
228, 245, 268, 288, 309 and 310: Procedure for checking valve timing on these engines is the same as described for 140 and 209 engines. If the timing is correct, the indicator at the flywheel inspection hole will



VALVE TIMING DIAGRAM. All GC engines.



Timing chain position for valve timing. Engines 140 and 209.



Timing chain position for valve timing. All engines except 140 and 209.

register with a point on the flywheel as indicated in the valve timing illustrations.

If the timing is incorrect, it will be necessary to reset the position of the chain. The "O" marks on the camshaft and crankshaft sprockets should be immediately opposite each other and on a straight line between the sprocket centers.

NOTE—The camshaft sprocket on the "high-torque" S-3-268 engine is identified by an "O" mark stamped on the side of the sprocket while on the S-3L-268 ("low-torque") engine, the sprocket is identified by an "X". See the valve timing illustrations for differences between the two engines. The S-3L-268 engine is identified by the engine number which will read "14DH—."

TIMING CHAIN & SPROCKETS

140 and 209: The crankshaft sprocket is keyed to the crankshaft and the camshaft sprocket is held to the camshaft by a special washer and nut. Lubrication of the chain and sprocket is provided from a small bleeding hole in front of the camshaft.

NOTE—When installing the chain and sprockets, the "O" marks on the camshaft and crankshaft sprockets should be set so that there are nine links (or ten pins) between the marks with No. 1 piston on UDC and No. 1 intake valve just starting to open.

When the camshaft sprocket is replaced, be sure to lock the nut in place with the special lock. The oil slinger on the front end of the camshaft must be installed with the flange pointing away from the crankshaft sprocket.

228, 245, 268, 288, 309, 310: On these engines, the crankshaft sprocket is keyed to the crankshaft and the camshaft sprocket is held to the camshaft by four screws, one screw being much longer than the others and is of the dowel type—which is for timing purposes.

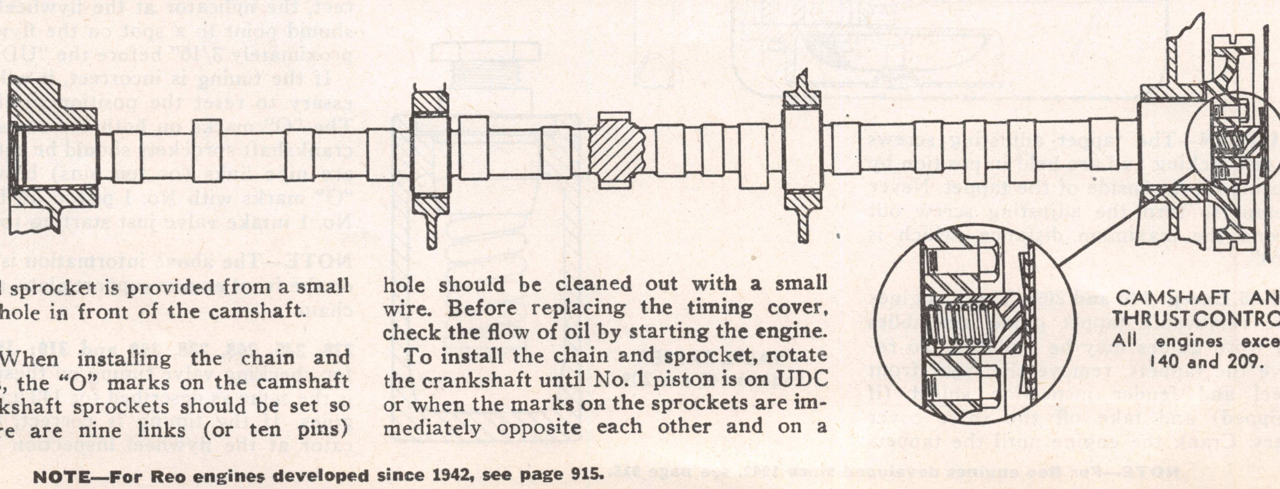
Lubrication of the chain and sprocket is from a small hole drilled in a pipe plug, which is screwed in the end of the main oil line and is located just behind the crankshaft sprocket. If a squeak or an unusual noise develops in the timing mechanism, remove the radiator and timing cover and inspect the oil bleed holes. If plugged, the hole should be cleaned out with a small wire. Before replacing the timing cover, check the flow of oil by starting the engine.

To install the chain and sprocket, rotate the crankshaft until No. 1 piston is on UDC or when the marks on the sprockets are immediately opposite each other and on a straight line between the sprocket centers. Adjust No. 1 intake valve to .012" clearance with the lifter on the base of the cam, and turn the camshaft clockwise until No. 1 intake valve just starts to open, as indicated when a slight drag is felt on the tappet. Place the chain on the camshaft sprocket and over the crankshaft sprocket, holding the camshaft sprocket so that when this sprocket is installed, the timing marks come in line as mentioned above.

NOTE—Place the cam sprocket on the camshaft and start the dowel screw in the top left hole. Install the other screws and tighten the sprocket evenly on the camshaft. Before replacing the cover, recheck the timing.

CAMSHAFT & BEARINGS

140 and 209: Camshaft end play is controlled by a thrust plate just behind the camshaft sprocket. End play should be held to approximately .005" and can be checked by forcing the shaft back to the limit of its



CAMSHAFT AND THRUST CONTROL. All engines except 140 and 209.

end play and inserting a feeler between the thrust plate and the front end of the shaft.

When necessary to replace bearings, they should be replaced in sets and line-reamed to provide a clearance within the limits given in the ENGINE BEARING SPECIFICATIONS table.

NOTE—On the 140 engine, No. 2 bushing, and No. 3 bushing on 209 engines, are cut out to accommodate the oil pump drive gear. To prevent these bushings from turning in the case, a pin is inserted through the outside of the crankcase.

228, 245, 268, 288, 309, 310: Camshaft end play is controlled by a hardened thrust plunger assembled with a strong coil spring, both located in front of the camshaft sprocket and held in place by the timing case cover. The camshaft is supported by four steel-backed babbitt-lined bushings pressed into the case. When necessary to replace bearings, they should be installed in sets and line-reamed to provide a clearance within the limits given in the ENGINE BEARING SPECIFICATIONS table.

PISTONS & RODS, REMOVE

1936-46 All: On 140 and 209 engines, the piston and rod assemblies can only be removed through the top of the engine. On all other engines, the pistons only are removed through the top and the rods through the bottom. To remove pistons and rods on these latter engines, push the piston up through the cylinder bore until the piston pin retainers are accessible. Use a pair of pliers to remove the snap rings, push out the piston pin and lift out the piston, after which, remove the rod from below.

Although regular production rods are marked with the cylinder number in which they are installed, replacement rods are not. Therefore, unmarked rods should be suitably identified with punchmarks, as they are removed.

PISTONS & RODS, ASSEMBLE

1936-46 All: Pistons and rods should be assembled so that the oil squirt hole in the rod and the slotted side of the piston are both facing the camshaft side of the engine. Regular production pistons are stamped with an arrow on the top which indicates that it should face toward the front of the engine.

NOTE—On 140 and 209 engines, the connecting rods are offset, and when installed, the wide side should face toward the rear of the engine in odd numbered cylinders; in even numbered cylinders, the wide side should face toward the front of the engine.

PISTONS, RENEW

1936-46 All: NOTE—A variation of 10 degrees between the temperature of the pistons and cylinder bores is sufficient to produce a difference of .0005". Therefore, both the pistons and cylinder bores should be at normal room temperature (about 70 degrees) when fitting pistons. This is particularly important because the clearances given in the PISTON & RING CLEARANCES table are minimum and pistons must not be fitted with less than specified.

Before any attempt is made to fit new pistons, cylinder bores should be carefully indicated and refinished. If bores do not require refinishing, be sure to remove the ridge at the top of each bore. If refinishing is required, it is good practice to do so in alternate cylinders due to the localized temperature build-up. Cylinder bores should not be out-of-round or tapered more than .0005".

Before fitting pistons, wipe the cylinder walls and pistons to remove all chips, dirt or other foreign matter. The feeler ribbon used to check piston fit should be about 12" long and ½" wide. Consult the PISTON & RING CLEARANCES table for the thickness of shim to use.

Insert the piston in the bore upside down and in its running position (see PISTON & ROD, ASSEMBLE). Place the feeler ribbon between the cylinder wall in a position at right angles to the piston pin hole.

After assembling the piston to the connecting rod, check the assembly for alignment on a suitable jig.

PISTON RINGS, RENEW

1936-46 All: NOTE—To prevent the possibility of bending or breaking the second ring land—thus ruining the piston—the ridge at the top of the cylinder bore should be cut away before removing the piston and rod assemblies. If the available ridge reamer has no provision to control the depth of the cut, it is good practice to bring the piston far enough up into the cylinder to allow the reamer to rest on top of the piston. This will serve to prevent cutting down into the ring travel area.

CAUTION—Never cut down into the ring travel area more than 1/32"—or more than half the depth of the top ring.

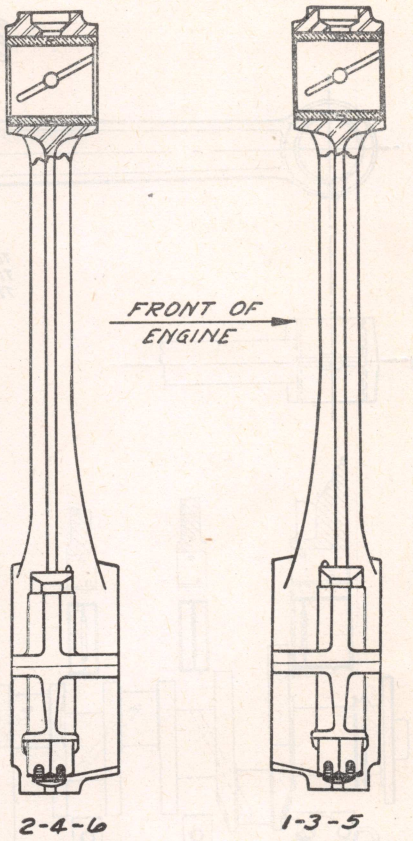
New rings should be fitted with end gaps and groove clearances as given in the PISTON & RING CLEARANCES table. Ring grooves must be clean and free from carbon, and must show no perceptible wear.

NOTE—Ring end gaps given in the PISTON & RING CLEARANCES table are for cylinder bores without taper. If rings other than standard are being installed, pay particular attention to the installation instructions which are usually included in the ring package. This applies to clearances, position in grooves, etc.

When rings are properly fitted to the pistons, be sure to stagger the ring gaps so they are spaced equal distances around the circumference of the piston. However, see that no gaps are over the piston pins.

PISTON PINS, RENEW

1936-46 All: The correct fit of aluminum pistons, at normal room temperature, should require a light tap fit with a rubber mallet to install the pin. However, to facilitate fitting pins in aluminum pistons, heat the piston in boiling water for a few minutes, after which the pin should enter the piston easily.



Connecting rod installation. Engines 140 and 209.

These pins are of the full-floating type, being held in place by snap rings in the grooves of the piston bosses.

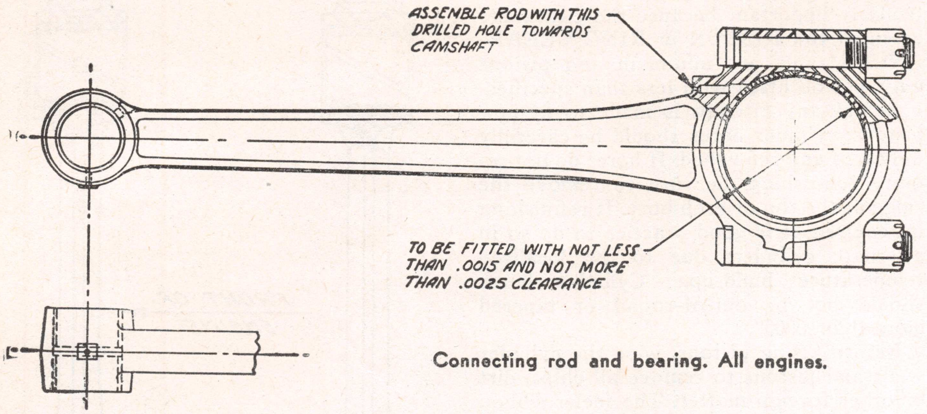
PISTON PIN BUSHINGS, RENEW

1936-46 All: New bushings should be pressed in place and reamed to provide a light push fit of the pin with the parts at normal room temperature. When installed, be sure the oil hole in the bushing lines up with the hole in the connecting rod.

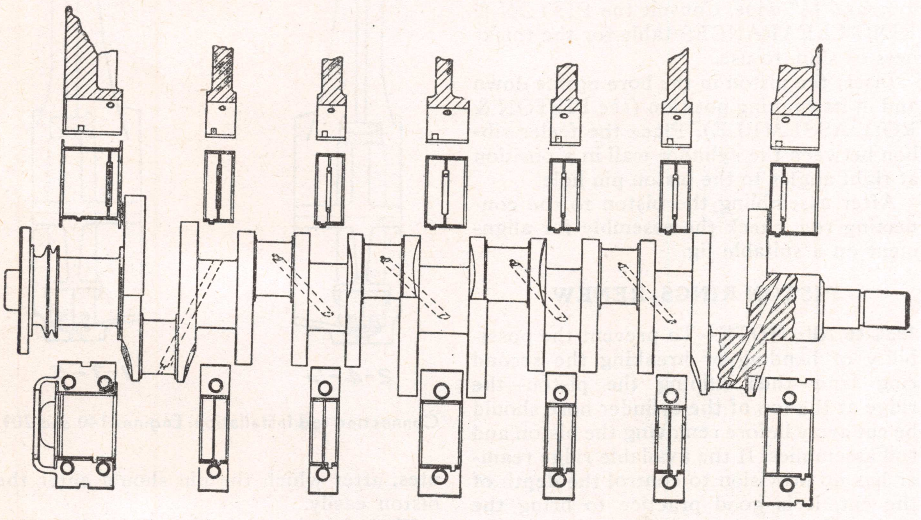
CONNECTING ROD, BEARINGS, RENEW

1936-46 All: These bearings are of the precision insert type and when worn, they may be replaced by simply taking off the bearing cap and slip the old shells out and the new ones in. Bearings should be replaced in sets and under no circumstances should rods or caps be filed, altered or mutilated in any way in an attempt to obtain proper bearing fit.

NOTE—Before replacing bearings, make sure that the crankpins are not nicked or scored, and that all parts are thoroughly clean. This is particularly important because the presence of one small particle of metal, carbon or other foreign matter, lodged between the back of the bearing and the rod, or between the face of the bearing and the crankpin, will very likely cause a hot spot due to the elimination of the oil


ASSEMBLE ROD WITH THIS DRILLED HOLE TOWARDS CAMSHAFT
TO BE FITTED WITH NOT LESS THAN .0015 AND NOT MORE THAN .0025 CLEARANCE

Connecting rod and bearing. All engines.



Crankshaft and main bearing. All engines except 140 and 209.

clearance at that point, eventually resulting in bearing failure or a scored crankpin.

CAUTION—These bearings are designed for use without shims and under no circumstances should shims be used in an attempt to obtain a bearing fit, because the proper "crush" fit of the bearings in the connecting rod bores will not be obtained.

To check the fit of new bearings, use a piece of brass shim stock ¼" wide, the length of which should be ¼" less than the length of the bearing, while the thickness should be approximately the same as the minimum allowable clearance.

CAUTION—To avoid damaging the bearing material, smooth down the edges of the shim stock on an oil stone so that no sharp edges remain. Install the shim between the bearing and the crankpin, in the center of the bearing, then tighten the cap bolts to the recommended torque tension. When fitted properly, it should not be possible to move the rod endwise by hand, but a light tap with a hammer should cause the rod to move endwise. Then remove the checking shim and re-install the cap, tightening the cap bolts with a torque wrench, after which the rod should move endwise by hand. If the rod is too loose with the checking shim in place, the crankpin should be turned down and undersize bearings fitted.

MAIN BEARINGS, RENEW

1936-46 All: NOTE—Before replacing bearings, make sure that the crankshaft journals are not nicked or scored. Use care also, to see that all parts are thoroughly clean. This is particularly important because one small particle of metal, carbon, dirt or other foreign matter, lodged between the back of the bearing and the cap or saddle, or between the bearing face and the crankshaft journal, will very likely cause a hot spot due to the elimination of the oil clearance at that point, eventually resulting in a bearing failure or a scored journal.

When bearings become worn, they can be replaced without removing the crankshaft in the following manner: Remove the bearing cap and take out the worn lower shell. A suitable tool can be made to remove the upper shell by using a cotter pin with the rounded end flattened to form a T shape. Insert the long end of the pin in the oil passage hole in the crankshaft journal and, by rotating the crankshaft in the reverse direction, the T-shaped head will contact the bearing and force it out.

To install, place a new upper shell on the crankshaft journal with the locating notch in the correct position and rotate the shaft to turn the shell in place. Then install the lower shell in the cap and replace the cap, tightening the cap bolts to the recommended torque tension.

NOTE—Bearings should be replaced in sets and under no circumstances should any attempt be made to shim, file, alter or otherwise mutilate the bearing caps to obtain proper bearing fit.

To check the fit of new bearings, use a piece of brass shim stock ¼" wide, the length of which should be ¼" less than the length of the bearing, while the thickness should be about the same as the minimum allowable clearance.

CAUTION—To avoid damaging the bearing material, smooth down the edges of the shim stock to remove sharp edges or turned over corners. And before inserting it in place, coat the shim on both sides with a light film of engine oil.

Then lay the shim lengthwise in the center of the bearing and install the bearing cap to the crankshaft, tightening the cap bolts to the recommended torque tension. Test the fit of the bearing by rocking the flywheel through an arc of 2"—not more than 1" in either direction. The bearing may be considered fitted properly if the shaft is movable with a fairly heavy drag.

NOTE—Remove the checking shim and replace the cap, but do not tighten the cap bolts, as this bearing must be loose in order to check the fit of the other bearings. It is good practice to fit bearings by starting at the center—or one of the intermediates on a four bearing job—then the rear bearing, front bearing, and finally, the intermediates.

CRANKSHAFT END THRUST

1936-46: On the 140 and 209 engines, the end thrust is controlled by shims on the front main bearing. On all other engines, the end thrust is controlled by flanges on the rear main bearing. Through normal wear, the end play will seldom become excessive but whenever new bearings are fitted, the clearance should be carefully checked and, if required, the bearing flanges may be dressed down, or shims removed, as the case may be, to obtain the desired end play.

CRANKSHAFT OIL SEALS

140 and 209: Oil sealing at the front and rear main bearing is accomplished by die cast filler blocks sealed with cork. When installing the front oil seal filler block, tighten the four screws which fasten it to the front engine support plate before tightening the two screws at the crankcase, being careful to place the oil pan gaskets in their proper position under the filler block.

When installing the rear oil seal, always install both the upper and lower seals. The upper seal may be replaced without dismantling the engine. To do this, rotate the seal retainer out of its position, remove the old seal and install the new, being sure that both ends protrude an equal distance at both sides to assure uniform compression when the filler blocks are installed.

228, 245, 268, 288, 309, 310: The rear main bearing support is provided with packing which forms an oil seal at the outer end of the shaft. In addition, an oil slinger, integral with crankshaft, deflects the major portion of the oil into the groove of the bearing cap and support.

NOTE—If it is necessary to replace the packing in the upper half of the rear main bearing, the crankshaft must be removed from the engine and the packing installed in the same manner as described below for the lower half of the bearing.

To install, insert the packing in the groove of the bearing cap and use a smooth, rounded tool to work the packing from each end towards the center of the cap. to force, and shape the packing in the groove. Then cut off the overlapping ends of the packing **flush** with the surface of the cap.

NOTE—Make sure that the packing is not pulled out of the groove when cutting off the ends. A special seal compressor, or a round block of wood of the same diameter as the crankshaft flange may be used to hold the packing firmly in position.

ENGINE OILING

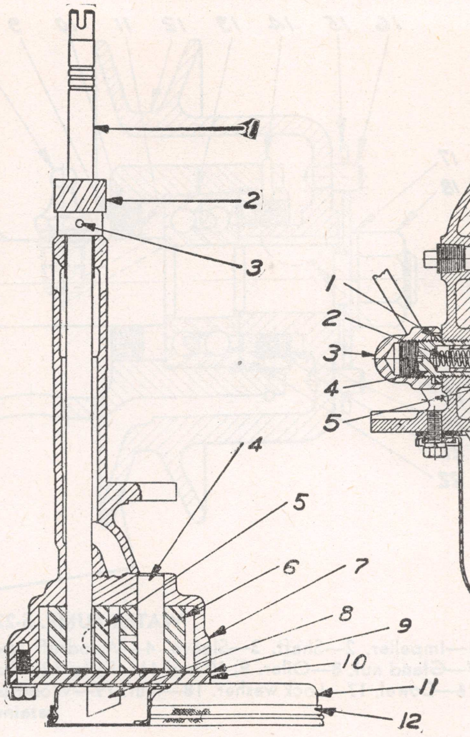
OIL PUMP

1936-46: If the oil pressure drops to zero suddenly or fluctuates violently while the engine is under load, check the oil level and examine the condition of the oil. If these conditions are not the cause, check the oil gauge by using another gauge known to be accurate, before attempting to tear down the engine. If the checking oil gauge shows a pressure drop, then remove and clean the oil pan thoroughly. At the same time, disassemble, clean and inspect the oil pump. The correct gauge pressure should be between 30 and 45 pounds at speeds above 30 miles per hour.

Before taking down the oil pan, it is good practice to remove the protecting cap from the oil pressure regulator and see if an adjustment of the oil pressure release valve affects the oil pressure. If foreign matter is lodged in the release valve, it may be removed by this change in adjustment. If adjustment does not correct the pressure. then take the valve out and clean it. It is rarely necessary to change the oil pressure adjustment. If the oil pressure is changed. be sure to determine the viscosity of the oil in the crankcase or use fresh oil before the final adjustment is made.

NOTE—The pump can easily be disassembled by taking off the upper drive gear and bottom cover, after which, the internal parts can readily be removed. Replace any gears which have an excessive amount of backlash. When assembling, dip the gears in fresh engine oil as a means of priming the pump.

Clearance between the gears and bottom cover may be checked by placing a steel scale across the face of the housing, and a feeler ribbon between the steel scale and gears. If the clearance is excessive, it may be reduced by grinding the lower face of the housing, using an abrasive compound evenly distributed on a perfectly flat surface.



OIL PUMP. Engines 140 and 209.

1—Drive shaft. 2—Upper drive gear. 3—Lock pin. 4—Driven gear shaft. 5—Drive gear. 6—Driven gear. 7—Pump body. 8—Suction tube. 9—Oil pump cover gasket. 10—Oil pump cover. 11—Oil pump screen shield. 12—Oil pump screen.

Examine the oil pressure regulator ball check, spring and seat, and if these parts show wear, new parts must be installed.

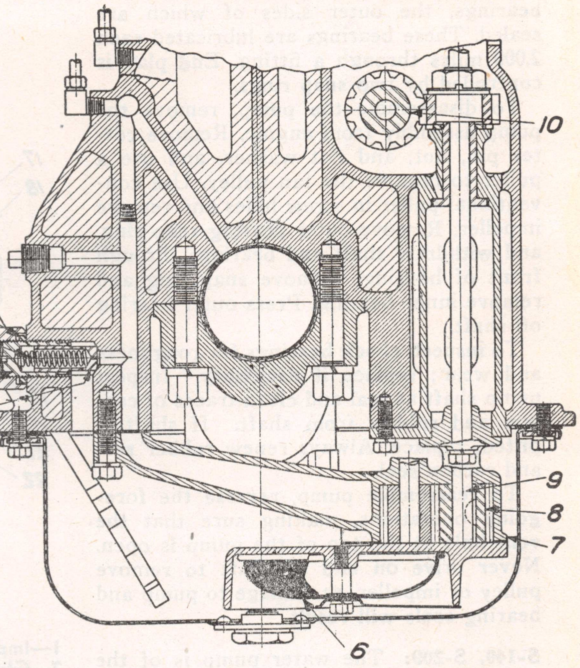
CAUTION—Before replacing the oil pump and oil pan, the oil screen, oil tubes and oil lines should be thoroughly cleaned, being sure that all openings in the screen are free and clean. If the screen is crushed, it is better to replace it rather than attempt to make a repair.

OIL FILTER

1936-46: Filters should be cleaned thoroughly every time the oil is changed. If the dip stick shows the oil to be very thick and dirty, it indicates that the filter requires service.

CRANKCASE VENTILATOR

1936-46: The crankcase ventilator breather should be inspected at least every 2,000 miles of operation, and if a sludge formation is evident, remove the breather and clean it thoroughly in gasoline. Allow the breather to soak in the gasoline for about 30 minutes, then blow it out with compressed air, and at the same time, tap it lightly to dislodge any particles of sludge.



Oil pump and by-pass valve. All engines except 140 and 209.

1—Lock nut. 2—Spring. 3—Acorn nut. 4—Adjuster sleeve. 5—Valve. 6—Oil pump screen. 7—Oil pump body. 8—Oil pump gear. 9—Drive shaft. 10—Drive gear.

If the breather is fitted with an air cleaner, it should be removed and washed every 1,000 miles. After the element is washed, blow it dry with compressed air and, if the cleaner is of the oil-wetted type, dip the element in fresh engine oil before assembling. If it is of the oil bath type, wipe out the oil reservoir thoroughly with a clean cloth and fill it to the proper level with fresh engine oil.

NOTE—The interval at which the ventilator and air cleaner should be cleaned can only be determined by the type of service to which the vehicle is subjected. Vehicles operating in dusty or sandy areas require more frequent service than those operating under more favorable conditions.

IMPORTANT—For vehicles operating in dust storm areas, the cleaner should be cleaned immediately after such storms occur.

COOLING SYSTEM

WATER PUMP, OVERHAUL

GC-228, GC-245, GC-288, GC-310: The water pump is of the packless type. The seal assembly is of composition rubber and is held in contact with the shaft and carbon washer by a bronze spring. The seal assembly is held in place by a retainer ring. The pump shaft is mounted on two ball bearings, the outer sides of which are sealed. These bearings are lubricated each 2,000 miles through a fitting. End play is controlled by two snap rings.

To disassemble the pump, remove the pump assembly from engine. Remove cotter pin, nut, and flat washer, and use a puller to remove the fan pulley. Use conventional puller in screw holes and remove impeller. Remove outer bearing snap ring, and withdraw shaft and bearings through front of housing. Remove snap ring and remove inner bearing. Press outer bearing off shaft.

To inspect, check bearings for roughness and wear; replace if necessary. Inspect pump shaft at seal and clean traces of carbon and rubber from shaft. If shaft is pitted, replace. Always renew rubber seal and carbon seal.

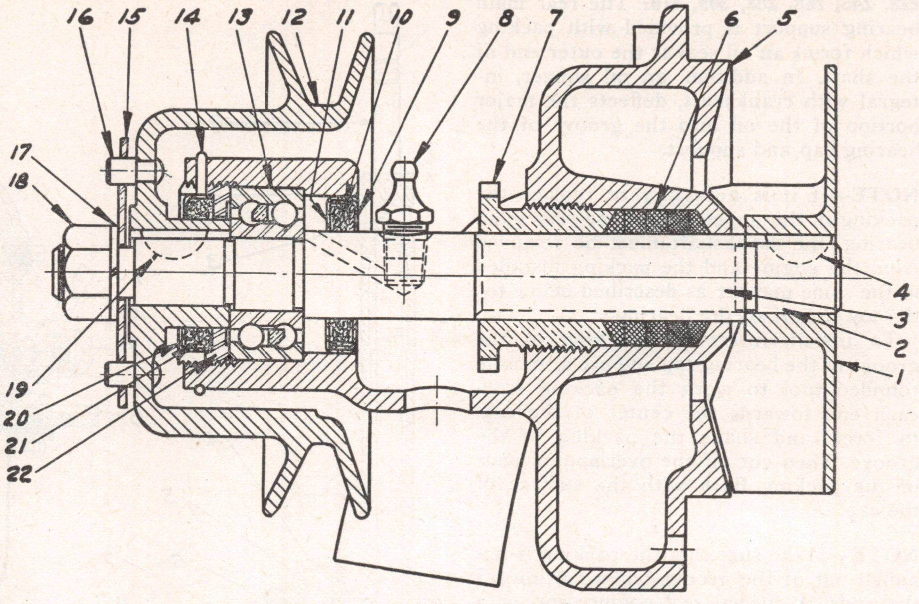
To reassemble pump, reverse the foregoing operations, making sure that the vent hole at the top of the pump is open. Never drive on end of shaft to remove pulley or impeller, as damage to pump and bearing seals will result.

S-140, S-209: The water pump is of the packless type. An assembled water seal of the flexible type provides protection against water leaks around the pump shaft. The pump shaft is mounted on two ball bearings that are packed with grease at time of assembly and need no further attention.

To disassemble water pump: Remove pump from front of cylinder block. Remove nut and press fan pulley off. Remove the screws and pump cover. Remove snap ring and remove the assembled shaft and impeller. Drive out the straight pin from the end of the shaft, and remove impeller. Press bearings and the spacer out through front end of housing. To reassemble, reverse the foregoing instructions.

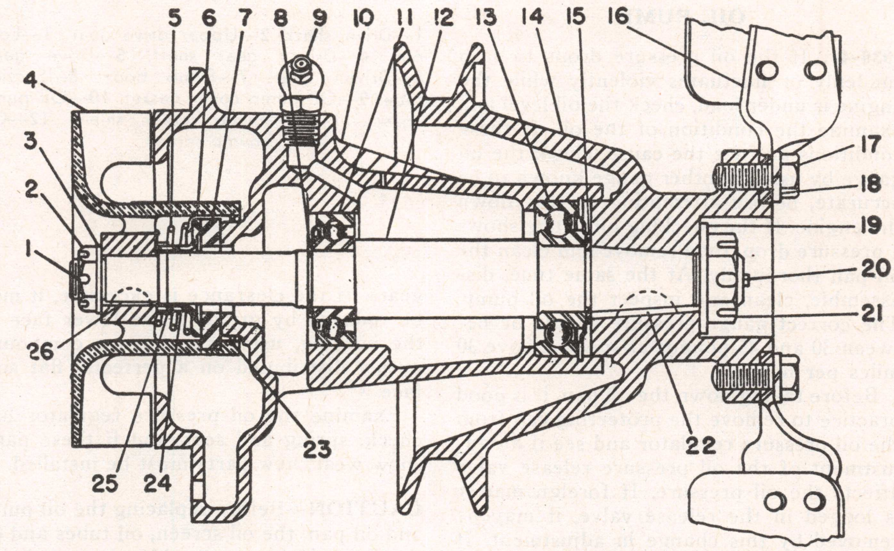
NOTE—When assembling bearings into the housing, be sure to pack the space between the bearings with a good grade of lime soap grease. Never dip the bearings in gasoline to clean; use a cloth and wipe clean.

S-228, S-3-268, S-3L-268, S-5-309: To disassemble water pump: Drain radiator and remove water pump from cylinder block.



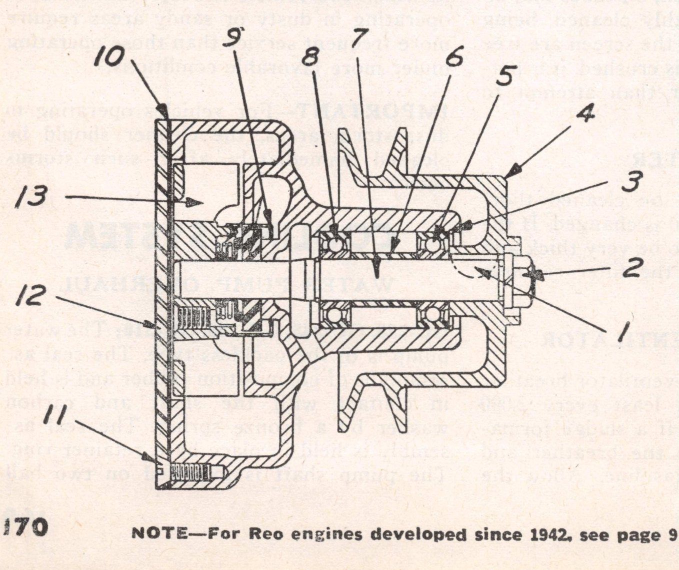
WATER PUMP. S-228, S-268, S-309.

1—Impeller. 2—Shaft. 3—Sleeve. 4—Woodruff key. 5—Pump body and fan support. 6—Packing. 7—Gland nut. 8—Oiler. 9, 10 and 11—Felts. 12—Pulley. 13—Bearing. 14—Lock spring. 15—Washer. 16—Dowel. 17—Lock washer. 18—Nut. 19—Woodruff key. 20—Retainer. 21—Cork seal. 22—Bearing retainer.



WATER PUMP. All GC engines.

4—Impeller. 5—Impeller seal spring. 6—Seal spring guide. 7—Carbon seal. 8—Shaft inner bearing snap ring. 10—Pump body. 11—Inner bearing. 12—Pump shaft. 13—Outer bearing. 14—Pulley. 15—Outer bearing snap ring. 16—Fan blades. 23—Impeller seal snap wire. 24—Impeller rubber seal. 25—Impeller seal clamp ring.



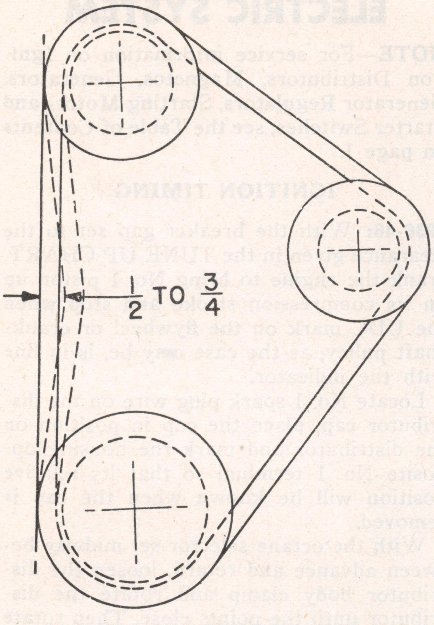
WATER PUMP. Engines 140 and 209.

1—Key. 2—Pulley retaining nut. 3—Snap ring. 4—Pulley. 5—Bearing. 6—Spacer. 7—Shaft. 8—Bearing. 9—Assembled seal. 10—Pump cover gasket. 11—Pump cover screws. 12—Pump cover. 13—Impeller.

Remove nut from end of shaft that holds fan pulley in place. Press the fan pulley from shaft. Remove Woodruff keys and oiler. Remove impeller and shaft assembly and remove gland packing nut and oil packing. Remove locking spring from bearing adjusting collar. Remove adjusting collar and bearing; also remove oil seals.

To reassemble water pump: Insert impeller shaft through pump body and gland nut and install five new packing rings. Screw gland nut into body of pump and

NOTE—For Reo engines developed since 1942, see page 915.



FAN BELT ADJUSTMENT. All engines.

tighten down lightly. Insert rear oil seal retainers and felts and press ball bearing over shaft and into pump housing. Install outer oil retainers and felt, then screw bearing retainer nut in place and install lock ring. Install oiler. Press fan hub on shaft and replace nut and washer. Replace pump in cylinder block and connect.

CAUTION—Do not tighten gland nut too much or it will cause packing to score the shaft.

ENGINE WATER THERMOSTAT

1936-46: The thermostat used on all models is rather fragile in construction and should be handled carefully. The bellows should be kept free from rust and scale particles as they will interfere with the proper operation of the thermostat. The thermostat is located in the cylinder-head water outlet and controls the circulation of water until such time as the water around the cylinders reaches a set temperature value (150 to 155 F for GC-228, GC-245, GC-288, GC-310 models; 140 to 145 F for S-140, S-209, S-228, S-3-268, S-3L-268, and S-5-309 models), at which time circulation starts and, at another higher set temperature (175 F for GC-228, GC-245, GC-288, and GC-310 models; 170 F for S-140, S-209, S-228, S-3-268, S-3L-268, and S-5-309 models), the thermostat is in the wide-open position—allowing a full head of water to pass around the thermostat valve into the radiator. It is recommended that the opening and closing points be checked from time to time to make certain that the thermostat is operating correctly.

To test the thermostat: Remove thermostat from the water outlet and place it in a container of water. Gradually heat the water and, by the use of a thermometer, check the temperature of the water. When it reaches the approximate temperature specified previously for each model, the thermostat should start to open and at 170 F or 175 F, depending upon the model as specified in the foregoing, the thermostat should show in the wide-open position.

NOTE—The water should be agitated while the test is being made.

FAN AND BELT

1936-46: The fan blades are mounted on a flange on the end of the pump shaft and are driven by a V-belt. This belt should always be kept in proper adjustment as shown in the illustration, to get the best results from the fan. Care should be taken that the belt is not adjusted too tightly as the drive is taken on the V sides of the belt, in place of the inner surface. Belts adjusted too tightly put an extra load on the pump shaft bearing and, in some cases, on the generator bearings.

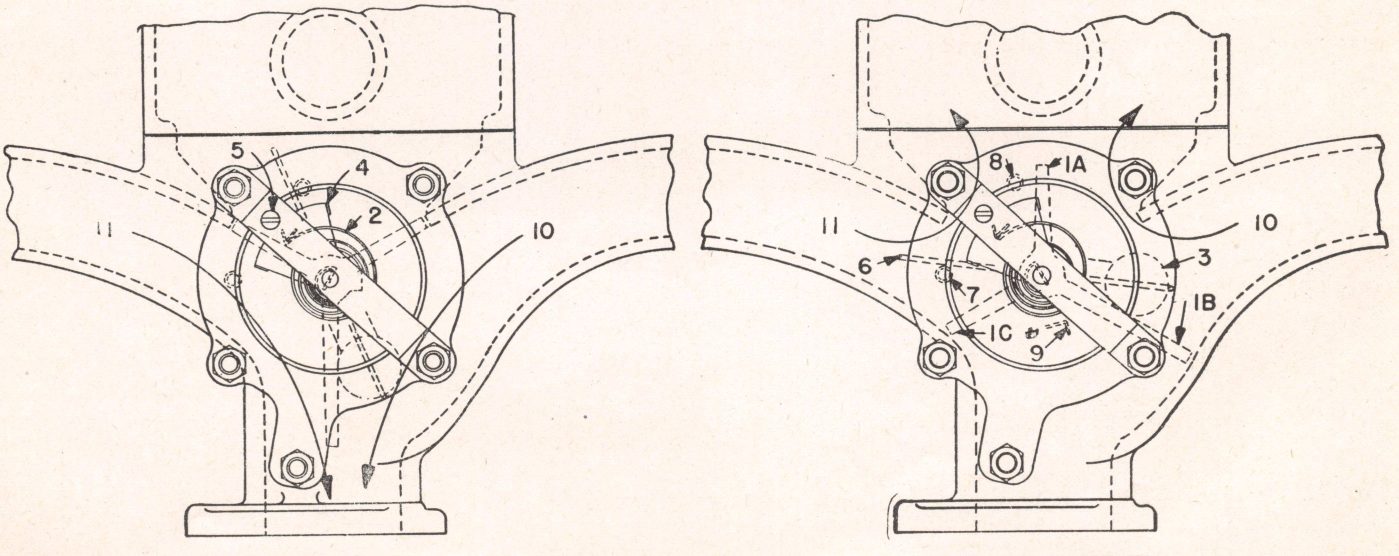
FUEL SYSTEM

NOTE—For service information on Carburetors, Automatic Chokes, Carburetor Governors, Fuel Pumps, Air Cleaners and Gasoline Gauges, see the Table of Contents on page 1.

MANIFOLD HEAT CONTROL

GC-228, GC-245, GC-288, GC-310: The exhaust manifold is equipped with a heat control valve that is adjustable for summer and winter operation. The heat control valve in the "on" position permits rapid warm-up of the intake manifold from cold starting by diverting a portion of the exhaust around the intake manifold. This valve should be in the "off" position in warm weather, and in the "on" position in cold weather. The change is made simply by loosening the lockscrews, moving the valve to the desired position, and tightening the lockscrew.

S-140, S-209, S-228, S-3-268, S-3L-268, S-5-309: The only actual adjustment is at the adjusting plate. When the unit is assembled completely, to increase the length of the "heat-on" period, loosen the clamp screw and rotate the plate counter-clockwise the desired amount up to the stop at the edge of the plate. To shorten the "heat-on" period as for warm weather, loosen the clamp screw and turn the plate clockwise up to the stop on the plate.



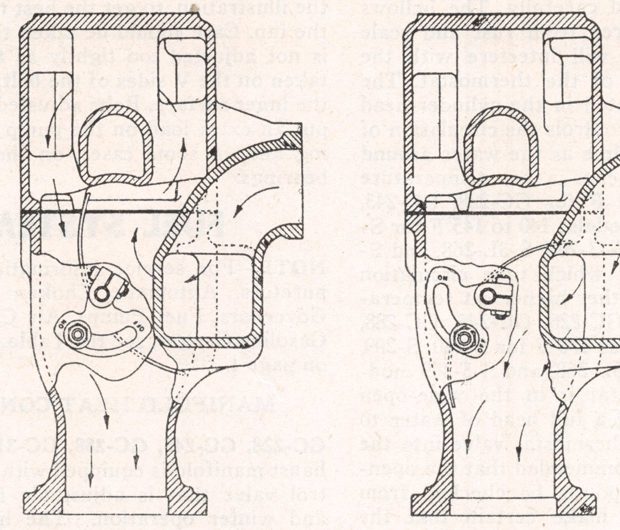
HEAT OFF POSITION

HEAT ON POSITION

MANIFOLD HEAT CONTROL. S-228, S-268, S-309.

1—Heat valve. 2—Thermostat. 3—Valve counterweight. 4—Adjusting plate. 5—Locking screw. 6—Stop wire. 7—Stop wire for "heat on." 8—Stop wire for "heat off." 9—Thermostat position unhooked. 10—Exhaust passage from forward cylinder. 11—Exhaust passage from rear cylinder.

NOTE—For Reo engines developed since 1942, see page 915.



HEAT "ON" POSITION HEAT "OFF" POSITION

MANIFOLD HEAT CONTROL. All GC engines.

This setting will be most satisfactory for all times in the warmer climates. In adjusting, the thermostat must never be wound up more than 200 to 220 degrees from rest point as it may cause permanent set in the coil, making it inoperative. The strap plate holding the adjusting plate must always be assembled in the position shown in the two illustrations.

Should the valve shaft stick, remove the four nuts holding the valve cover in place and remove the cover; loosen the clamp holding the counterweight on the rear of the shaft (outside of manifold) and remove counterweight. The shaft with valve can now be removed. Clean the shaft at the bushings with fine emery paper; also clean bushings before reinstalling. When reinstalling, place the valve and shaft in position with long vane hanging in practically a perpendicular position. Then attach the counterweight so that the wire is touching stop post. In attaching, rotate thermostat approximately 200 degrees counter-clockwise and hook on adjusting plate.

ELECTRIC SYSTEM

NOTE—For service information on Ignition Distributors, Magnetos, Generators, Generator Regulators, Starting Motors and Starter Switches, see the Table of Contents on page 1.

IGNITION TIMING

1936-46: With the breaker gap set to the clearance given in the TUNE UP CHART, crank the engine to bring No. 1 piston up on its compression stroke and stop when the UDC mark on the flywheel or crankshaft pulley, as the case may be, is in line with the indicator.

Locate No. 1 spark plug wire on the distributor cap, place the cap in position on the distributor and mark the housing opposite No. 1 terminal so that its relative position will be known when the cap is removed.

With the octane selector set midway between advance and retard, loosen the distributor body clamp and rotate the distributor until the points close. Then rotate the distributor in the opposite direction until the points just begin to open. Tighten the clamp bolt.

NOTE—For best results, use a Neon timing light or a conventional test lamp to check the timing. Advance or retard the octane selector to compensate for the grade of fuel being used. For best performance and fuel economy, this setting should be one which will provide smooth engine performance with a slight "ping" on wide-open throttle at comparatively low vehicle speed.

STUDEBAKER GASOLINE ENGINES

Year	Engine Model	Number Cylinders and Valve Arrangement	Bore and Stroke	Displacement Cubic Inches	Compression Ratio	Taxable H. P.	Brake H. P. at R. P. M.	Maximum Torque at R. P. M. Pounds Feet	Oil Capacity Quarts
1936	2T-2	6-L	3¼x4⅜	217.8	6.0	25.4	75@2800	160@1260	6
	2W-6①	6-L	3⅝x4¼	262	5.1	31.0	80@2800	173@1200	8
	2W-7②	6-L	3¾x4¼	282	5.1	33.7	82@2800	192@1400	8
	2W-8③	6-F	4 x4¾	358	5.1	38.5	110@2800	256@800	9
1937	J15	6-L	3¼x4⅜	217.8	6.0	25.35	85@3200	160@1200	6
	J20⑥	6-L	3⅝x4¼	263	5.83	31.54	79@2800	178@1200	6
	J25④	6-L	4 x4¼	320	5.63	38.4	86@2600	218@1200	6
	J30⑤	6-L	4¼x4½	383	5.5	43.3	98@2500	262@1200	7
1938—40	K5, L5	6-L	3 5/16x4⅜	226	6.0	26.35	90@3400	175@1200	5½
	K10	6-L	3 5/16x4⅜	226	6.0	26.35	79@3200	152@1200	5½
	K15	6-L	3 5/16x4⅜	226	6.0	26.35	85@3200	175@1200	5½
	K20⑥	6-L	3⅝x4¼	263	5.83	31.54	80@2800	178@1200	6
	K25④	6-L	4 x4¼	320	5.63	38.4	86@2600	218@1200	6
	K30⑤	6-L	4¼x4½	383	5.5	43.3	106@2800	268@800	7
1941—46	M5, M15	6-L	3x4	170	6.5	21.6	80@4000	134@2000	5
	M16	6-L	3 5/16x4⅜	226	6.5	26.35	94@3600	176@1600	6

① For service information, see Waukesha 6BM.
② For service information, see Waukesha 6BK.
③ For service information, see Waukesha 6-110.
④ For service information, see Hercules JXD.
⑤ For service information, see Hercules WXC3.
⑥ For service information, see Hercules JXB.

TUNE UP CHART

Year	Engine Model	Firing Order	Spark Plug Gap	Breaker Gap	Cam Angle, Degrees	Timing Mark Location	Spark Timing, Degrees	Tappet Clearance		
								For Running, Hot		For Timing, Intake	Battery Terminal Grounded
								Int.	Exh.		

Year	Engine Model	Firing Order	Spark Plug Gap	Breaker Gap	Cam Angle, Degrees	Timing Mark Location	Spark Timing, Degrees	Tappet Clearance For Running, Hot Int.	Tappet Clearance For Running, Hot Exh.	Tappet Clearance For Timing, Intake	Battery Terminal Grounded
1936	2T-2	153624	.025	.020	40	Vib. Damp.	2BTDC	.016C	.016C	.020	Positive
	2W-6①	153624	.025	.020	35	Flywheel	TDC	.012C	.014C	.010	Positive
	2W-7①	153624	.025	.020	35	Flywheel	TDC	.012C	.014C	.010	Positive
	2W-8①	153624	.025	.020	35	Flywheel	3BTDC	.012C	.016C	.010	Positive
1937	J15	153624	.025	.020	40	Vib. Damp.	2BTDC	.016C	.016C	.020	Positive
	J20①	153624	.025	.020	35	Flywheel	TDC	.008	.010	.010	Positive
	J25①	153624	.025	.020	35	Flywheel	TDC	.008	.010	.010	Positive
	J30①	153624	.025	.020	35	Flywheel	TDC	.006	.010	.010	Positive
1938—40	K5, L5	153624	.025	.018–.024	35	Vib. Damp.	9/64"BTDC	.016C	.016C	.020	Positive
	K10	153624	.025	.018–.024	35	Vib. Damp.	9/64"BTDC	.016C	.016C	.020	Positive
	K15	153624	.025	.018–.024	35	Vib. Damp.	9/64"BTDC	.016C	.016C	.020	Positive
	K20①	153624	.025	.018–.024	35	Flywheel	TDC	.006	.006	.010	Positive
	K25①	153624	.025	.018–.024	35	Flywheel	TDC	.006	.006	.010	Positive
	K30①	153624	.025	.018–.024	35	Flywheel	TDC	.006	.010	.010	Positive
1941–46	M5, M15	153624	.025	.018–.024	35	Flywheel	TDC	.016C	.016C	.020	Positive
	M16	153624	.025	.018–.024	35	Vib. Damp.	TDC	.016C	.016C	.020	Positive

① See footnotes at bottom of first table referring to service information. C. Cold.

VALVE SYSTEM

Year	Engine Model	Stem Clearance		Tappet Guide Clearance	Tappet Clearance				Valve Spring Pressure Test		Valve Seat Angle Degrees
					Running Hot		Timing				
		Intake	Exhaust		In-take	Ex-haust	In-take	Ex-haust	Free Length, Inches	Pounds at Inches, Length	
1936	2T-2	.002-.003	.003-.004	.001-.002	.016C	.016C	.020	.020	2½	123@1¾	45
	2W-6①	.002-.003	.003-.004	.001-.002	.012C	.014C	.010	.012	2²³⁄₃₂	73@1¾	45
	2W-7①	.002-.003	.003-.004	.001-.002	.012C	.014C	.010	.012	2²³⁄₃₂	73@1¾	45
	2W-8①	.002-.003	.003-.004	.001-.002	.012C	.016C	.010	.014	④	②	45
1937	J15	.002-.003	.003-.004	.001-.002	.016C	.016C	.020	.020	2½	123@1¾	45
	J20①	.002-.003	.003-.004	.001-.002	.008	.010	.010	.016	2¹³⁄₁₆	58@1¹⁹⁄₃₂	45
	J25①	.002-.003	.003-.004	.001-.002	.008	.010	.010	.016	2¹³⁄₁₆	58@1¹⁹⁄₃₂	45
	J30①	.002-.003	.003-.004	.001-.002	.006	.010	.010	.016	3¹⁄₁₆	88@2⅛	45
1938-40	K5, L5	.002-.003	.003-.004	.001-.002	.016C	.016C	.020	.020	2⅛	130@1¾	45
	K10	.002-.003	.003-.004	.001-.002	.016C	.016C	.020	.020	2½	130@1¾	45
	K15	.002-.003	.003-.004	.001-.002	.016C	.016C	.020	.020	2½	130@1¾	45
	K20①	.0025-.003	.0025-.003	.001-.002	.006	.006	.010	.016	2¹³⁄₁₆	77@③	45
	K25①	.0025-.003	.0025-.003	.001-.002	.006	.006	.010	.016	2¹³⁄₁₆	77@③	45
	K30①	.0025-.003	.0025-.003	.001-.002	.006	.010	.010	.016	3¹⁄₁₆	82@③	45
1941-46	M5, M15	.002-.003	.003-.004	.001-.002	.016C	.016C	.020	.020	2⅛	79@1⁷⁄₁₆	45
	M16	.002-.003	.003-.004	.001-.002	.016C	.016C	.020	.020	2⁷⁄₁₆	130@1¾	45

① See footnotes at bottom of first table referring to service information.

② Intake outer, 65@2½"; intake inner, 32@2⁷⁄₃₂"; exhaust, 90@1⁴⁷⁄₆₄".

③ With valve open.

④ Intake, 2⁶¹⁄₆₄"; exhaust, 2⁴¹⁄₆₄".

C. Cold

PISTON AND RING CLEARANCES

Year	Engine Model	Piston Skirt, Inches		Fitting Pistons with Shim and Spring Scale		Ring End Gap, Inch ①		Ring and Groove, Inch	
		Top	Bottom	Shim Thickness	Pounds Pull on Scale	Com-pression	Oil	Com-pression	Oil
1936	2T-2	.002	.002	.002	15 to 20	.013-.018	.013-.018	.002-.003	.002-.003
	2W-6②	.003	.003	.003	8 to 12	.015-.020	.015-.020	.0015-.003	.0015-.003
	2W-7②	.003	.003	.003	8 to 12	.015-.020	.015-.020	.0015-.003	.0015-.003
	2W-8②	.004	.004	.004	8 to 12	.015-.020	.015-.020	.0015-.003	.0015-.003
1937	J15	.002	.002	.002	15 to 20	.013-.018	.013-.018	.002-.003	.002-.003
	J20②	.003	.003	.003	8 to 12	.015-.020	.015-.020	.0015-.003	.0015-.003
	J25②	.0035	.0035	.0035	8 to 12	.015-.020	.015-.020	.0015-.003	.0015-.003
	J30②	.004	.004	.004	8 to 12	.015-.020	.015-.020	.0015-.003	.0015-.003
1938-40	K5	.0005	.0005	.002	7 to 15	.013-.018	.013-.018	.0015-.003	.0015-.003
	K10	.0005	.0005	.002	7 to 15	.013-.018	.013-.018	.0015-.003	.0015-.003
	K15	.0005	.0005	.002	7 to 15	.013-.018	.013-.018	.0015-.003	.0015-.003
	K20②	.003	.003	.003	8 to 12	.015-.020	.015-.020	.0015-.003	.0015-.003
	K25②	.0035	.0035	.0035	8 to 12	.015-.020	.015-.020	.0015-.003	.0015-.003
	K30②	.004	.004	.004	8 to 12	.015-.020	.015-.020	.0015-.003	.0015-.003
1941-46	M5, M15	.0015	.0015	.002	16 to 22	.007-.017	.007-.017	.0015-.003	.0015-.003
	M16	.0015	.0015	.002	14 to 19	.009-.014	.009-.014	0015-.003	.0015-.003

① End gaps are for cylinder bores without taper. Fit rings in tapered bores with not less than the maximum dimension given.

② See footnotes at bottom of first table referring to service information.

ENGINE BEARING SPECIFICATIONS

Year	Engine Model	Camshaft		Connecting Rod			Mains				
		Journal Diameter	Clearance	Journal Diameter	Clearance	Bearing Bolt Tension Lb. Ft.	Journal Diameter	Clearance	Bearing Bolt Tension Lb. Ft.	Thrust on No.	End-play
1936	2T-2	④	②	2.1865–2.1875	.001–.003	50–55	2.4995–2.5000	.001–.003	90–100	1	.003–.006
	2W-6①	⑥	.002	1.999–2.000	.0005–.0025	65–70	2.624–1.625	.0015–.0035	50–55	7	.004–.006
	2W-7①	⑥	.002	1.999–2.000	.0005–.0025	65–70	2.624–2.625	.0015–.0035	50–55	7	.004–.006
	2W-8①	2.247–2.248	.002	2.249–2.250	.001–.003	95–105	2.874–2.875	.003–.0055	50–55	7	.004–.006
1937	J15	④	②	2.1865–2.1875	.001–.003	50–55	2.4995–2.5000	.001–.003	90–100	1	.003–.006
	J20①	2.053–2.054	.002	1.987–1.988	.0015–.0035	50–55	2.497–2.498	.002–.003	⑤	7	.002–.004
	J25①	2.053–2.054	.002	1.987–1.988	.0015–.0035	50–55	2.497–2.498	.002–.003	⑤	7	.002–.004
	J30①	2.121–2.122	.002	2.247–2.248	.002–.004	50–55	2.622–2.623	.002–.003	⑤	7	.003–.004
1938–40	K5, L5	④	②	2.1865–2.1875	.0005–.002	50–55	2.4995–2.5000	.0005–.0025	90–100	1	.003–.006
	K10	④	②	2.1865–2.1875	.0005–.002	50–55	2.4995–2.5000	.0005–.0025	90–100	1	.003–.006
	K15	④	②	2.1865–2.1875	.0005–.002	50–55	2.4995–2.5000	.0005–.0025	90–100	1	.003–.006
	K20①	2.053–2.054	.002	1.987–1.988	.0015–.0035	50–55	2.497–2.498	.002–.003	⑤	7	.002–.004
	K25①	2.053–2.054	.002	1.987–1.988	.0015–.0035	50–55	2.497–2.498	.002–.003	⑤	7	.002–.004
	K30①	2.121–2.122	.002	2.247–2.248	.002–.004	50–55	2.622–2.623	.002–.003	⑤	7	.003–.004
1941–46	M5, M15	③	.002	1.81175–1.81275	.0005–.002	25–27	2.437–2.4375	.0005–.0025	91	1	.003–.006
	M16	④	.002	2.18675–2.18775	.0005–.002	54	2.4995–2.5000	.0005–.0025	91	1	.003–.006

① See footnotes at bottom of first table referring to service information.

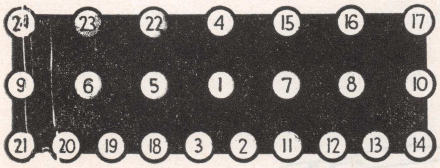
② Front .00075″ to .00225″; others .002″ to .00375″.

③ No. 1, 1.7475″–1.7480″. No. 2, 1.71625″–1.717″. No. 3, 1.68575″–1.6865″. No. 4, 1.62325″–1.624″.

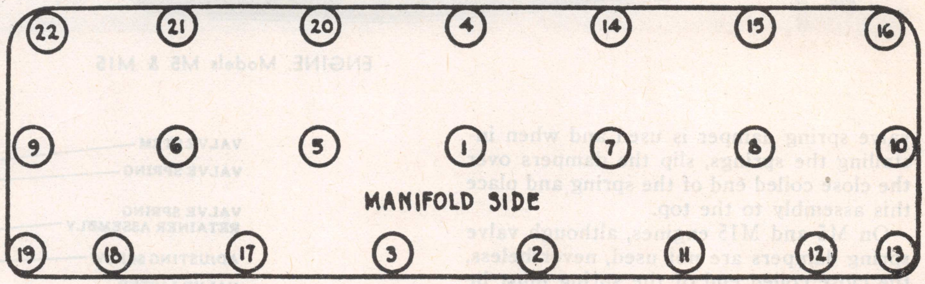
④ No. 1, 1.9975″–1.998″. No. 2, 1.96625″–1.967″. No. 3, 1.93575″–1.9365″. No. 4, 1.2325″–1.124″.

⑤ For center and rear bearings, 55 to 60; front and intermediates 65 to 70.

⑥ No. 1, 2.124″–2.125″; others, 1.999″–2.000″.



HEAD TIGHTENING SEQUENCE. Models 2T-2, J15, K10, K15 & M16.



HEAD TIGHTENING SEQUENCE. Models M5 & M15.

ENGINE

NOTE—For service information on the following Studebaker engine model designations, see the Hercules or Waukesha chapter for the corresponding model designation. However, the specifications for these engines are included in the Studebaker tables.

Studebaker 2W-6...... see Hercules JXB
Studebaker 2W-7.....see Waukesha 6BK
Studebaker 2W-8.... see Waukesha 6-110
Studebaker J20, K20... see Hercules JXB
Studebaker J25, K25... see Hercules JXD
Studebaker J30, K30 see Hercules WXC-3

CYLINDER HEAD TIGHTENING

1936-46: The cylinder head bolts should be tightened gradually and evenly in the order shown. A final tightening should be made on engines with cast iron heads after the engine has been run sufficiently long to bring the parts to normal operating temperature.

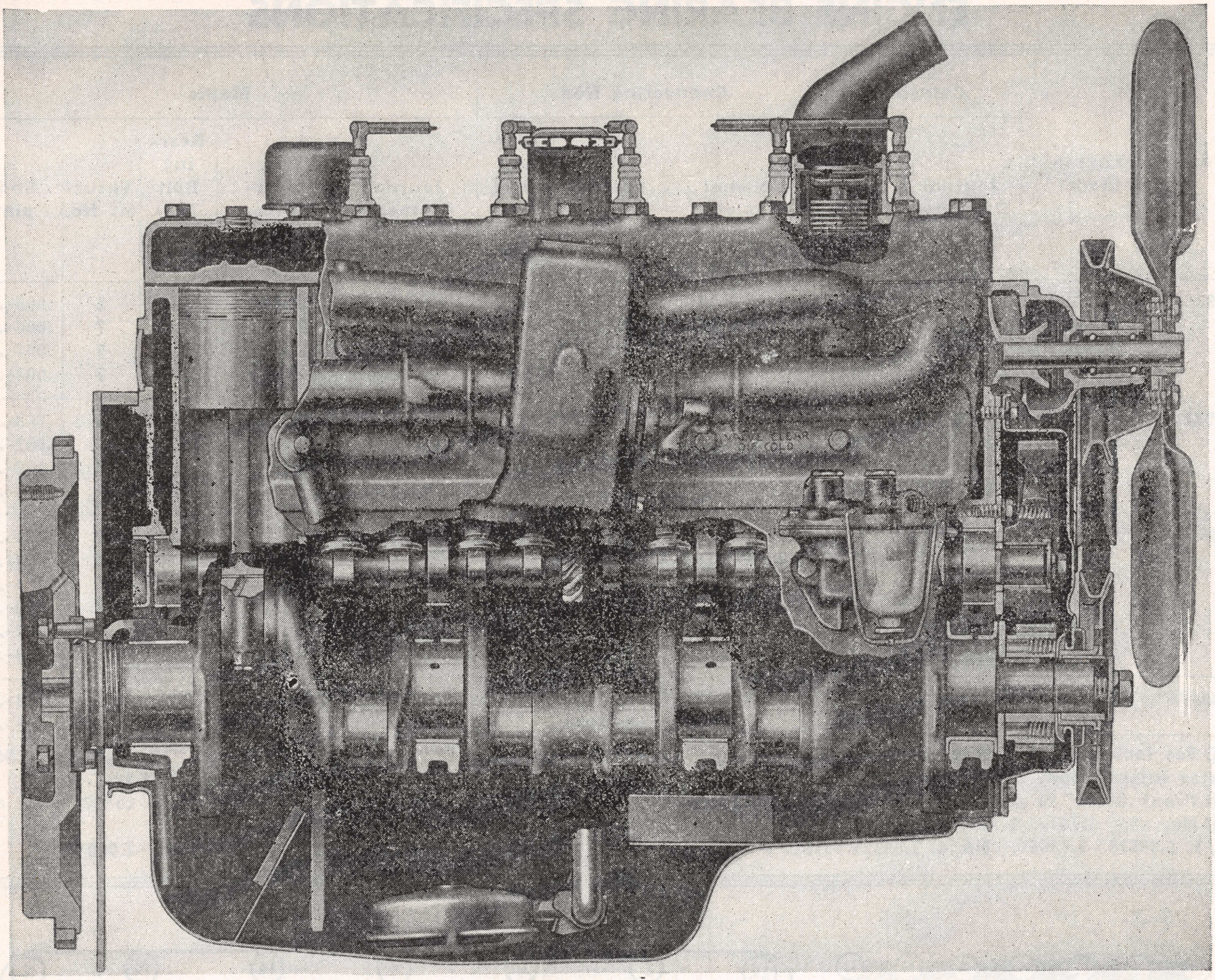
For engines equipped with aluminum cylinder heads, check the tension after the engine has been run and cooled, and while it is still cool.

When using a torque indicating wrench, the final tightening should be 83 pounds feet on all engines except M5 and M15. On these latter engines, the final tightening should be from 50 to 55 pounds feet.

VALVE SPRINGS, R&R

1936-46: When removing the valve springs, the valve-seat locks and the valves must be removed first—before the valve spring seats and valve springs. When installing the valve springs, place the valve spring seat on the bottom of the spring and use a double-jaw-type valve spring compressor to force the spring and spring seat up and over the valve lifter. The valve spring, in its extended position, will not clear the valve lifter and the tappet adjusting screws, so it is necessary to compress the spring slightly and push it over the lifter in a vertical position. Next, install the valves, compress the springs and again install the valve spring seat locks.

On all engines except M5 and M15, a



ENGINE. Models M5 & M15

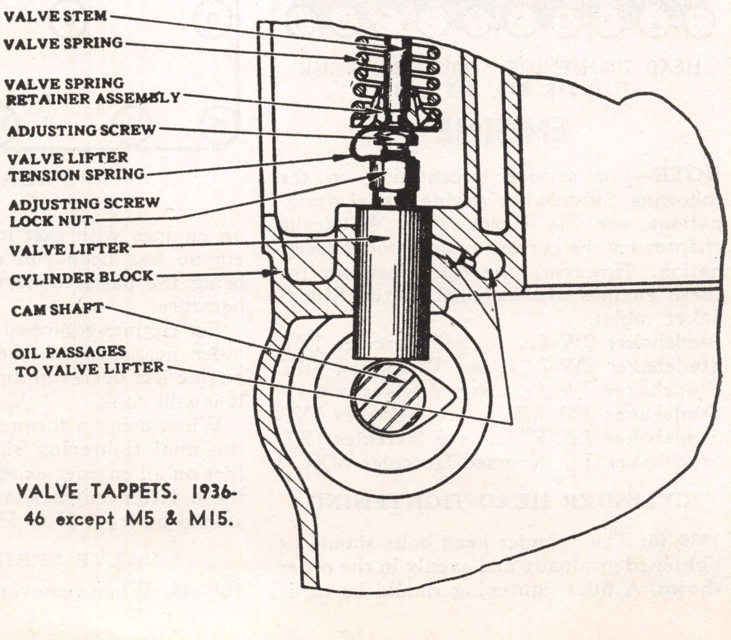
valve spring damper is used and when installing the springs, slip the dampers over the close coiled end of the spring and place this assembly to the top.

On M5 and M15 engines, although valve spring dampers are not used, nevertheless, the close coiled end of the spring must be assembled to the top.

VALVE STEM GUIDES

1936-46: To replace valve stem guides on all engines except M5 and M15, remove the valves and valve springs and lift out the valve tappets. Then use a suitable puller to remove the guides. If a puller is not available, use a drift, preferably one having a pilot which is the same size as the valve stem, to drive out the guide.

On M5 and M15 engines, run the tappet adjusting screw all the way down and crank the engine to bring the tappet on the low point of the cam. After removing the valves and valve springs, drive out the guides with the type drift mentioned above. If the guide comes in contact with the


VALVE STEM
VALVE SPRING
VALVE SPRING RETAINER ASSEMBLY
ADJUSTING SCREW
VALVE LIFTER TENSION SPRING
ADJUSTING SCREW LOCK NUT
VALVE LIFTER
CYLINDER BLOCK
CAM SHAFT
OIL PASSAGES TO VALVE LIFTER

VALVE TAPPETS. 1936-46 except M5 & M15.

tappet before it is all the way out, the lower portion may be broken off.

NOTE—On all engines it is good practice to install one guide at a time. When replacing an intake guide, measure the depth of an intake guide not yet removed in order to determine the correct depth of the guide being installed. Similarly, this procedure should be followed when installing an exhaust valve guide.

When installed, the guides should be reamed to provide a clearance within the limits given in the VALVE SYSTEM table.

VALVE TAPPETS & GUIDES

1936-46: Tappets must be a free fit in their guides without side play. If the fit is too loose, remove the tappet, ream the guide hole and install an oversize tappet, being sure the tappet is provided with a clearance within the limits given in the VALVE SYSTEM table.

NOTE—On all engines except M5 and M15, the tappets can be removed without taking out the camshaft by simply removing the valve springs and tappet adjusting screws and lift out the tappets. On M5 and M15 engines, the camshaft will have to be removed since the tappets are of the mushroom type.

NOTE—On M5 and M15 engines, the construction of the tappet adjusting screw makes a lock nut unnecessary. Whenever a tappet screw is replaced, the effort required to move the screw should be checked. A force of at least 4 pounds should be required to move the screw. This force can be measured by hooking a spring scale on the end of a six-inch wrench. Use another wrench to prevent the tappet from turning, and pull on the end of the scale.

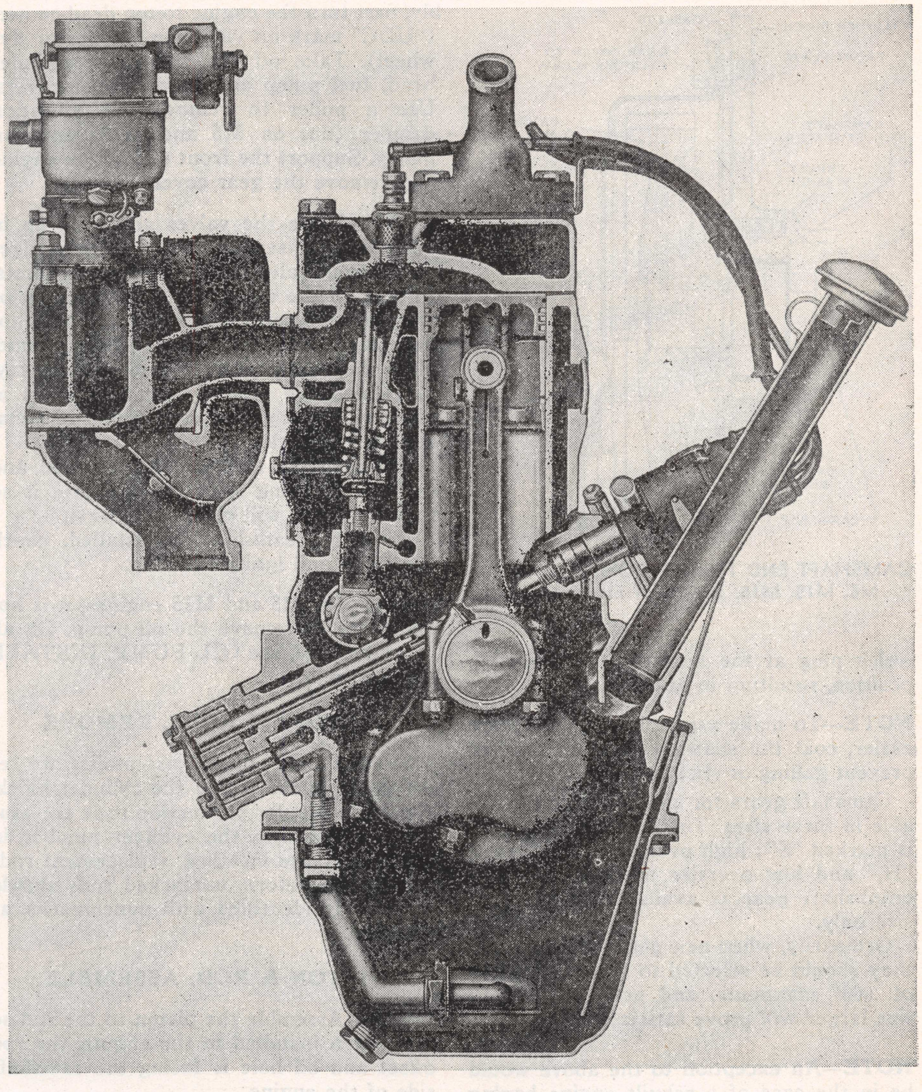
VALVE TIMING

1936-46: With the engine at normal room temperature and No. 1 intake valve tappet set to the clearance for timing as given in the VALVE SYSTEM table, crank the engine until the "IN OP 1-6" mark on the rim of the vibration damper (flywheel on M5 and M15 engines) is in line with the indicator on the timing gear cover (flywheel housing on M5 and M15). In this position, No. 1 intake valve should be just starting to open.

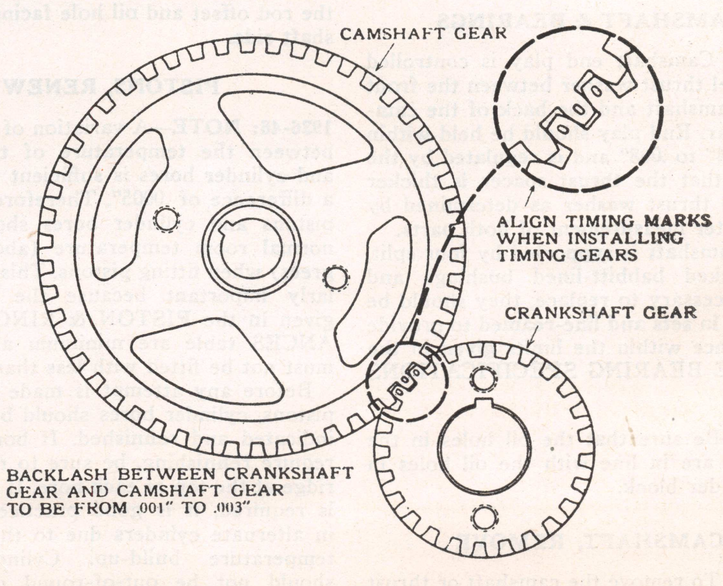
TIMING GEARS

1936-46: Whenever these gears are removed or disturbed for any reason, it is important that they be assembled so that the marked tooth on the camshaft gear is meshed between the two marked teeth of the crankshaft gear, otherwise the valve timing will be incorrect.

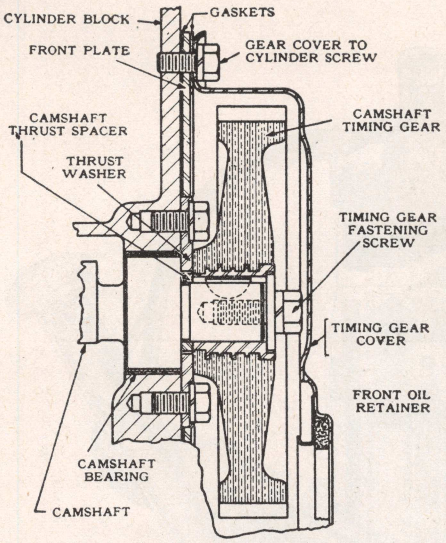
Always use suitable puller and pusher equipment when removing and replacing these gears. This is particularly important in the case of the camshaft gear because, any attempt to drive on this gear with hammer blows will not only cause damage to the gear but will very likely loosen the



ENGINE. Model M16.


CAMSHAFT GEAR
ALIGN TIMING MARKS WHEN INSTALLING TIMING GEARS
CRANKSHAFT GEAR
BACKLASH BETWEEN CRANKSHAFT GEAR AND CAMSHAFT GEAR TO BE FROM .001" TO .003"

TIMING GEAR INSTALLATION. 1936-46 All Models.



CAMSHAFT END THRUST CONTROL. Models M5, M15, M16. Typical of other models.

welsh plug at the rear camshaft bearing position, resulting in an oil leak.

NOTE—To make assembly of these gears easier, coat the shafts with white lead to prevent galling or sticking.

Camshaft gears for all engines are available in three sizes. The standard size gear is marked "S"; high oversize limit marked "H," and low oversize marked "L." The crankshaft gear is available in standard size only.

Ordinarily, when new gears are installed, they should be selected to give a backlash of .003" maximum, and usually the next size larger will prove satisfactory.

NOTE—An exception to the above would be in the case of a rebuilt engine having new camshaft and crankshaft bearings, in which case, use a camshaft gear which is the same size as the one removed.

CAMSHAFT & BEARINGS

1936-46: Camshaft end play is controlled by a steel thrust washer between the front of the camshaft and the back of the camshaft gear. End play should be held within from .004" to .008" and is regulated by the amount that the thrust spacer is thicker than the thrust washer as determined by micrometer measurement of both parts.

The camshaft is supported by four split, steel-backed babbitt-lined bushings and when necessary to replace, they should be installed in sets and line-reamed to provide a clearance within the limits given in the ENGINE BEARING SPECIFICATIONS table.

NOTE—Be sure that the oil holes in the bearings are in line with the oil holes in the cylinder block.

CAMSHAFT, REMOVE

1936-46: To remove the camshaft or thrust plate without removing the engine assembly, first turn the engine to top dead center ("UDC" mark on vibration damper or flywheel). Take off the manifolds, cylinder head, fuel pump and valve tappet covers. Use a puller to remove the vibration damper (not on M5 and M15) and fan pulley. Support the front end of the engine and remove the gear cover.

NOTE—Raise the valves and hold up in position by inserting two wooden wedges under each valve head, at opposite points, to prevent the valve head from cocking or warping. Of course, this operation is not necessary if the valves are to be reground, since they will have to be removed anyway. Lift the valve tappets and hold them in place with spring-type clothes pins or metal supports or jacks.

The camshaft may then be removed, and while it is being withdrawn, rotate it so that the cams will clear all objects.

After the camshaft is installed, check the valve and ignition timing.

NOTE—On M5 and M15 engines, it is not necessary to remove the oil pump. On all other engines, see OIL PUMP, INSTALL for instructions.

PISTONS & RODS, REMOVE

1936-46: Piston and rod assemblies are removed from the top of the cylinder block. Although regular production rods are usually marked with the cylinder number in which they are installed, replacement rods are not, therefore, unmarked rods should be suitably identified with punchmarks, as removed.

PISTON & ROD, ASSEMBLE

1936-37: Assemble the piston to the rod so that when installed in the engine, the rod offset and oil hole is facing the camshaft side of the engine.

Aluminum pistons should be assembled to the rods so that when installed in the cylinder bores, the slotted side of the piston is on the side opposite the camshaft, with the rod offset and oil hole facing the camshaft side.

PISTONS, RENEW

1936-46: NOTE—A variation of 10 degrees between the temperature of the pistons and cylinder bores is sufficient to produce a difference of .0005". Therefore, both the pistons and cylinder bores should be at normal room temperature (about 70 degrees) when fitting pistons. This is particularly important because the clearances given in the PISTON & RING CLEARANCES table are minimum and pistons must not be fitted with less than specified.

Before any attempt is made to fit new pistons, cylinder bores should be carefully indicated and refinished. If bores do not require refinishing, be sure to remove the ridge at the top of each bore. If refinishing is required, it is good practice to do so in alternate cyinders due to the localized temperature build-up. Cylinder bores should not be out-of-round or tapered more than .0005".

Before fitting pistons, wipe the cylinder walls and pistons to remove all chips, dirt or other foreign matter. The feeler ribbon used to check piston fit should be about 12" long and ½" wide. Consult the PISTON & RING CLEARANCES table for the thickness of shim to use, as well as the recommended pounds pull on a spring scale required to withdraw the feeler ribbon past the piston.

Insert the piston in the bore upside down and in its running position (see PISTON & ROD, ASSEMBLE). Place the feeler ribbon between the cylinder wall and the thrust side of the piston (opposite slotted side on aluminum pistons) in a position at right angles to the piston pin hole.

After assembling the piston to the connecting rod, check the assembly for alignment on a suitable jig.

NOTE—All 1942 models after Serials 4686 on M5, 1231 on M15 and 2525 on M16, are provided with cast-iron pistons. Installation of these pistons in the cylinder should be made with the piston pattern number toward the front of the engine after the piston and ring assembly has been submerged in a clean oil bath. The number is located on the piston inside surface below and near one of the two pin bosses. Pistons of later production will be marked with a raised boss inside the piston skirt and level with the piston-pin holes. Install the piston and ring assembly with the boss toward the camshaft side by the engine. Piston-fitting procedure is the same as for aluminum-alloy pistons, except for the difference in spring-scale pull indicated in the PISTON AND RING CLEARANCES table.

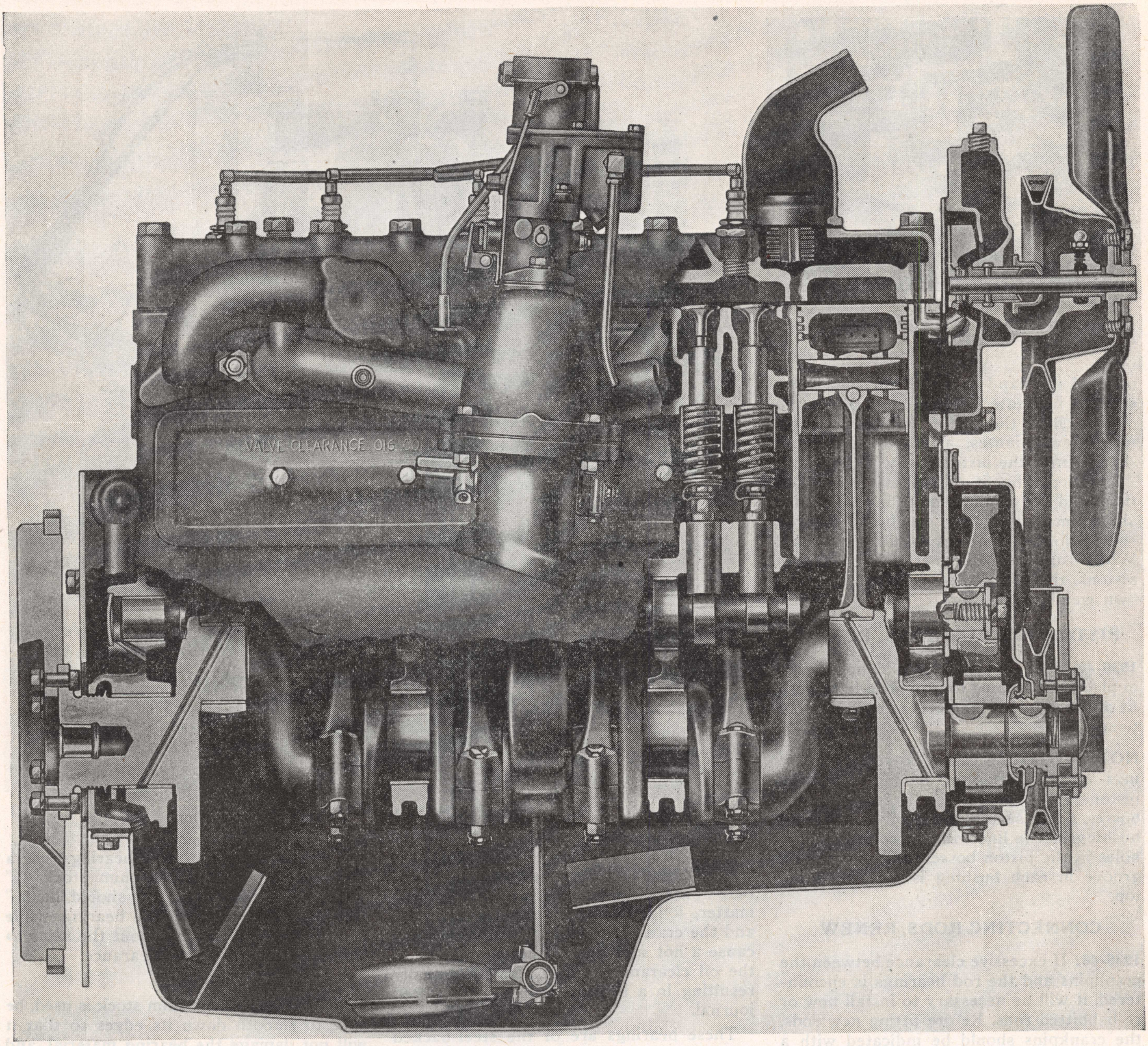
PISTON RINGS, RENEW

1936-46: NOTE—To prevent the possibility of bending or breaking the second ring land—thus ruining the piston—the ridge at the top of the cylinder bore should be cut away before removing the piston and rod assemblies. If the available ridge reamer has no provision to control the depth of the cut, it is good practice to bring the piston far enough up into the cylinder to allow the reamer to rest on top of the piston. This will serve to prevent cutting down into the ring travel area.

CAUTION—Never cut down into the ring travel area more than 1/32"—or more than half the depth of the top ring.

New rings should be fitted with end gaps and groove clearances as given in the PISTON & RING CLEARANCES table. Ring grooves must be clean and free from carbon, and must show no perceptible wear.

NOTE—Ring end gaps given in the PISTON & RING CLEARANCES table are for cylinder bores without taper. Fit rings in tapered bores with not less than the maximum dimension given. When fitting rings, pay particular attention to the installation instructions which are usually in-


VALVE CLEARANCE .016 COLD

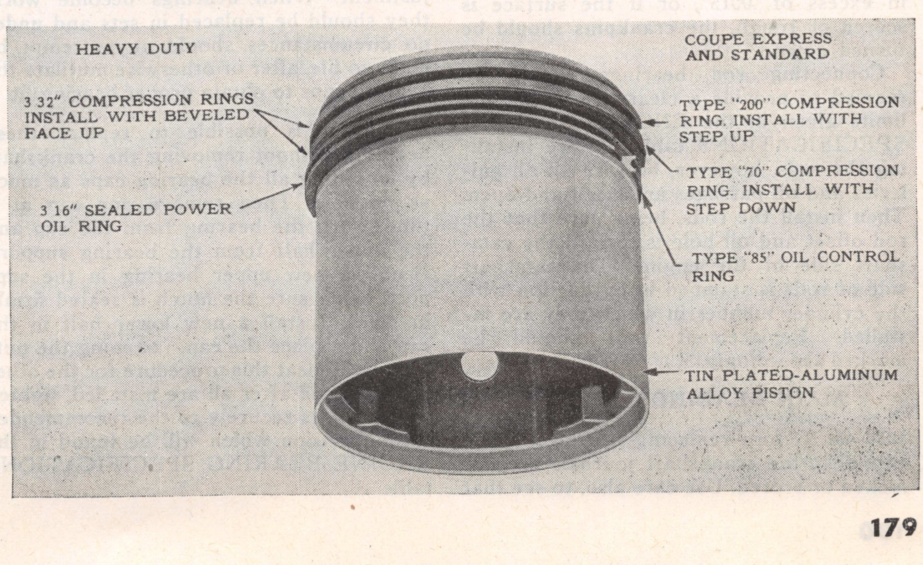
ENGINE. 1938-40.

cluded in the ring package. This applies to clearances, position in grooves, etc.

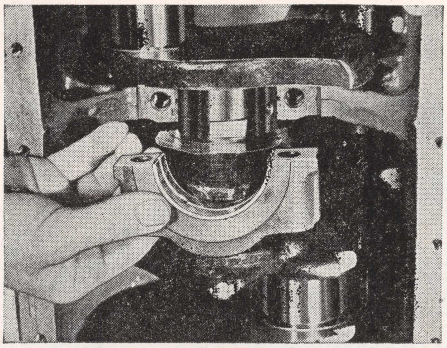
When rings are properly fitted to the pistons, be sure to stagger the ring gaps so they are spaced equal distances around the circumference of the piston. However, see that no gaps are over the piston pins.

PISTON PINS, RENEW

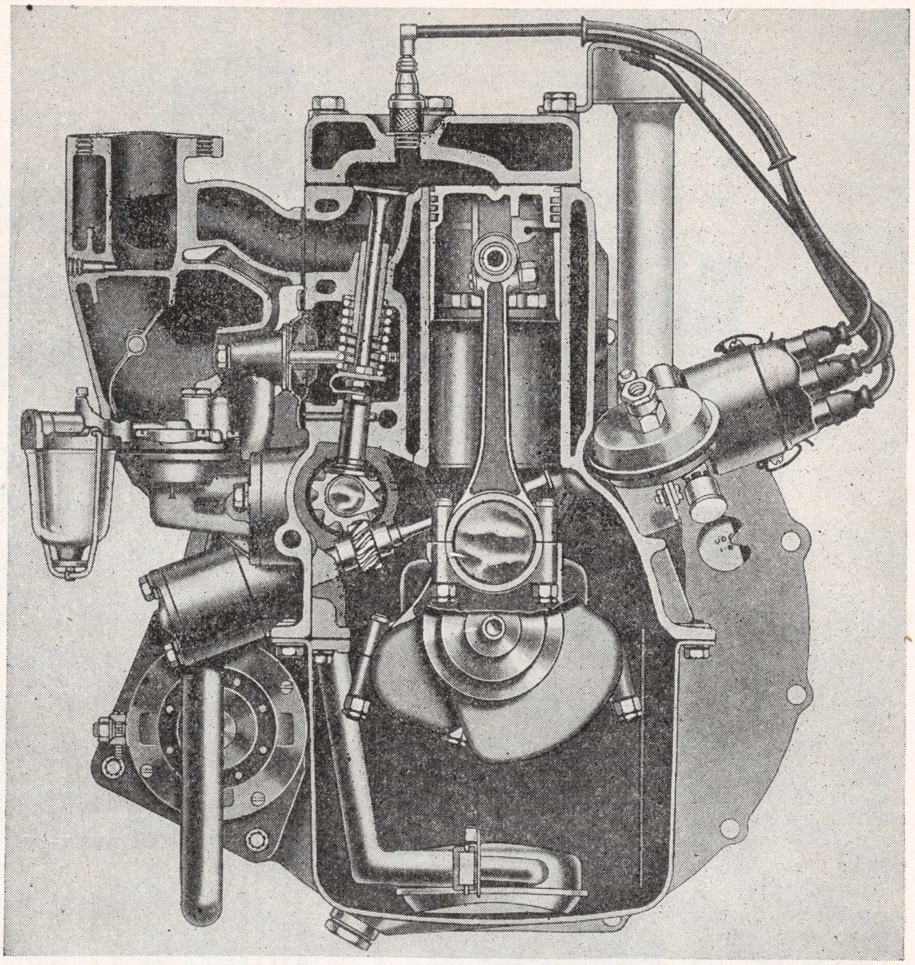
1936-46: The correct fit of piston pins in cast iron pistons should be one which requires a light push fit with the palm of the hand to insert the pin. For aluminum pistons, at normal room temperature, it should require a hard push fit with the


HEAVY DUTY
3 32" COMPRESSION RINGS INSTALL WITH BEVELED FACE UP
3 16" SEALED POWER OIL RING
COUPE EXPRESS AND STANDARD
TYPE "200" COMPRESSION RING. INSTALL WITH STEP UP
TYPE "70" COMPRESSION RING. INSTALL WITH STEP DOWN
TYPE "85" OIL CONTROL RING
TIN PLATED-ALUMINUM ALLOY PISTON

PISTON & RING ASSEMBLY. Models M5. M15 & M16.



Method of checking fit of main bearings. 1936-46.



ENGINE. Models M5 & M15.

palm of the hand to install the pin. However, to facilitate fitting pins in aluminum pistons, heat the piston in boiling water for a few minutes, after which the pin should enter the piston easily.

To check the fit of pins after installation, hold the piston in both hands and, for aluminum pistons, the weight of the rod should not be sufficient to allow it to fall. When using the same method on cast iron pistons, the rod should drop easily by its own weight.

PISTON PIN BUSHINGS, RENEW

1936-46: New bushings should be pressed in place and reamed to provide a light push fit of the pin with the parts at normal room temperature.

NOTE—When necessary to replace bushings on 1942 engines having cast iron pistons, they should be pressed in the bosses, being sure that the oil holes in the bushings are in line with the corresponding holes in the piston bosses, and that the oil groove in each bushing is located at the top.

CONNECTING RODS, RENEW

1936-46: If excessive clearance between the crankpins and the rod bearings is encountered, it will be necessary to install new or re-babbitted rods. Before fitting new rods, the crankpins should be indicated with a micrometer and if out-of-round or tapered in excess of .0015", or if the surface is scored or rough, the crankpins should be turned down.

Connecting rod bearings should be reamed to provide a clearance within the limits given in the ENGINE BEARING SPECIFICATIONS table. Before installing the rods, however, be sure all oil galleries and oil passages are clean and open. Then install the rods, being sure that the rod offset and oil hole is toward the camshaft side of the engine. The camshaft side of rods is stamped in production with the cylinder number in which they are installed. Replacement rods should be marked accordingly.

MAIN BEARINGS, RENEW

1936-46: Before replacing bearings, make sure that the crankshaft journals are not nicked or scored. Use care also, to see that all parts are thoroughly clean. This is particularly important because one small particle of metal, carbon, dirt or other foreign matter, lodged between the bearing face and the crankshaft journal will very likely cause a hot spot due to the elimination of the oil clearance at that point, eventually resulting in a bearing failure or a scored journal.

These bearings are of the steel-backed babbitt design with no provision for adjustment. When bearings become worn, they should be replaced in sets and under no circumstances should any attempt be made to file, alter or otherwise mutilate the bearing caps to obtain proper bearing fit.

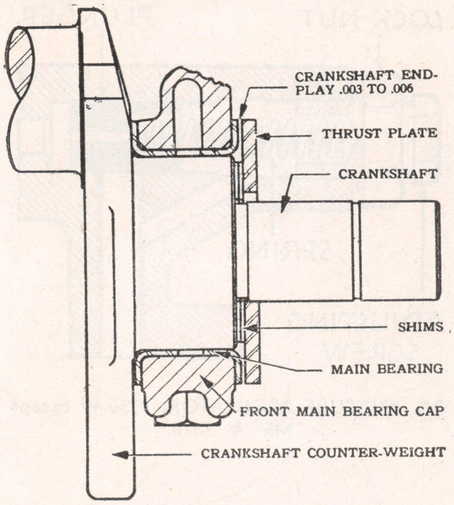
NOTE—It is possible to replace these bearings without removing the crankshaft by loosening all the bearing caps as much as possible. Then remove one cap at a time, work the bearing from the cap and the upper half from the bearing support. Install a new upper bearing in the support, being sure the notch is seated firmly in place. Install a new lower half in the cap and replace the cap, fastening the nuts loosely. Repeat this procedure for the other bearings and after all are installed, tighten the cap nuts securely to the recommended torque tension which will be found in the ENGINE BEARING SPECIFICATIONS table.

To check the fit of new bearings, use a piece of paper or brass shim stock ¼" wide, the length of which should be ¼" less than the length of the bearing, while the thickness should be about the same as the minimum allowable clearance.

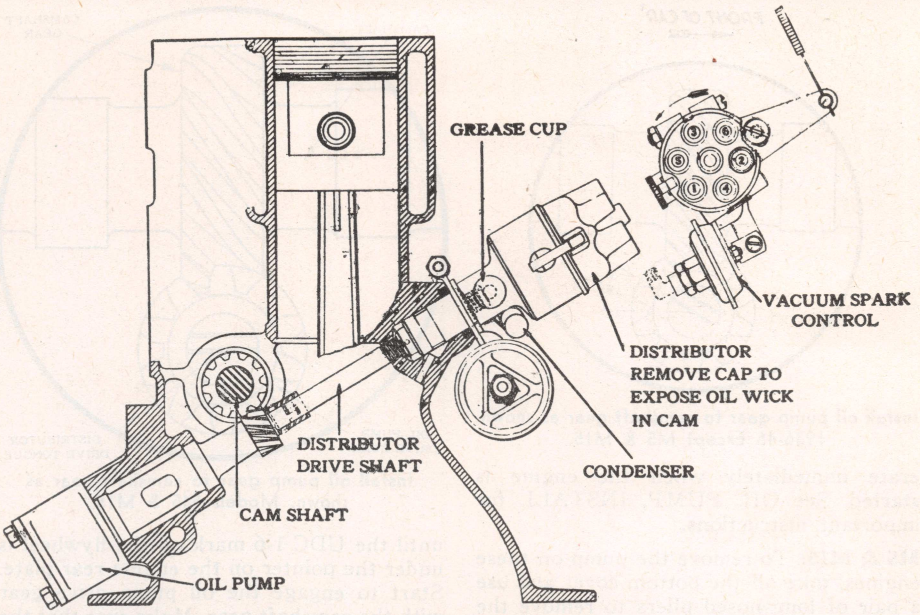
CAUTION—If brass shim stock is used, be sure to smooth down its edges so that it will not damage the bearing material, and before inserting it in place, coat the shim on both sides with a light film of engine oil.

Then lay the checking shim lengthwise in the center of the bearing and install the bearing cap to the crankshaft, tightening the cap bolts to the recommended torque tension. Test the fit of the bearing by rocking the flywheel through an arc of 2"—not more than 1" in either direction. The bearing may be considered fitted properly if the shaft is movable with a fairly heavy drag. If the shaft moves freely with the checking shim in place, the crankshaft should be turned down and undersize bearings fitted.

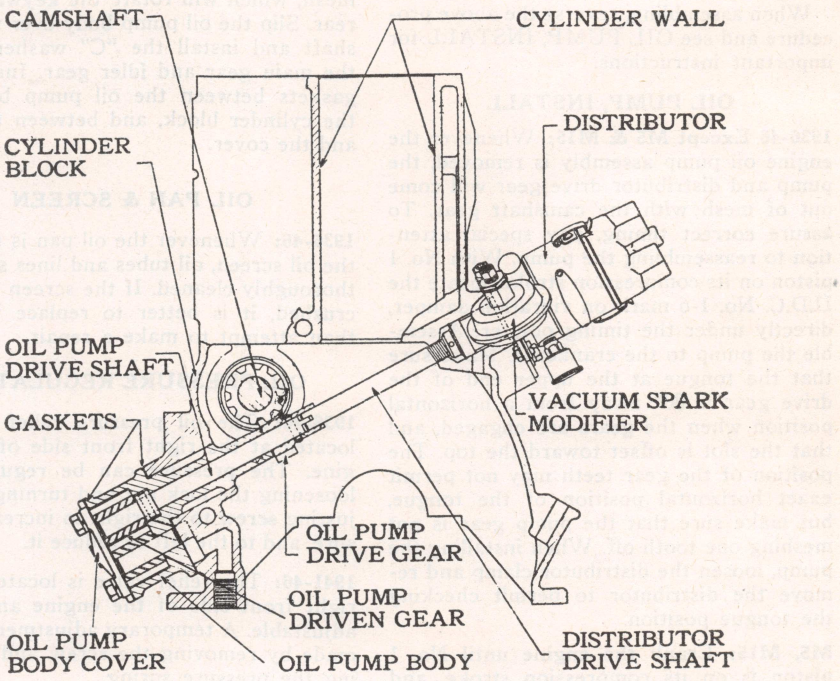
NOTE—Remove the checking shim and replace the cap, but do not tighten the cap bolts as this bearing must be loose in order to check the fit of the other bearings. It is


CRANKSHAFT END-PLAY .003 TO .006
THRUST PLATE
CRANKSHAFT
SHIMS
MAIN BEARING
FRONT MAIN BEARING CAP
CRANKSHAFT COUNTER-WEIGHT

CRANKSHAFT END THRUST CONTROL. 1936-46.


GREASE CUP
5
6
3
2
1
4
VACUUM SPARK CONTROL
DISTRIBUTOR REMOVE CAP TO EXPOSE OIL WICK IN CAM
DISTRIBUTOR DRIVE SHAFT
CONDENSER
CAM SHAFT
OIL PUMP

DISTRIBUTOR & OIL PUMP DRIVE. 1936-46 Except M5 & M15.


CAMSHAFT
CYLINDER WALL
DISTRIBUTOR
CYLINDER BLOCK
OIL PUMP DRIVE SHAFT
GASKETS
VACUUM SPARK MODIFIER
OIL PUMP DRIVE GEAR
OIL PUMP DRIVEN GEAR
OIL PUMP BODY COVER
OIL PUMP BODY
DISTRIBUTOR DRIVE SHAFT

DISTRIBUTOR & OIL PUMP DRIVE. Models M5 & M15.

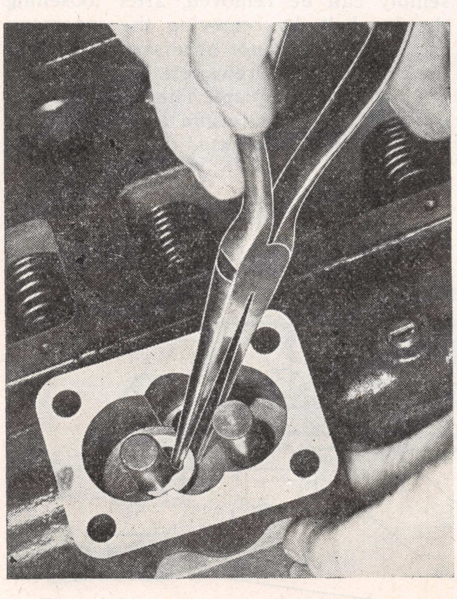
good practice to fit bearings by starting at one of the intermediates, then the rear bearing, front bearing and finally, the other intermediate bearing. Be sure to use new oil seals in the rear bearing cap.

CRANKSHAFT END THRUST

1936-46: End thrust of the crankshaft is controlled by shims at the front main bearing. Through normal wear, the end play will seldom become excessive but whenever new bearings are fitted, the clearance should be carefully checked and, if required, remove or add shims to obtain the desired end play. See the ENGINE BEARING SPECIFICATIONS table for the correct end play limits.

REAR MAIN BEARING OIL SEAL

1936-46: Specially treated wooden plugs are used at the rear main bearing caps to prevent oil leaks. In addition, an oil slinger, integral with the crankshaft, is used to throw off surplus oil which is returned to the oil pan through an oil passage and tube.



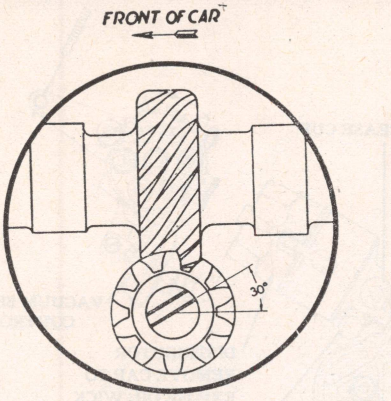
Disassembling oil pump. Models M5 & M15.

ENGINE OILING

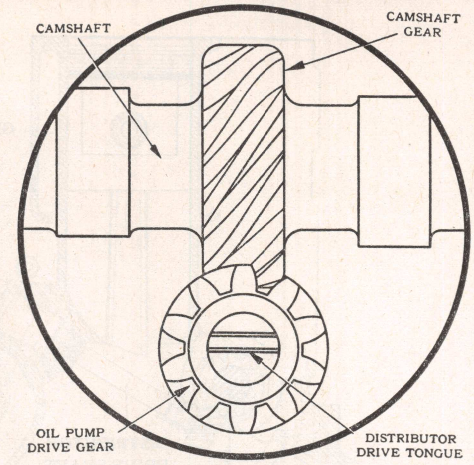
OIL PUMP, OVERHAUL

1936-46 except M5 & M15: To remove the pump, take out the four capscrews which fasten the pump to the crankcase and withdraw the pump from the engine. To disassemble, drive out the pin which holds the upper drive gear to the pump shaft. Then remove the bottom cover and pull out the shaft and gears.

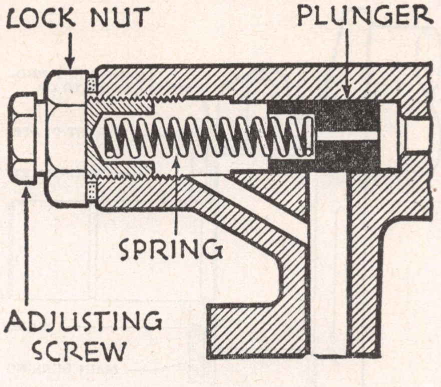
End play in the shaft is controlled by the distance between the shaft drive gear and thrust collar next to the oil pump gear. After installing a new shaft and collar assembly in the pump body, the correct end play can be obtained by inserting a .003" to .005" feeler gauge between the face of the gear and housing, when pressing the drive gear on the shaft. Then, using the hole in the drive gear as a pilot, drill through the shaft and ream the hole to 3/16", after which, insert the pin and peen it securely to the drive shaft gear. Slip the Woodruff key in the shaft and install the gear. Before replacing the bottom cover, prime the pump with oil so that it will op-



Install oil pump gear to camshaft gear as shown. 1936-46 Except M5 & M15.



Install oil pump gear to camshaft gear as shown. Models M5 & M15.



OIL PRESSURE REGULATOR. 1936-40 Except M5 & M15.

erate immediately when the engine is started. See OIL PUMP, INSTALL for important instructions.

M5 & M15: To remove the pump on these engines, take off the bottom cover and use a pair of long-nosed pliers to remove the "C" washer from the pump shaft. Remove the oil pump body and pull out the shaft and gears.

When assembling, reverse the above procedure and see OIL PUMP, INSTALL for important instructions.

OIL PUMP, INSTALL

1936-46 Except M5 & M15: Whenever the engine oil pump assembly is removed, the pump and distributor drive gear will come out of mesh with the camshaft gear. To assure correct timing, pay special attention to reassembling the pump. With No. 1 piston on its compression stroke, locate the U.D.C. No. 1-6 mark on vibration damper, directly under the timing pointer. Assemble the pump to the crankcase. Make sure that the tongue at the upper end of the drive gear is 30° away from a horizontal position when the gears are engaged, and that the slot is offset toward the top. The position of the gear teeth may not permit exact horizontal position of the tongue, but make sure that the pump gear is not meshing one tooth off. When installing the pump, loosen the distributor clamp and remove the distributor to permit checking the tongue position.

M5, M15: Crank the engine until No. 1 piston is on its compression stroke, and until the UDC 1-6 mark on the flywheel is under the pointer on the engine rear plate. Start to engage the oil pump drive gear with the camshaft gear. Make sure that the keyway in the drive shaft is pointing downward. Pull the shaft and gear into mesh, which will rotate the keyway to the rear. Slip the oil pump body over the drive shaft and install the "C" washer. Install the main gear and idler gear. Install new gaskets between the oil pump body and the cylinder block, and between the body and the cover.

OIL PAN & SCREEN

1936-46: Whenever the oil pan is removed, the oil screen, oil tubes and lines should be thoroughly cleaned. If the screen has been crushed, it is better to replace it rather than attempt to make a repair.

OIL PRESSURE REGULATOR

1936-40: The oil pressure relief valve is located at the right front side of the engine. The pressure can be regulated by loosening the lock nut and turning the adjusting screw to the right to increase pressure, and to the left to reduce it.

1941-46: The relief valve is located at the right front side of the engine and is not adjustable. A temporary adjustment can be made by removing the screw and stretching the pressure spring.

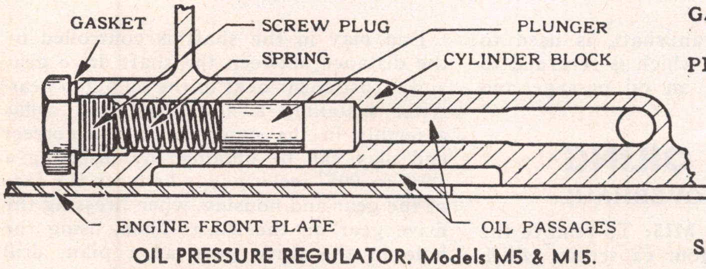
COOLING SYSTEM

WATER PUMP, OVERHAUL

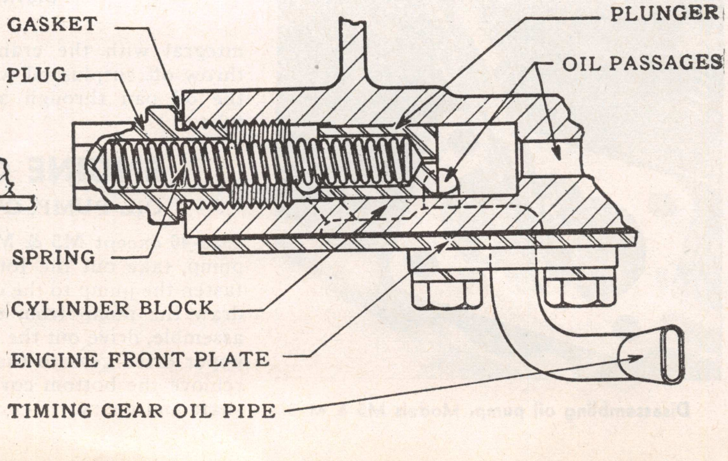
2T-2, J15, K15: The water pump is of the "glandless" type and requires no packing. The annular ball bearings require no adjustment. The pump is pre-packed with lubricant and, under normal operating conditions, should not require additional lubricant.

To disassemble the pump, remove the assembly from the engine and take off the fan blades. Use a suitable puller to remove the impeller. Remove the seal retaining cup, carbon seal, seal clamp ring, flexible seal and spring. After releasing the retaining snap wire, the pump shaft and bearing assembly can readily be pulled out from the front end of the housing. Turn back the lockwasher, unscrew the bearing lock nut and remove the rear bearing, bearing spacer and front bearing. Reverse the order of the above procedure to assemble the pump.

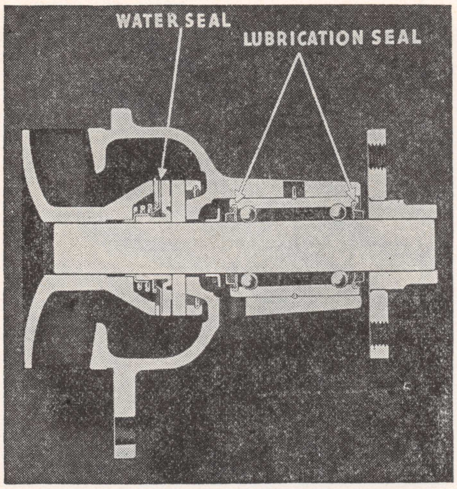
K5, K10, L5: The water pump and fan assembly can be removed, after loosening the fan belt, by removing the capscrews retaining it. It is not necessary to remove the countersunk screws retaining the pump body to the rear plate. The front bushing is fitted for pressure-gun lubrication; the rear bushing is lubricated through a grease cup.



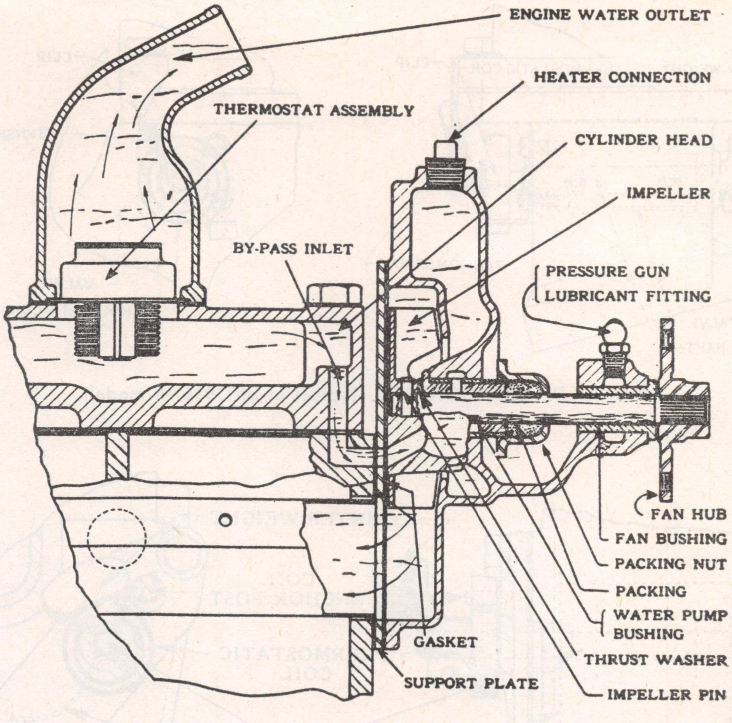
OIL PRESSURE REGULATOR. Models M5 & M15.



OIL PRESSURE REGULATOR. Model M16.


WATER SEAL
LUBRICATION SEAL

WATER PUMP. Models M5 & M15.


ENGINE WATER OUTLET
HEATER CONNECTION
THERMOSTAT ASSEMBLY
CYLINDER HEAD
IMPELLER
BY-PASS INLET
PRESSURE GUN LUBRICANT FITTING
FAN HUB
FAN BUSHING
PACKING NUT
PACKING
WATER PUMP BUSHING
GASKET
THRUST WASHER
SUPPORT PLATE
IMPELLER PIN

WATER PUMP. Models J15, K5, L5 & K10.

To disassemble the water pump, the unit first should be removed from the engine. The fan blades and fan pulley are attached to a hub which is pressed on the serrated portion of the front end of the pump shaft and can be removed by loosening the four retaining cap screws.

To remove the pump shaft it is necessary to take off the rear support plate and the fan pulley hub. The pump shaft and impeller assembly can then be withdrawn from the rear.

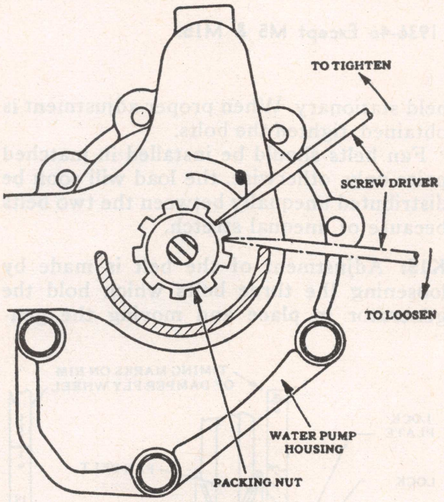
NOTE—The fan pulley hub is tightly pressed in place on a serrated portion of the shaft. If the hub is removed, it should be replaced with a new hub to insure a tight fit on the serrations.

After the shaft is removed, the front bushing can be pressed out toward the front. By removing the water pump bushing packing nut, the rear bushing can be pressed out toward the rear. "Graphometal" pump packing is used in the packing nut. To assemble the pump, reverse the preceding operations, making sure that the impeller thrust washer is installed between the impeller and the bushing.

The factory specification for the water pump shaft end play is from .003" to .005" when the water pump is completely assembled. The water pump bushings do not require reaming after being pressed into the pump body. The specified clearance between the bushing and the pump shaft is from .001" to .003".

If a water leak occurs around the pump shaft, tightening the packing nut will usually eliminate the leak. Care must be taken not to draw the nut so tightly that it will score the shaft.

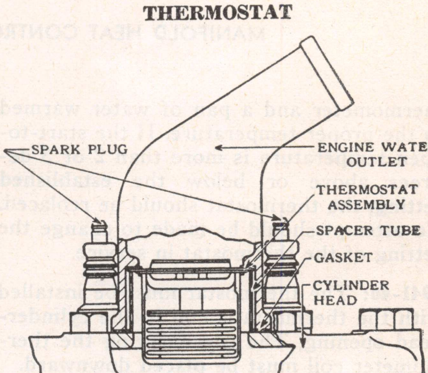
If the leak cannot be stopped by tightening the nut, the packing must be replaced. It is unnecessary to disassemble the pump to replace the packing. The packing nut should be backed away from the bushing and the old packing removed with a pen knife or sharp punch. Insert one ring of packing and draw the nut up tightly on the pump bushing. Back off and insert another ring of packing and again draw the nut up on the bushing. Repeat this procedure until four packing rings have been installed.


TO TIGHTEN
SCREW DRIVER
TO LOOSEN
WATER PUMP HOUSING
PACKING NUT

Water pump packing adjustment. Models J15, K5, L5 & K10.

M5, M15, M16: Since these water pumps have pre-lubricated shaft ball bearings and non-adjustable pump packings, under ordinary driving conditions, further lubrication is not required for the life of the pump.

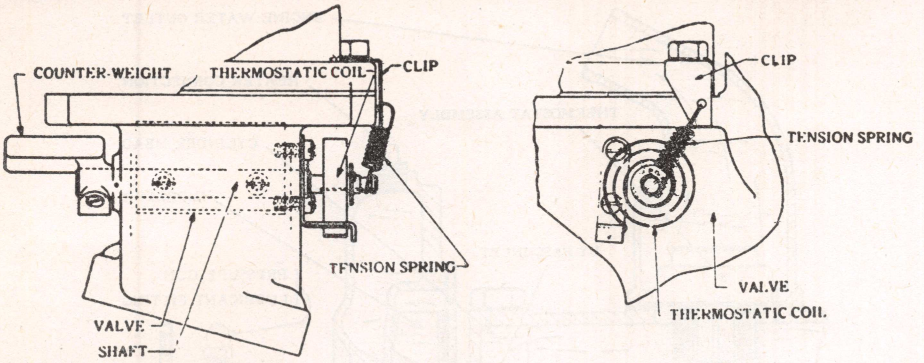
If the thrust seal surface becomes rough, it should be refaced with a water pump facing tool. If any part of the impeller assembly requires replacement, the entire assembly must be replaced. If the fan hub is **removed, it should be replaced with a new one to insure a tight fit on the shaft. Press on the fan hub until it is flush with the end of the shaft. In pressing the impeller onto the shaft, allow 1/32" clearance between the impeller and the housing.**


THERMOSTAT
SPARK PLUG
ENGINE WATER OUTLET
THERMOSTAT ASSEMBLY
SPACER TUBE
GASKET
CYLINDER HEAD

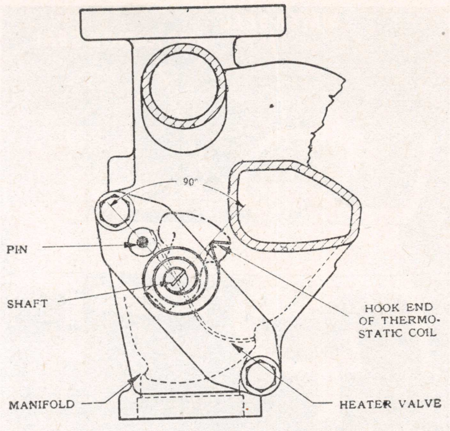
Engine water thermostat. Models M5, M15 & M16.

ENGINE WATER THERMOSTAT

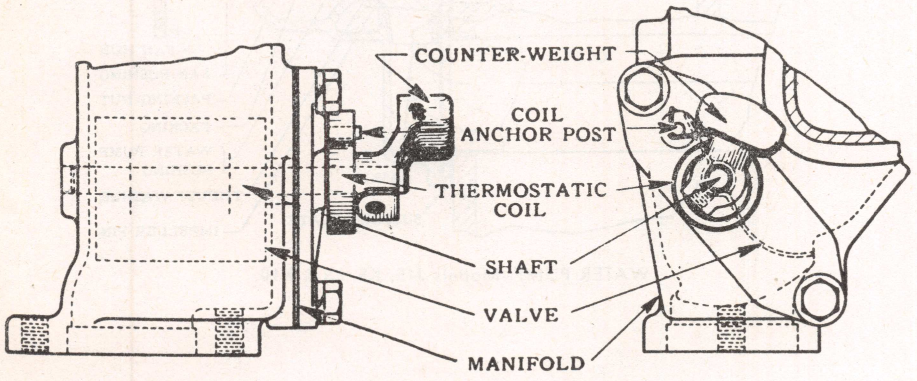
1936-40: When installing a thermostat, the end carrying the thermostatic metal coil must be mounted downward in the engine water outlet, otherwise, it will be inoperative. To check the operation of the thermostat, remove the assembly from the engine water outlet. The thermostat valve is set to start to open at 145 to 150 degrees F. This can be checked with an accurate


COUNTER-WEIGHT
THERMOSTATIC COIL
CLIP
TENSION SPRING
VALVE
SHAFT
CLIP
TENSION SPRING
VALVE
THERMOSTATIC COIL

MANIFOLD HEAT CONTROL. Typical of all 1936-46 models.


90°
PIN
SHAFT
HOOK END OF THERMOSTATIC COIL
MANIFOLD
HEATER VALVE

MANIFOLD HEAT CONTROL. Models M5 & M15.


COUNTER-WEIGHT
COIL ANCHOR POST
THERMOSTATIC COIL
SHAFT
VALVE
MANIFOLD

MANIFOLD HEAT CONTROL. 1936-46 Except M5 & M15.

thermometer and a pan of water warmed to the proper temperature. If the start-to-open temperature is more than 2 or 3 degrees above or below the established setting, the thermostat should be replaced. No attempt should be made to change the setting of the thermostat in service.

1941-46: The thermostat must be installed with the thermostatic coil in the cylinder-head opening. The end carrying the thermometer coil must be placed downward.

When the thermostat is not functioning properly, replace the assembly. The valve is set to start opening at 151 to 155 degrees F. This can be checked with an accurate thermometer and a pan of water warmed to a corresponding temperature. If it starts to open at a temperature of more than 2 degrees above or below the established setting, the thermostat should be replaced. Never attempt to change the valve setting. Checking the temperature at the fully open point is not necessary.

FAN BELT, ADJUST

2T-2, J-15, K5, K10, L5: To adjust the dual V-belts that drive the generator, water pump and fan, first loosen the bolts which pass through the slotted bracket at the front of the generator; also the two bolts in the bottom of the generator which serve as hinges. Proper adjustment of the belts is obtained by pulling the generator away from the engine to a point where it is just possible to rotate the fan with the belts held stationary. When proper adjustment is obtained, tighten the bolts.

Fan belts should be installed in matched pairs only, otherwise, the load will soon be distributed unequally between the two belts because of unequal stretch.

K15: Adjustment of the belt is made by loosening the three bolts which hold the generator in place and moving the generator away from the engine. The adjustment has been obtained when it is just possible to rotate the fan with the belt held stationary.

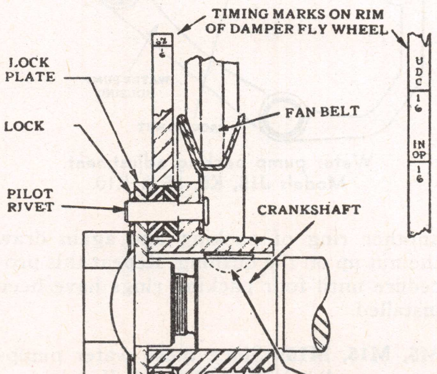
M5, M15, M16: The fan belt should be adjusted to provide from ⅜" to ½" slack movement of the belt. Adjustment is made by loosening the lock nut and the generator bracket screws.

FUEL SYSTEM

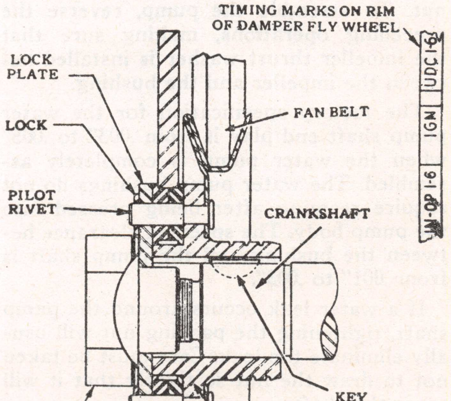
NOTE—For service information on Carburetors, Automatic Chokes, Governors, Fuel Pumps, Air Cleaners and Gasoline Gauges, see Table of Contents on page 1.

MANIFOLD HEAT CONTROL

1936-46: The correct amount of heat for the gasoline-air mixture entering the cyl


TIMING MARKS ON RIM OF DAMPER FLY WHEEL
UDC 1-6
IN OP 1-6
LOCK PLATE
LOCK
FAN BELT
PILOT RIVET
CRANKSHAFT
KEY
DAMPER NUT
PULLEY HUB
RUBBER SPACERS
CRANKSHAFT FAN DRIVE PULLEY
FLYWHEEL

TIMING MARKS. Models 2T-2 & J15.


TIMING MARKS ON RIM OF DAMPER FLY WHEEL
UDC 1-6
IGN
IN-OP 1-6
LOCK PLATE
FAN BELT
LOCK
PILOT RIVET
CRANKSHAFT
KEY
DAMPER NUT
PULLEY HUB
RUBBER SPACERS
CRANKSHAFT FAN DRIVE PULLEY
FLYWHEEL

TIMING MARKS. Models K10 & K15.

inders is provided by a thermostatically controlled inlet manifold heat control valve. To test the thermostatic coil tension, unhook the coil from the pin. With the thermostat valve in a closed position (counterweight up), the hook in the end of the coil should assume approximately a 90-degree angle with the coil temperature at 70 degrees F. Install a new coil if the angle is incorrect.

A sticking heater valve affects engine performance adversely. Loosen the shaft with a mixture of kerosene and soda. Then remove the shaft and reduce the diameter to give .005" clearance. Do not disturb the shaft bore in the manifold because a protective scale has been deposited, and it will merely form again if the scale is removed.

ELECTRIC SYSTEM

NOTE—For service information on Distributors, Magnetos, Generators, Generator Controls, Starting Motors and Starting Switches, see the Table of Contents on page 1.

IGNITION TIMING

1936-46: With the breaker gap set to the clearance given in the TUNE UP CHART, crank the engine to bring No. 1 piston up on its compression stroke and stop when the "IGN" mark on the vibration damper (flywheel on M5 and M15) is in line with the indicator.

Locate No. 1 spark plug wire on the distributor cap, place the cap in position on the distributor and mark the housing opposite No. 1 terminal so that its relative position will be known when the cap is removed.

With the octane selector set midway between advance and retard, loosen the distributor body clamp and rotate the distributor until the points close. Then rotate the distributor in the opposite direction until the points just begin to open. Tighten the clamp bolt.

NOTE—For best results, use a Neon timing light or a conventional test lamp to check the timing. Advance or retard the octane selector to compensate for the grade of fuel being used. For best performance and fuel economy, this setting should be one which will provide smooth engine performance with a slight "ping" on wide-open throttle at comparatively low vehicle speed.

Year	Engine Model	Number Cylinders and Valve Arrangement	Bore and Stroke	Displacement, Cubic Inches	Compression Ratio	Taxable H. P.	Brake H. P. at R. P. M.	Maximum Torque at R. P. M. Pounds Feet	Oil Capacity Quarts ①
1936-39	6BA	6-L	3⅜x4¼	228	5.70	27.34	64@2800	145@1300	7
1936-46	6BK	6-L	3¾x4¼	282	5.70	33.75	82@2800	189@1100	8
1936-46	6BL	6-L	3½x4¼	245	5.70	29.40	72@2800	165@1300	8
1936-46	6BM	6-L	3⅝x4¼	263	5.70	31.54	76@2800	178@1100	8
1937-46	6BZ	6-L	4x4¼	320	5.75	38.40	86@2800	210@1000	8
1941-46	6BZR	6-L	4x4¼	320	5.75	38.40	106@2800	---------	8
1936-46	FC	4-L	3¼x4	133	5.58	16.90	35@2600	92@1200	4
1936-40	FL	4-L	3x4	113	5.58	14.40	30@2600	70@1400	4
1936-46	FCL	4-L	3x4	113	5.58	14.40	30@2600	70@1400	4
1936-46	FCS	4-L	2¾x4	95	4.85	12.10	25@2600	67@1100	4
1936-40	FS	4-L	2¾x4	95	4.85	12.10	25@2600	67@1100	4
1937-46	6GAK	6-I	5½x5½	784	4.80	72.60	155@2000	545@900	18
1936-41	6GAL	6-I	5x5½	648	5.00	60.00	136@2000	462@750	18
1936-37	6MK	6-L	4⅛x4¾	381	6.10	40.84	82@2500	252@1000	8
1938-46	6MKR	6-L	4⅛x4¾	381	5.34	40.84	98@2500	270@800	8
1937-38	6ML	6-L	4x4¾	358	6.20	38.40	78@2500	234@900	8
1937-38	6MS	6-L	3¾x4¾	315	6.20	33.75	72@2500	212@800	8
1936-39	6MZ	6-L	4¼x4¾	404	5.70	43.35	88@2400	263@900	8
1938-46	6MZR	6-L	4¼x4¾	404	5.38	43.35	106@2500	286@800	8
1936-37	6RB	6-L	5x5¾	677	4.75	60.00	125@1900	441@600	14
1938-41	6RBR	6-L	5x5¾	677	5.35	60.00	145@2000	492@800	14
1936-37	6SRK	6-L	4⅝x5⅛	517	4.50	51.34	110@2250	330@800	10
1938-46	6SRKR	6-L	4⅝x5⅛	517	5.50	51.34	125@2250	369@600	10
1936-37	6SRL	6-L	4⅜x5⅛	462	4.60	45.94	101@2250	302@700	10
1938-46	6SRLR	6-L	4⅜x5⅛	462	5.50	45.94	111@2250	330@600	10
1937-39	6SRS	6-L	4⅛x5⅛	411	4.60	40.84	86@2000	---------	10
1939-46	6WAK	6-I	6¼x6½	1197	5.20	93.60	235@1800	865@900	32
1939-46	6WAL	6-I	5¾x6½	1013	5.00	79.35	200@1800	735@800	32
1936-46	XAH	4-L	3⅝x4½	186	4.60	21.02	42@2200	121@900	4
1936-39	XAK	4-L	3¾x4¾	210	4.60	22.50	40@2000	---------	4
1936-39	6-110	6-F	4x4¾	358	5.10	38.40	106@2500	254@1300	8
1936-39	6-125	6-F	4⅜x5⅛	462	5.00	45.94	123@2300	330@1000	10

① Capacity is for oil pan only. When equipped with oil filters, oil coolers or other accessories requiring oil, add the capacity of these accessories.

NOTE—For Tune Up Chart on these engines, see page 914.

VALVE SYSTEM

Year	Engine Model	Stem Clearance		Tappet Guide Clearance ①	Tappet Clearance				Valve Spring Pressure Test		Valve Seat Angle, Degrees
					Running, Cold		Timing				
		Intake ①	Exhaust ①		Intake	Exhaust	Intake	Exhaust	Free Length, Inches	Pounds at Inches, Length ③	
1936-39	6-BA	.002-.003	.003-.004	.001-.003	.010-.012	.014-.016	.004	.008	2 21/32	82@1¾	45
1936-46	6-BK	.002-.003	.003-.004	.001-.003	.010-.012	.014-.016	.004	.008	2 21/32	82@1¾	45
1936-46	6-BL	.002-.003	.003-.004	.001-.003	.010-.012	.014-.016	.004	.008	2 21/32	82@1¾	45
1936-46	6-BM	.002-.003	.003-.004	.001-.003	.010-.012	.014-.016	.004	.008	2 21/32	82@1¾	45
1937-46	6-BZ	.002-.003	.003-.004	.001-.003	.010-.012	.014-.016	.004	.008	2 21/32	82@1¾	45

Continued on next page

NOTE—For Waukesha engines developed since 1942, see page 915.

Continued from previous page

VALVE SYSTEM

Year	Engine Model	Stem Clearance		Tappet Guide Clearance ①	Tappet Clearance				Valve Spring Pressure Test		Valve Seat Angle, Degrees
		Intake ①	Exhaust ①		Running, Cold		Timing		Free Length, Inches	Pounds at Inches, Length ③	
					In-take	Ex-haust	In-take	Ex-haust			
1941-46	6-BZR	.002-.003	.003-.004	.001-.003	.010-.012	.014-.016	.004	.008	2 21/32	82@1¾	45
1936-46	FC	.002-.003	.003-.004	.001-.003	.005-.007	.009-.011	.005	.006	2¼	66@1⅝	45
1936-40	FL	.002-.003	.003-.004	.001-.003	.005-.007	.009-.011	.005	.006	2¼	66@1⅝	45
1936-46	FCL	.002-.003	.003-.004	.001-.003	.005-.007	.009-.011	.005	.006	2¼	66@1⅝	45
1936-46	FCS	.002-.003	.003-.004	.001-.003	.005-.007	.009-.011	.005	.006	2¼	66@1⅝	45
1936-40	FS	.002-.003	.003-.004	.001-.003	.005-.007	.009-.011	.005	.006	2¼	66@1⅝	45
1937-46	6-GAK	.002-.003	.003-.004	.001-.003	.015-.017	.024-.026	.011	.014	I 2 19/32 O 2 27/32	I 79@1 25/32 O 140@2 1/16	45
1936-41	6-GAL	.002-.003	.003-.004	.001-.003	.015-.017	.024-.026	.011	.014	I 2 19/32 O 2 27/32	I 79@1 25/32 O 140@2 1/16	45
1936-37	6-MK	.002-.003	.003-.004	.001-.003	.008-.010	.016-.018	.004	.008	2 29/32	64@2 1/16	45
1938-42	6-MKR	.002-.003	.003-.004	.001-.003	.008-.010	.016-.018	.004	.008	2 29/32	64@2 1/16	45
1937-38	6-ML	.002-.003	.003-.004	.001-.003	.008-.010	.016-.018	.004	.008	2 29/32	64@2 1/16	45
1937-38	6-MS	.002-.003	.003-.004	.001-.003	.008-.010	.016-.018	.004	.008	2 29/32	64@2 1/16	45
1936-39	6-MZ	.002-.003	.003-.004	.001-.003	.008-.010	.016-.018	.004	.008	2 29/32	64@2 1/16	45
1938-46	6-MZR	.002-.003	.003-.004	.001-.003	.008-.010	.016-.018	.004	.008	2 29/32	64@2 1/16	45
1936-37	6-RB	.002-.003	.003-.004	.001-.003	.006-.008	.010-.012	.008	.008	4⅝	140@3¼	45
1938-41	6-RBR	.002-.003	.003-.004	.001-.003	.006-.008	.010-.012	.008	.008	4⅝	140@3¼	45
1936-37	6-SRK	.002-.003	.003-.004	.001-.003	.008-.010	.018-.020	.004	.008	3 9/16	87@2 17/32	30
1938-46	6-SRKR	.002-.003	.003-.004	.001-.003	.008-.010	.018-.020	.004	.008	3 9/16	87@2 17/32	30
1936-37	6-SRL	.002-.003	.003-.004	.001-.003	.008-.010	.018-.020	.004	.008	3 9/16	87@2 17/32	30
1938-46	6-SRLR	.002-.003	.003-.004	.001-.003	.008-.010	.018-.020	.004	.008	3 9/16	87@2 17/32	30
1937-39	6-SRS	.002-.003	.003-.004	.001-.003	.008-.010	.018-.020	.004	.008	3 9/16	87@2 17/32	30
1939-46	6-WAK	.002-.003	.003-.004	.001-.003	.013-.015	.022-.024	.012	.016	I 3 17/32 O 3⅞	I 125@2½ O 140@2 13/16	IN 30 EX 45
1939-46	6-WAL	.002-.003	.003-.004	.001-.003	.013-.015	.022-.024	.012	.016	I 3 17/32 O 3⅞	I 125@2½ O 140@2 13/16	IN 30 EX 45
1936-46	XAH	.002-.003	.003-.004	.001-.003	.009-.011	.009-.011	.010	.010	3	68@1⅝	45
1936-39	XAK	.002-.003	.003-.004	.001-.003	.004	.006-.008	.004	.006	3	68@1⅝	45
1936-39	6-110	.002-.003	.003-.004	.001-.003	.012	.016	.010	.014	I 2 19/32 O 72135	②	45
1936-39	6-125	.002-.003	.003-.004	.001-.003	.012	.016	.010	.014	I 2 19/32 O 72135	②	45

① Average safe clearances.

② Intake, outer 65@2½"; inner, 32@2 7/32". Exhaust, 90@1 47/64".

③ Average pressure.

NOTE—For Waukesha engines developed since 1942, see page 915.

PISTON AND RING CLEARANCES

Year	Engine Model	Piston Skirt, Inches		Fitting Pistons with Shim and Spring Scale		Ring End Gap, Inch ①		Ring and Groove, Inch	
		Top	Bottom	Shim Thickness ②	Pounds Pull on Scale ③	Compression	Oil	Compression ⑨	Oil ⑩
1936–39	6BA	.0035	.0035	.0035	.004	.007–.015	.007–.015	.0015–.003	.001–.0025
1936–46	6BK	.004⑥ .0045⑦	.004⑥ .0025⑦	.004⑥ .0025⑦	.0045⑥ .003⑦	.007–.015	.007–.015	.0015–.003	.001–.0025
1936–46	6BL	.0045⑧	.0045⑥ .0035⑦	.0045⑥ .0035⑦	.005⑥ .004⑦	.007–.015	.007–.015	.0015–.003	.001–.0025
1936–46	6BM	.004⑥ .002⑦	.004⑥ .002⑦	.004⑥ .002⑦	.0045⑥ .0025⑦	.007–.015	.007–.015	.0015–.003	.001–.0025
1937–46	6BZ	.005⑦	.003⑥ .0035⑦	.003⑥ .0035⑦	.0035⑥ .004⑦	.007–.015	.007–.015	.0015–.003	.001–.0025
1941–46	6BZR	.005⑦	.0035⑦	.0035⑦	.004⑦	.007–.015	.007–.015	.0015–.003	.001–.0025
1936–46	FC	.004	.004	.004	.0045	.007–.017	.007–.017	.0015–.003	.001–.0025
1936–40	FL	.0035	.0035	.0035	.004	.007–.017	.007–.017	.0015–.003	.001–.0025
1936–46	FCL	.0035	.0035	.0035	.004	.007–.017	.007–.017	.0015–.003	.001–.0025
1936–46	FCS	.003	.003	.003	.0035	.007–.017	.007–.017	.0015–.003	.001–.0025
1936–40	FS	.003	.003	.003	.0035	.007–.017	.007–.017	.0015–.003	.001–.0025
1937–46	6GAK	.0075④ .010⑦	.0075④ .0055⑤ .006⑦	.0075④ .0055⑤ .006⑦	.008④ .006⑤ .0065⑦	.020–.030	.020–.030	.0015–.003	.001–.003
1936–41	6GAL	.006④	.006④	.006④	.0065④	.013–.023	.013–.023	.0015–.003	.001–.0025
1936–37	6MK	.005⑧	.005⑥ .0035⑦	.005⑥ .0035⑦	.0055⑥ .004⑦	.010–.020	.010–.020	.0015–.003	.001–.0025
1938–46	6MKR	.005⑧	.005⑥ .0035⑦	.005⑥ .0035⑦	.0055⑥ .004⑦	.010–.020	.010–.020	.0015–.003	.001–.0025
1937–38	6ML	.005⑧	.005⑥ .0035⑦	.005⑥ .0035⑦	.0055⑥ .004⑦	.010–.015	.010–.015	.0015–.003	.001–.0025
1937–38	6MS	.0045⑧	.0045⑥ .0025⑦	.0045⑥ .0025⑦	.005⑥ .003⑦	.010–.015	.010–.015	.0015–.003	.001–.0025
1936–39	6MZ	.0055⑦	.004⑧	.004⑧	.0045⑧	.013–.023	.013–.023	.0015–.003	.001–.0025
1938–46	6MZR	.0055⑦	.004⑧	.004⑧	.0045⑧	.013–.023	.013–.023	.0015–.003	.001–.0025
1936–37	6RB	.0065⑧	.0065⑥ .0045⑦	.0065⑥ .0045⑦	.007⑥ .005⑦	.025–.030	.025–.030	.0015–.003	.001–.0025
1938–41	6RBR	.0065⑧	.0065⑥ .0045⑦	.0065⑥ .0045⑦	.007⑥ .005⑦	.025–.030	.025–.030	.0015–.003	.001–.0025
1936–37	6SRK	.0055④ .007⑦	.0055④ .0045⑤ .005⑦	.0055④ .0045⑤ .005⑦	.006④ .005⑤ .0055⑦	.013–.023	.013–.023	.0015–.003	.001–.0025
1938–46	6SRKR	.0055④ .007⑦	.0055④ .0045⑤ .005⑦	.0055④ .0045⑤ .005⑦	.006④ .005⑤ .0055⑦	.013–.023	.013–.023	.0015–.003	.001–.0025
1936–37	6SRL	.0055⑧	.0055④ .0045⑤ .004⑦	.0055④ .0045⑤ .004⑦	.006④ .005⑤ .0045⑦	.013–.023	.013–.023	.0015–.003	.001–.0025
1938–46	6SRLR	.0055⑧	.0055④ .0045⑤ .004⑦	.0055④ .0045⑤ .004⑦	.006④ .005⑤ .0045⑦	.013–.023	.013–.023	.0015–.003	.001–.0025
1937–39	SRS	.005⑧	.005⑥ .0035⑦	.005⑥ .0035⑦	.0055⑥ .004⑦	.013–.023	.013–.023	.0015–.003	.001–.0025
1939–46	6WAK	.007④ .009⑦	.007④ .0065⑦	.007④ .0065⑦	.0075④ .007⑦	.020–.030	.020–.030	.0015–.003	.001–.003
1939–46	6WAL	.006④	.006④	.006④	.0065④	.020–.030	.020–.030	.0015–.003	.001–.003

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NOTE—For Waukesha engines developed since 1942, see page 915.

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PISTON AND RING CLEARANCES

Year	Engine Model	Piston Skirt, Inches		Fitting Pistons with Shim and Spring Scale		Ring End Gap, Inch ①		Ring and Groove, Inch	
		Top	Bottom	Shim Thickness ②	Pounds Pull on Scale ③	Compression	Oil	Compression ⑨	Oil ⑩
1936–46	XAH	.004④	.004④ .0045⑤	.004④ .0045⑤	.0045④ .005⑤	.007–.017	.007–.017	.0015–.003	.001–.0025
1936–39	XAK	.0045④	.0045④	.0045④	.005④	.007–.017	.007–.017	.0015–.003	.001–.0025
1936–39	6-110	.004	.004	.004	.0045	.015–.020	.015–.020	.0015–.003	.001–.0025
1936–39	6-125	.004	.004	.004	.0045	.015–.020	.015–.020	.0015–.003	.001–.0025

① End gaps are for cylinder bores without taper. Fit rings in tapered bores with not less than the maximum dimension given.
② Piston should pass on shim thickness shown.
③ Piston should lock on shim thickness shown.
④ Round cast iron.
⑤ Cam ground cast iron.
⑥ Cast iron.
⑦ Aluminum.
⑧ Cast iron or aluminum.
⑨ For top or fire ring only.
⑩ All rings except top.

ENGINE BEARING SPECIFICATIONS

Year	Engine Model	Camshaft		Connecting Rod			Mains				
		Journal Diameter	Clearance	Journal Diameter	Clearance	Bearing Bolt Tension Lb. Ft.	Journal Diameter	Clearance	Bearing Bolt Tension Lb. Ft.	Thrust on No.	End-play
1936-39	6-BA	2.000–1.999	.002–.0045	1.999–2.000	.0015–.0035	65– 70	2.624–2.625	.0015–.0035	88– 92	7	.003–.006
1936-46	6-BK	2.000–1.999	.002–.0045	1.999–2.000	.0015–.0035	65– 70	2.624–2.625	.0015–.0035	88– 92	7	.003–.006
1936-46	6-BL	2.000–1.999	.002–.0045	1.999–2.000	.0015–.0035	65– 70	2.624–2.625	.0015–.0035	88– 92	7	.003–.006
1936-46	6-BM	2.000–1.999	.002–.0045	1.999–2.000	.0015–.0035	65– 70	2.624–2.625	.0015–.0035	88– 92	7	.003–.006
1939-46	6-BZ	2.000–1.999	.002–.0045	1.999–2.000	.0015–.0035	65– 70	2.624–2.625	.0015–.0035	88– 92	7	.003–.006
1941-46	6-BZR	2.000–1.999	.002–.0045	1.999–2.000	.0015–.0035	65– 70	2.624–2.625	.0015–.0035	88– 92	7	.003–.006
1936-46	FC	②	.0015–.003	1.749–1.750	.0005–.0025	45– 48	2.124–2.125	.0005–.0025	88– 92	3	.005–.009
1936-40	FL	②	.0015–.003	1.749–1.750	.0005–.0025	45– 48	2.124–2.125	.0005–.0025	88– 92	3	.005–.009
1936-46	FCL	②	.0015–.003	1.749–1.750	.0005–.0025	45– 48	2.124–2.125	.0005–.0025	88– 92	3	.005–.009
1936-46	FCS	②	.0015–.003	1.749–1.750	.0005–.0025	45– 58	2.124–2.125	.0005–.0025	88– 92	3	.005–.009
1936-40	FS	②	.0015–.003	1.749–1.750	.0005–.0025	45– 48	2.124–2.125	.0005–.0025	88– 92	3	.005–.009
1937-46	6-GAK	③	.002–.0035	3.1865–3.1875	.0015–.004	72– 75	3.999–4.000	.0025–.0045	125–130	7	.004–.007
1936-41	6-GAL	③	.002–.0035	3.1865–3.1875	.0015–.004	72– 75	3.999–4.000	.0025–.0045	125–130	7	.004–.007
1936-37	6-MK	2.1875–2.1865	.0015–.003	2.249–2.250	.001–.003	65– 70	①	①	96–100	7	.003–.005
1938-46	6-MKR	2.1875–2.1865	.0015–.003	2.249–2.250	.001–.003	65– 70	①	①	96–100	7	.003–.005
1937-38	6-ML	2.1875–2.1865	.0015–.003	2.249–2.250	.001–.003	65– 70	①	①	96–100	7	.003–.005
1937-38	6-MS	2.1875–2.1865	.0015–.003	2.249–2.250	.001–.003	65– 70	①	①	96–100	7	.003–.005
1936-39	6-MZ	2.1875–2.1865	.0015–.003	2.249–2.250	.001–.003	65– 70	①	①	96–100	7	.003–.005
1938-46	6-MZR	2.1875–2.1865	.0015–.003	2.249–2.250	.001–.003	65– 70	①	①	96–100	7	.003–.005
1936-37	6-RB	④	.002–.004	2.749–2.750	.002–.004	73– 75	3.499–3.500	.002–.004	129–133	4	.003–.005

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NOTE—For Waukesha engines developed since 1942, see page 915.

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ENGINE BEARING SPECIFICATIONS

		Camshaft		Connecting Rod			Mains				
Year	Engine Model	Journal Diameter	Clearance	Journal Diameter	Clearance	Bearing Bolt Tension Lb. Ft.	Journal Diameter	Clearance	Bearing Bolt Tension Lb. Ft.	Thrust on No.	End-play
1938-41	6-RBR	④	.002-.004	2.749-2.750	.002-.004	73- 75	3.499-3.500	.002-.004	129-133	4	.003-.005
1936-37	6-SRK	⑤	.0025-.004	2.749-2.750	.001-.003	120-125	2.999-3.000	.002-.0045	129-133	7	.003-.005
1938-46	6-SRKR	⑤	.0025-.004	2.749-2.750	.001-.003	120-125	2.999-3.000	.002-.0045	129-133	7	.003-.005
1936-37	6-SRL	⑤	.0025-.004	2.749-2.750	.001-.003	120-125	2.999-3.000	.002-.0045	129-133	7	.003-.005
1938-46	6-SRLR	⑤	.0025-.004	2.749-2.750	.001-.003	120-125	2.999-3.000	.002-.0045	129-133	7	.003-.005
1937-39	6-SRS	⑤	.0025-.004	2.749-2.750	.001-.003	120-125	2.999-3.000	.002-.0045	129-133	7	.003-.005
1939-46	6-WAK	2.743-2.742	.002-.0035	3.374-3.375	.0015-.003	85- 88	3.999-4.000	.0025-.0045	242-250	7	.004-.007
1936-46	6-WAL	2.743-2.742	.002-.0035	3.374-3.375	.0015-.003	85- 88	3.999-4.000	.0025-.0045	242-250	7	.004-.007
1936-46	XAH	⑥	.0015-.003	1.999-2.000	.001-.003	65- 70	1.999-2.000	.001-.003	½" 81- 83 ⅝" 108-112	3	.003-.005
1936-39	XAK	⑥	.0015-.003	1.999-2.000	.001-.003	65- 70	1.999-2.000	.001-.003	½" 81- 83 ⅝" 108-112	3	.003-.005
1936-39	6-110	2.248-2.247	.001-.003	2.249-2.250	.002	95-105	①	①	50- 55	7	.004-.006
1936-39	6-125	⑦	.001-.003	2.749-2.750	.001-.003	95-105	2.999-3.000	.002-.0045	50- 55	7	.004-.006

① Engines having a journal diameter of 2.624"-2.625" using precision insert dowel type bearings should have .0015"-.0035" oil clearance. Engines having a journal diameter of 2.874"-2.875" should have .003"-.0035" oil clearance.

② Front, 2.1235-2.123; intermediate, 1.8735-1.873; rear, 1.4985-1.4980.

③ Front, 2.743-2.742; intermediate, 2.493-2.492; rear, 2.056-2.055.

④ Front, 2.125-2.124; Intermediate, 2.4375-2.4374; rear, 1.9375-1.9365.

⑤ Front and rear, 1.750-1.749; intermediate, 2.1875-2.1865.

⑥ Front, 1.7805-1.7795; intermediate, 1.7495-1.7485; rear, 1.687-1.686.

⑦ Front, 1.7495-1.7485; intermediate, 2.3105-2.3095; rear, 1.7495-1.7485.

ENGINE

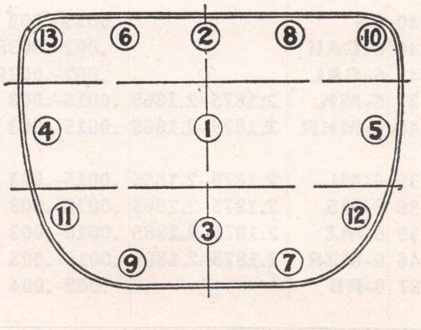
CYLINDER HEAD

1936-46 ALL: Cylinder heads should be tightened down by starting from the center, working outward toward the sides and to the ends. A typical cylinder head layout is illustrated. Draw down the studs evenly and repeat the operation until all are normally tight. After the engine has been run sufficiently long to bring all the parts to normal operating temperature, a final tightening should be made.

NOTE—When using a torque indicating wrench, the final tightening should be within the torque values recommended by the wrench manufacturer. If two torque values are shown, use the lower limit for clean and oily threads; and the high limit for clean and dry threads. In any case, the threads should be free from rust or dirt, otherwise a false reading will be obtained due to the increased friction. When the final tightening is made on overhead valve engines, check the valve tappet clearance according to the recommendations given in the VALVE SYSTEM table.

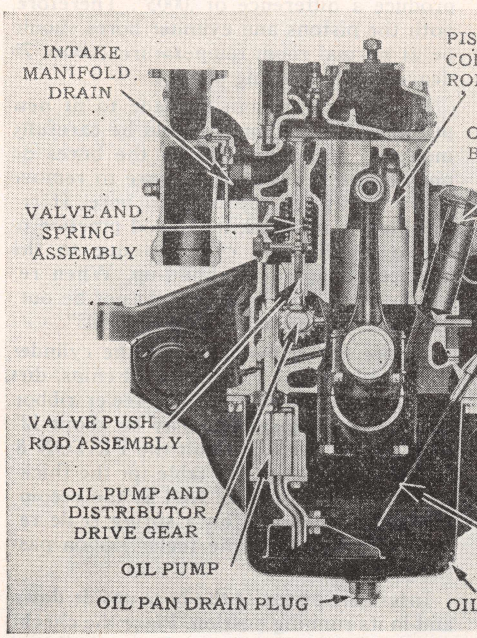
ROCKER ARMS & PUSH RODS

1936-46 ALL: On overhead valve engines, it is good practice to remove the push

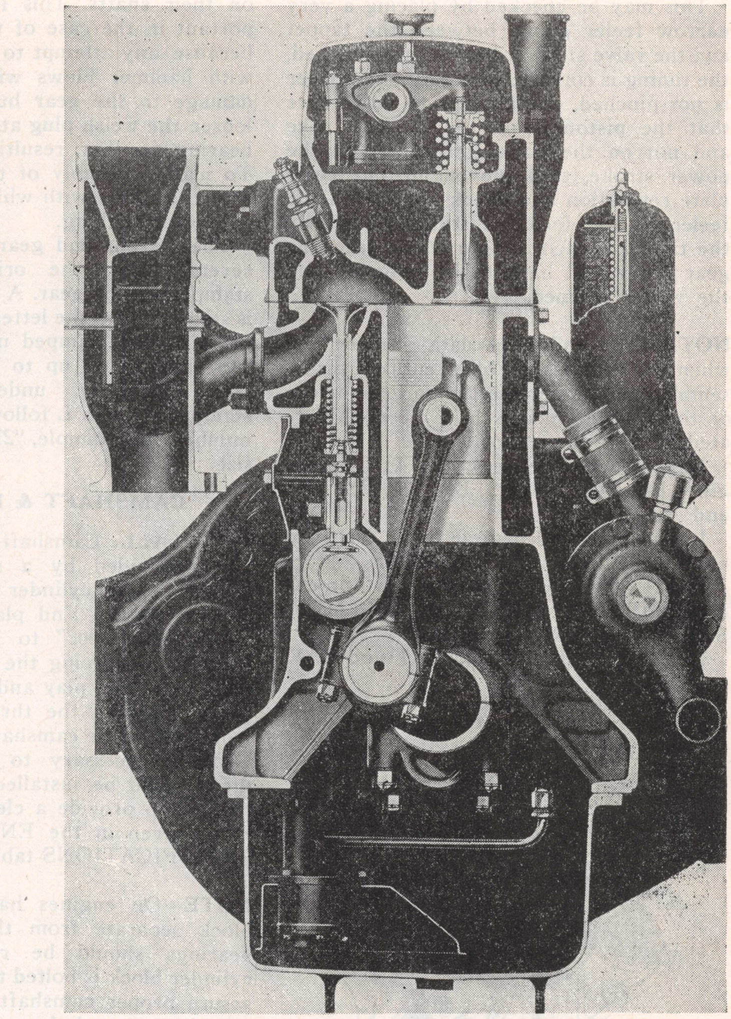


Typical Cylinder Head Layout. Tighten Nuts in Order Shown.

NOTE—For Waukesha engines developed since 1942, see page 915.


INTAKE MANIFOLD DRAIN
PISTON AND CONNECTING ROD ASSEMBLY
OIL FILLER AND BREATHER PIPE
VALVE AND SPRING ASSEMBLY
VALVE PUSH ROD ASSEMBLY
OIL PUMP AND DISTRIBUTOR DRIVE GEAR
OIL LEVEL GAUGE
OIL PUMP
OIL PAN DRAIN PLUG
OIL PAN

Engine Models 6BK, 6BM.



Engine Models 6-110, 6-125.

rods before taking off the cylinder head to prevent the push rods from bending or twisting. Likewise, when installing the head, replace the push rods after the head is in place.

Whenever the rocker shaft is disassembled, place all parts on the bench in their relative position to assure correct assembly. And before assembling the rocker arms, be sure the faces are free from pits or rough spots, otherwise it will be difficult to maintain the proper tappet clearance.

NOTE—On engines 6-110 and 6-125 having the intake valve in the cylinder head and the exhaust valve in the block, it is not necessary to disturb the connecting oil lines when removing rocker assemblies. It is recommended that all three clusters be removed as an assembly and connecting oil lines should not be disturbed unless parts replacements are required.

When the rocker assemblies are removed, note that the center stud is provided with a cork gasket which is positioned in a recess under the rocker arm post. This stud extends through the intake passage cast integral with the cylinder head, and when assembling, new gaskets should be used at this point to prevent air leaking into the intake passage. If this precaution is not taken, it will be difficult to secure proper engine idle.

VALVE STEM GUIDES

1936-46 ALL: When necessary to replace guides on L-head engines with tappet guides integral with the block, run the tappet adjusting screw all the way down and crank the engine to bring the tappet on the low point of the cam. Then use a suitable drift, preferably one having a pilot which is the same size as the valve **stem, to drive out the guide. If the guide comes in contact with the tappet before it is all the way out, break off the lower part.**

On L-head engines equipped with removable tappet guides, simply remove the tappet and guide assemblies and drive out the guides.

NOTE—On all engines, it is good practice to remove and install one guide at a time. When installing an intake guide, measure the depth of an intake guide not yet removed in order to determine the correct depth of the guide being installed. Of course, this procedure should be followed when installing exhaust guides.

When installed, the guides should be reamed to provide a clearance within the limits given in the VALVE SYSTEM **table.**

VALVE TAPPETS & GUIDES

1936-46 ALL: Tappets must be a free fit in their guides without excessive side play. If the fit is too loose, remove the tappet, ream the guide hole and install an oversize tappet, being sure the tappet is provided with a clearance within the limits given in the VALVE SYSTEM table.

NOTE—If the tappet guides are integral with the cylinder block, and the available reaming equipment requires the removal of the valve stem guides, be sure to install new guides rather than attempt to make use of the old ones.

On engines equipped with tappet guide clusters, and if all or most of the tappets are too loose a fit, it is probably more economical to install a new cluster and standard size tappets.

On engines equipped with tappet guide bushings pressed into the block, the camshaft will have to be removed and the old bushings pressed out and new ones installed. Likewise, to remove mushroom type tappets from any engine, the camshaft will have to be taken out.

VALVE TIMING

1936-46 ALL: With the engine at normal room temperature and No. 1 intake valve tappet set to the clearance for timing as given in the VALVE SYSTEM table, crank the engine until the "IN-O" mark on the flywheel is in line with the indicator on the flywheel housing. In this position, No. 1 intake valve should be just starting to open.

This may be checked by placing a very narrow feeler gauge between the tappet and the valve stem. If the feeler is pinched, the timing is correct; whereas, if the feeler is not pinched, check again to make sure that the piston is on the intake stroke and not on the power stroke. If on the power stroke, turn the engine one complete revolution and check again with the feeler. If the feeler is still not pinched, the timing is incorrect, in which case, the gear cover will have to be removed and the valves retimed.

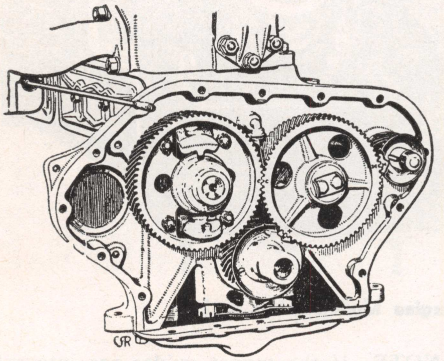
NOTE—The following data are for use when the engine has been entirely disassembled and, either the timing gear marks or the flywheel marks have been obliterated, or if they are not legible.

Intake opens 5 degrees after TDC on engines FC, FCS, FL, FS, BA, BL, BM, BK and BZ.

Intake opens 10 degrees after TDC on engines XAH, XAK, RB and RBR.

Intake opens 8 degrees after TDC on engines MS, ML, MK, MKR, MZ, MZR, SRL, SRLR, SRK and SRKR.

Intake opens at TDC on GAL and GAK engines.



Typical Timing Gear Layout.
For correct valve timing, similarly marked gears should be meshed as shown.

TIMING GEARS

1936-46 ALL: Whenever these gears are removed or disturbed for any reason, it is important that they be assembled so that the similarly marked teeth are meshed, otherwise the valve timing will be incorrect.

NOTE—A typical timing gear layout is illustrated showing the proper arrangement of the several timing gear markings. Note that the "C" marks on the camshaft and idler gears are meshed, while at the same time, the "X" marks on the crankshaft and idler gears, and the "M" marks on the idler gear and the magneto drive gear are all meshed at the same time. In this position, the relationship of the pistons and valves, as well as the ignition, is properly synchronized.

Whenever it becomes necessary to replace the crank and cam gears, suitable puller and pusher equipment is essential, due to the extremely tight fit of these gears on their shafts. This is particularly important in the case of the camshaft gear because, any attempt to drive on this gear with hammer blows will not only cause damage to the gear but will very likely loosen the welsh plug at the rear camshaft bearing position, resulting in an oil leak. To make assembly of these gears easier, coat the shafts with white lead to prevent galling or sticking.

These front end gears are available in several sizes, the original size being stamped on the gear. A standard size gear is stamped with the letter "S." If the gear is oversize, the stamped mark will be "2S," "4S" and so on up to "10S," in steps of .002". Similarly, undersize gears are stamped with an L following the undersize number, for example, "2L" for .002" undersize.

CAMSHAFT & BEARINGS

1936-46 ALL: Camshaft end thrust is usually controlled by a steel thrust plate bolted to the cylinder block behind the camshaft gear. End play should be held within from .002" to .005" and can be checked by forcing the shaft back to the limit of its end play and inserting a feeler gauge between the thrust plate and the front end of the camshaft.

When necessary to replace bearings, they should be installed in sets and line reamed to provide a clearance within the limits given in the ENGINE BEARING SPECIFICATIONS table.

NOTE—On engines having the cylinder block separate from the crankcase, the bearings should be reamed **after** the cylinder block is bolted to the crankcase to assure proper camshaft fit. Be sure that the oil passage holes are clean and open, and that the oil holes in the bearings are in line with the oil passage hole in the crankcase.

PISTONS & RODS, REMOVE

1936-46 ALL: Piston and rod assemblies are removed from the top of the block on all engines except series XAH and XAK, in which case, they are removed from below. Although regular production rods are marked with the cylinder number in which they are installed, replacement rods are not; therefore, unmarked rods should be suitably identified with punch marks, as removed.

The number of the rod is usually stamped on the lower end of the rod and cap on the camshaft side of the engine and should be installed in this manner.

PISTON & ROD, ASSEMBLE

1936-46 ALL: Aluminum pistons should be assembled to the rods so that when installed in the cylinder bores, the slotted side of the piston is on the side opposite the camshaft.

PISTONS, RENEW

1936-46 ALL: NOTE—A variation of 10 degrees between the temperature of the pistons and cylinder bores is sufficient to produce a difference of .0005". Therefore, both the pistons and cylinder bores should be at normal room temperature (about 7 degrees) when fitting pistons.

Before any attempt is made to fit new pistons, cylinder bores should be carefull indicated and refinished. If the bores do not require refinishing, be sure to remove the ridge at the top of each bore. If refinishing is required, it is good practice to do so in alternate cylinders due to the localized temperature build-up. When refinished, cylinder bores should not be out of-round or tapered more than .0005".

Before fitting pistons, wipe the cylinder walls and pistons to remove all chips, dirt or other foreign matter. The feeler ribbon used to check piston fit may be about 12" long and ½" wide. Consult the PISTON & RING CLEARANCES table for the thickness of shim to use as well as the recommended pounds pull on a spring scale required to withdraw the feeler ribbon past the piston.

Insert the piston in the bore upside down and in its running postion. Place the checking feeler between the cylinder wall and the thrust side of the piston (opposite the slotted side on aluminum pistons) in a position at right angles to the piston pin hole

After assembling the piston to the connecting rod, check the assembly for alignment on a suitable jig.

PISTON RINGS, RENEW

1936-46 ALL: NOTE—To prevent the possibility of bending or breaking the second ring land—thus ruining the piston—the ridge at the top of the cylinder bore should be carefully cut away before removing the piston and rod assemblies. If the available ridge reamer has no provision to control the depth of the cut, it is good practice to bring the piston far enough up into the cylinder bore to allow the reamer to rest on top of the piston. This will serve to prevent cutting into the ring travel area Never cut down into the ring travel area more than 1/32"—or more than half the depth of the top ring.

New rings should be fitted with end gaps and groove clearances as given in the PISTON & RING CLEARANCES table. Ring grooves must be clean and free from carbon, and must show no perceptible wear.

NOTE—Ring end gaps given in the PISTON & RING CLEARANCES table are for cylinder bores without taper. Fit rings in tapered bores with not less than the maximum dimension given. If rings other than standard are being installed pay particular attention to the installation instructions which usually are included in the ring package. This applies to clearances, position of rings in groves, etc.

When rings are properly fitted to the pistons, be sure to stagger the ring gaps so they are spaced equal distances around the circumference of the piston, yet having no gaps over the piston pins.

PISTON PINS, RENEW

1936-46 ALL: The correct fit of piston pins in cast iron pistons should be one which requires a light push with the palm of the hand to insert the pin. For aluminum pistons, at normal room temperature, it should require a hard push with the palm of the hand to install the pin. However, to facilitate fitting pins in aluminum pistons, heat the piston in boiling water for a few minutes, after which, the pin should enter the piston easily.

To check the fit of pins after installation, hold the piston in both hands and, for aluminum pistons, the weight of the rod should not be sufficient to allow it to fall. When using the same method on cast iron pistons, the rod should drop easily by its own weight.

PISTON PIN BUSHINGS, RENEW

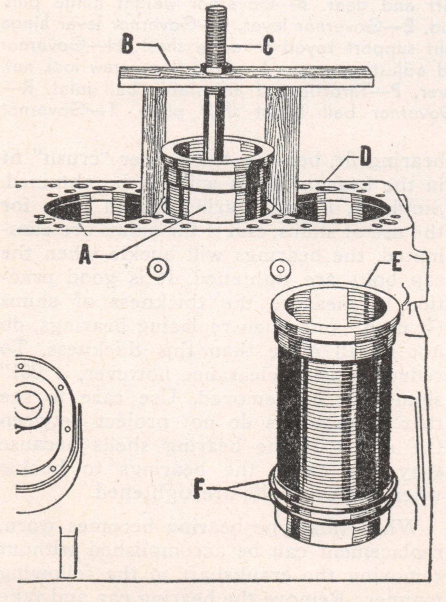
1936-46 ALL: New bushings should be pressed in place and reamed to provide a light push fit of the pin with the parts at normal room temperature.

CYLINDER SLEEVES, RENEW

6GAL, 6GAK: Engines in this series only are equipped with removable cylinder sleeves of the dry type and special equipment is required to exert sufficient pressure to remove these liners.

NOTE—When new sleeves are being installed, coat the outside surface with white lead so that when they are being pressed into the bore, the possibility of galling or sticking will be largely eliminated. When installed, run a hone down through the sleeve bores so that a proper piston fit will be assured.

On some special industrial and agricultural engines, the wet-sleeve type liner is used and special equipment is not needed to remove this type. To remove the sleeve, insert a long bolt through the sleeve and attach a cross bar at the bottom and at the top, supporting the top cross bar on two blocks, being sure the blocks are long enough to be supported across the entire width of the cylinder block (see illustration). By running the nut down on the bolt, the sleeve will be released.



Method of Removing Wet Type Sleeves.
A—Old sleeve being removed. E—New sleeve.
F—Rubber sealing rings.

Each sleeve is sealed by the cylinder head and head gasket at the top, while a rubber packing ring is fitted in the recessed groove at the bottom of the water jacket case to keep the lower end tight and permits the required expansion.

When replacing the sleeve, remove the old rubber ring in the bottom packing groove and insert a new one, being sure that none of the old ring falls into the crankcase to clog the oiling system.

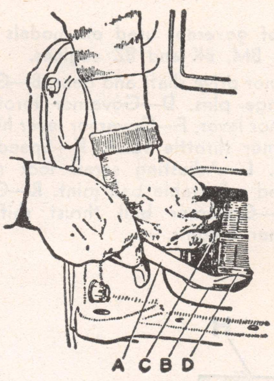
CONNECTING ROD BEARINGS, RENEW

1936-46 ALL: Some of these engines use spun type bearings while others are equipped with the precision insert replaceable type. If spun bearings are used and an adjustment is required, remove the same thickness of shims from each side until a metal-to-metal contact is established with the crankpin. The bearing may then be scraped to provide maximum bearing surface, and sufficient shims installed on both sides to provide a clearance within the limits given in the ENGINE BEARING SPECIFICATIONS table.

If the engine is equipped with the precision insert type, they may be replaced by simply taking off the bearing cap and slip the old shells out and the new ones in. Bearings should be replaced in sets and under no circumstances should rods or caps be filed, altered or mutilated in any way in an attempt to obtain proper bearing fit.

NOTE—Before replacing bearings, make sure that the crankpins are not nicked or scored, and that all parts are thoroughly clean. This is particularly important because the presence of one small particle of metal, carbon or other foreign matter, lodged between the back of the bearing and the rod, or between the face of the bearing and the crankpin, will very likely cause a hot spot due to the elimination of the oil clearance at that point, eventually resulting in a bearing failure or a scored crankpin.

CAUTION—Some of these engines use shims between the bearing cap and the rod **only** on the side opposite the bearing lock notch. When shims are used, measure the thickness of shims removed and never install more than this amount. Some engines use no shims at all, while others use them on each side. Where no shims are used, under no circumstances should they be installed in an attempt to obtain a bearing fit, because the proper "crush" fit of the bearings in the connecting rod bores will not be obtained. Similarly, if the bearing design calls for the use of shims, and if the shims are eliminated, the bearings will buckle when the cap bolts are tightened.



Testing Rod Bearings
Through Hand Hole Cover.

To check the fit of new bearings, use a piece of brass shim stock ¼" wide, the length of which should be ¼" less than the length of the bearing, while the thickness should be approximately the same as the minimum allowable clearance. To avoid damaging the bearing material, smooth down the edges of the shim stock on an oil stone so that no sharp edges remain. Install the shim between the bearing and the crankpin, in the center of the bearing, then tighten the cap bolts to the recommended torque tension. When fitted properly, it should not be possible to move the rod endwise by hand, but a light tap with a hammer should cause the rod to move endwise. Then remove the checking shim and re-install the cap, tightening the cap bolts with a torque wrench, after which, the rod should move endwise by hand. If the rod is too loose with the checking shim in place, the crankpin should be turned down and undersize bearings fitted.

NOTE—Some engines are equipped with hand hole covers on the side of the crankcase, which, when removed, bearings may be adjusted or new inserts fitted—without removing the oil pan.

MAIN BEARINGS, RENEW

1936-46 ALL: Two types of bearings have been used on these engines. One type employs a babbitt-lined removable bearing for the upper half, while in the lower half, the babbitt is poured directly in the bearing caps.

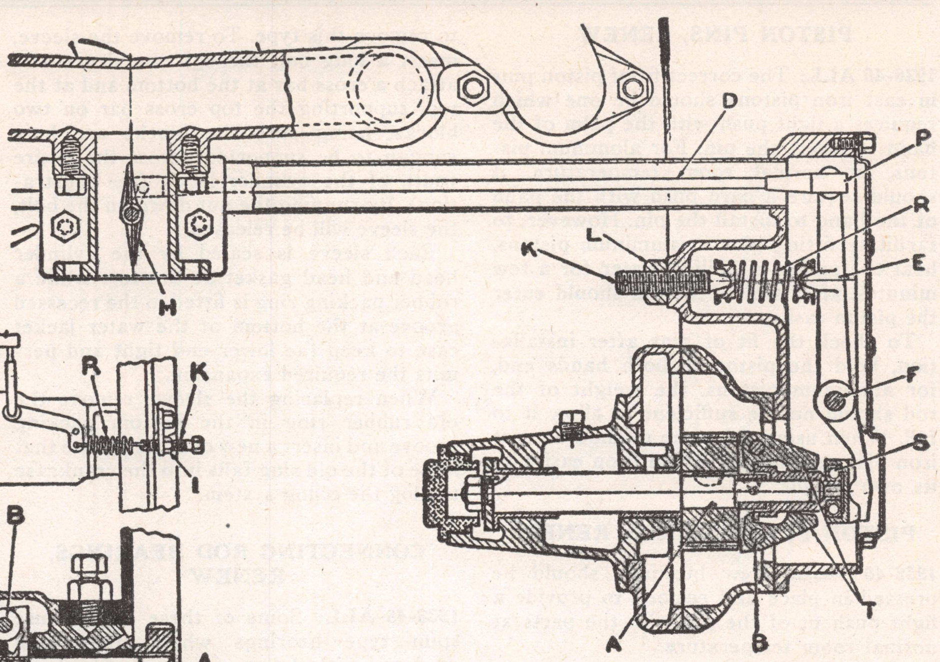
The alternate type is the precision insert shell bearings, which, when worn, can be replaced without removing the crankshaft.

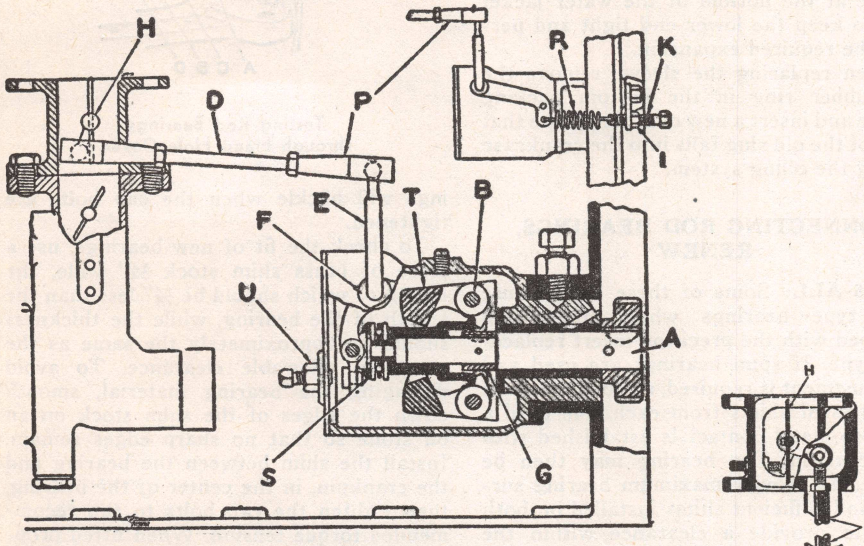
To make an adjustment on the babbitt-lined type, remove the same thickness of shims from each side until a metal-to-metal contact is established with the crankshaft journal. If the bearing material is scored, rough or shows only partial contact, the bearing may be scraped to obtain maximum contact. Then install the same thickness of shims on each side to provide a clearance within the limits given in the ENGINE BEARING SPECIFICATIONS table. If the babbitt is cracked or worn

NOTE—For Waukesha engines developed since 1942, see page 915.

Diagram of governor used on models BA, BL, BM, BK and BZ engines.

A—Governor drive shaft and gear. B—Governor weight hinge pins. D—Governor throttle rod. E—Governor lever. F—Governor lever hinge pin. H—Governor throttle valve. K—Speed adjusting screw. L—Adjusting screw lock nut. P—Throttle rod adjustable ball joint. R—Governor spring. S—Governor ball thrust shift plate. T—Governor weights.





Governor used on engines FCS, FS, FL, FC, XAH and XAK.

A—Governor drive shaft and gear. B—Governor weight hinge pins. D—Governor throttle rod. E—Governor lever. F—Governor lever hinge pin. G—Governor weight support keyed to drive shaft. H—Governor throttle valve. K—Speed adjusting screw. L—Adjusting screw lock nut. P—Throttle rod adjustable ball joint. R—Governor spring. S—Governor ball thrust shift plate. T—Governor weights. U—Stop screw to prevent surging.

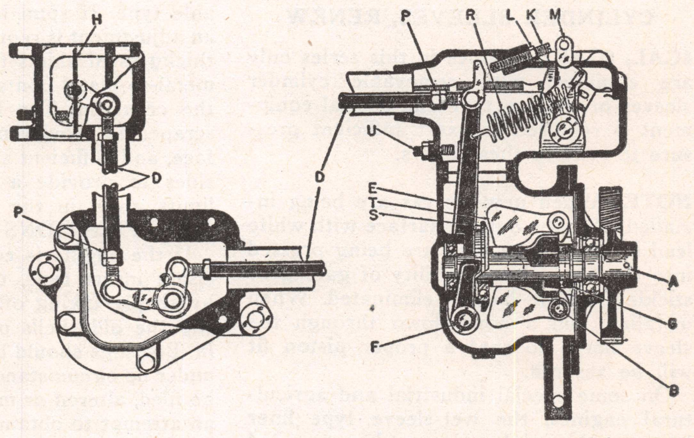


Diagram of Close Regulating Type Governor Used on Models 6-GAL and 6-GAK.

A—Governor drive shaft and gear. B—Governor weight hinge pins. D—Governor throttle rod. E—Governor lever. F—Governor lever hinge pin. G—Governor weight support keyed to drive shaft. H—Governor throttle valve. K—Speed adjusting screw. L—Adjusting screw lock nut. M—Speed adjusting lever. P—Throttle rod adjustable ball joint. R—Governor spring. S—Governor ball thrust shift plate. T—Governor weights.

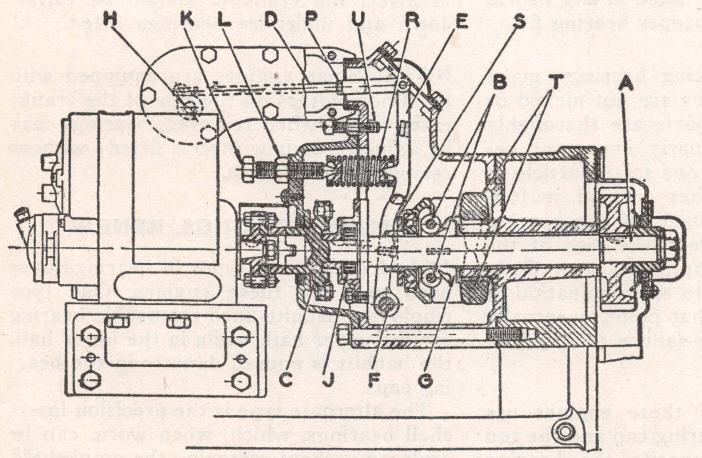


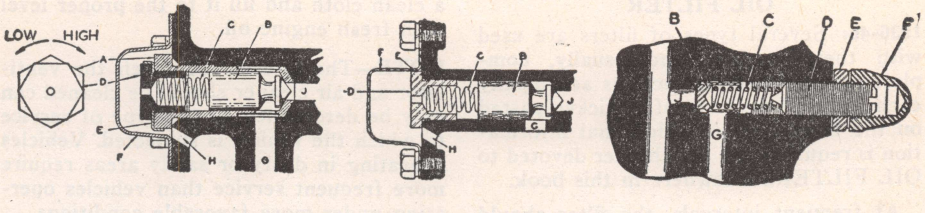
Diagram of Governor for Overhead Valve Engines.

A—Governor drive shaft and gear. B—Governor weight hinge pins. C—Magneto impulse coupling. D—Governor throttle rod. E—Governor lever. F—Governor lever hinge pin. G—Governor weight support keyed to drive shaft. H—Governor throttle valve rod. J—Magneto impulse coupling spring. K—Speed adjusting screw. L—Adjusting screw lock nut. P—Throttle rod adjustable ball joint. R—Governor spring. S—Governor ball thrust shift plate. T—Governor weights. U—Stop screw to prevent surging.

excessively, new bearings should be fitted and line reamed to fit the crankshaft.

NOTE—Bearings of the precision insert type should be replaced in sets and under no circumstances should any attempt be made to file, alter or otherwise mutilate the bearing caps to obtain proper bearing fit. If the bearing design does not provide for shims, under no circumstances should they be installed in an attempt to obtain a bearing fit, because the proper "crush" fit in the bearing bores will not be obtained. Similarly, if the bearing design calls for the use of shims, and if the shims are eliminated, the bearings will buckle when the cap bolts are tightened. It is good practice to measure the thickness of shims (if used) and when replacing bearings, do not install more than this thickness. To reduce bearing clearance however, a .001" shim may be removed. Use care to see that these shims do not project between the edges of the bearing shells because they will cause the bearings to buckle when the cap bolts are tightened.

When this type bearing becomes worn, replacement can be accomplished without removing the crankshaft in the following manner: Remove the bearing cap and take out the worn lower shell. A suitable tool can be made to remove the upper shell by



Showing Three Types of Oil Relief Valves Used.

A—Steel shell valve body screwed into crankcase. B—Cylindrical valve plunger. C—Pressure control spring. D—Pressure adjusting screw. E—Adjusting screw lock. F—Protecting cap. G & H—Overflow passage to crankcase when valve B is open. J—Oil pressure duct from main oil line.

using a cotter pin with the rounded end flattened to form a T shape. Insert the T-shaped end of the pin in the oil passage hole in the crankshaft journal and, by rotating the crankshaft in the reverse direction, the T-shaped head will contact the bearing and force it out.

To install, place a new upper shell on the crankshaft journal with the locating notch in the correct position, and rotate the shaft to turn the shell in place. Then install the lower shell in the cap and replace the cap, being sure the proper thickness shim pack (if used) is placed between the cap and support. Then tighten the cap bolts to the recommended torque tension which will be found in the ENGINE BEARING SPECIFICATIONS table.

To check the fit of new bearings, use a piece of brass shim stock ¼" wide, the length of which should be ¼" less than the length of the bearing, while the thickness should be about the same as the minimum allowable clearance.

CAUTION—To avoid damaging the bearing material, smooth down the edges of the shim stock to remove sharp edges or turned over corners. And before inserting this checking shim in place, it should be coated on both sides with a light film of engine oil.

Lay the checking shim lengthwise in the center of the bearing and install the bearing cap to the crankshaft, being sure the shim packs (if used) are properly placed between the cap and support. Then tighten the cap bolts to the recommended torque tension. Test the fit of the bearing by rocking the crankshaft through an arc of 2"—not more than 1" in either direction. The bearing may be considered fitted properly if the shaft is movable with a fairly heavy drag.

NOTE—Remove the checking shim and replace the cap, but do not tighten the cap bolts, as this bearing must be loose in order to check the fit of the other bearings. It is good practice to fit bearings by starting at the center—or one of the intermediates on a four-bearing job—then the rear bearing, the front, and finally, the intermediates.

CRANKSHAFT END THRUST

1936-46 ALL: Crankshaft end thrust is controlled by flanges on a bearing (see the ENGINE BEARING SPECIFICATIONS table for the bearing which takes the thrust and for the proper end play limits).

Through normal wear, the end play will seldom become excessive but, whenever new bearings are fitted, the clearance should be carefully checked and, if required, the bearing flanges may be dressed down to obtain the desired end play.

REAR MAIN BEARING OIL SEAL

1936-46 ALL: Various methods of preventing oil leaks at the rear main bearing are used in these engines. On some engines, an oil slinger is used and surplus oil is returned to the oil pan through an oil passage and tube. Another installation is one which consists of a retainer in which packing is inserted, and whenever the engine is dismantled for repairs, new packing should be installed. If the rear main bearing support is provided with packing, there is usually an oil slinger, integral with the crankshaft, which deflects the major portion of oil into the groove of the bearing cap and support.

An examination of the engine being serviced will readily show which method is used to control oil leaks, and no difficulty should be met with if a reasonable amount of care is used when replacing packing.

ENGINE OILING

OIL PUMP

1936-46 ALL: If the oil pressure drops to zero suddenly or fluctuates violently while the engine is under load, check the oil level and examine the condition of the oil. Oil that has been used too long will be thinned by dilution, which will cause the pressure to drop. If these conditions are not the cause, before taking down the oil pan and pump, check the oil gauge with another gauge known to be accurate. If the pressure continues to drop, remove and clean the oil pan thoroughly, and disassemble, clean and inspect the oil pump.

NOTE—Before taking down the oil pan, remove the protecting cap from the oil pressure regulator which is usually attached to the outside of the crankcase, and check to see that no dirt or foreign matter is lodged under the relief valve. If this is not the cause of the pressure drop, remove the oil pan and examine the oil lines to see that they are not broken.

Usually, the pump can easily be disassembled by taking off the upper drive gear and bottom cover, after which, the internal parts can readily be removed. Replace any gears which have an excessive amount of backlash. When assembling the pump, dip the gears in fresh engine oil as a means of priming the pump.

Clearance between the gears and cover may be checked by placing a steel scale across the face of the housing, and a feeler ribbon between the steel scale and gears. If the clearance is excessive, it may be reduced by grinding the lower face of the housing, using an abrasive compound evenly distributed on a perfectly flat surface.

CAUTION—Before replacing the oil pump and oil pan, the oil screen, oil tubes and lines should be thoroughly cleaned, being sure that all openings in the screen are free and clean. If the screen is crushed, it is better to replace it rather than attempt to make a repair.

NOTE—On some engines, the upper end of the pump shaft is provided with a slightly offset tongue which is used to drive the ignition distributor shaft. In the event that the pump drive gear is disengaged from the camshaft gear, it is important that it be assembled in the same relative position to obtain proper ignition timing, and is accomplished in the following manner:

Crank the engine to bring No. 1 piston on top dead center of its compression stroke (D C mark on flywheel). Then mesh the oil pump gear with the camshaft gear so that the small portion (offset) of the tongue drive faces the rear of the engine. In this position, the oil pump may then be bolted to the engine and the tongue of the shaft will readily enter the tongue drive of the distributor shaft.

OIL PRESSURE REGULATOR

1936-46 ALL: Oil pressure is automatically controlled by a compression spring which controls the action of a relief valve. On some engines, the regulator is located on the right side of the crankcase, and on the left side on others. As a still further precaution against the possibility of abnormal pressure, some engines have an emergency relief valve incorporated in the pump body, which requires no service whatsoever.

Oil pressure should not be judged too high or too low until it is known whether the proper weight of oil is used, and the engine is warmed up to normal operating temperature.

As the engine bearings become worn, the oil pressure will be slightly lower, due to more oil escaping around the bearings. It is not advisable to try to correct this slight pressure loss by an adjustment of the pressure regulator, because the extra amount of oil being thrown off by the worn bearings is already over-oiling the cylinder walls.

If an adjustment is required, remove the protecting cap and turn the adjusting screw in (clockwise) to increase pressure, and out (counter-clockwise) to decrease pressure.

NOTE—For Waukesha engines developed since 1942, see page 915.

OIL FILTER

1936-46: Several types of filters are used with these engines and usually, complete maintenance instructions accompany each filter in the form of a sticker pasted on the filter itself. If additional information is required, see the chapter devoted to OIL FILTERS elsewhere in this book.

At frequent intervals, the filter should be drained to get rid of any solid matter which may have settled in the filter sump. Whenever this is done, be sure to add sufficient oil to the crankcase to compensate for the oil drained.

Filters should be cleaned thoroughly every time the oil is changed and after every thousand miles of operation, or 50 hours of operation in the case of industrial units. If the dip stick shows that the oil is thick and very dirty, it indicates that the filter element requires service.

CRANKCASE VENTILATOR

1936-46: The crankcase ventilator breather should be inspected at least every 2,000 miles, and if a sludge formation is evident, remove the breather and clean it thoroughly in gasoline. Allow the breather to soak in the gasoline for about 30 minutes, then blow it out with compressed air, and at the same time, tap it lightly to dislodge any solid particles of sludge.

If the breather is fitted with an air cleaner, it should be removed and washed every 1000 miles. After the element is washed, blow it dry with compressed air and, if the cleaner is of the oil-wetted type, dip the element in fresh engine oil before assembling. If it is of the oil bath type, wipe out the oil reservoir thoroughly with a clean cloth and fill it to the proper level with fresh engine oil.

NOTE—The interval at which the ventilator and air cleaner should be cleaned can only be determined by the type of service to which the vehicle is subjected. Vehicles operating in dusty or sandy areas require more frequent service than vehicles operating under more favorable conditions.

IMPORTANT—For vehicles operating in dust storm areas, the cleaner should be cleaned immediately after such storms occur.

COOLING SYSTEM

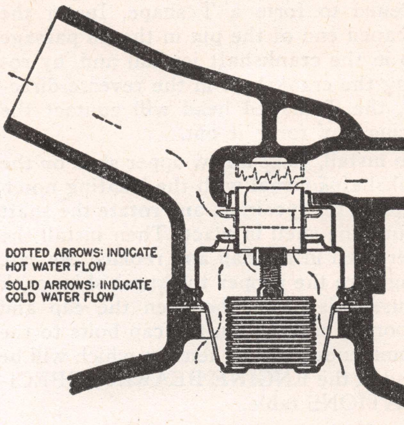
WATER PUMP, OVERHAUL

1936-46: The pump commonly used on all engines except series 6GAL and 6GAK is mounted on the side of the engine and is driven by a coupling through the timing gears. Series 6GAL and 6GAK uses a combination fan and water pump mounted on the front of the cylinder block.

To remove and repair the side-mounted type, take off the magneto (if equipped) and disconnect the coupling. Remove the bolts which fasten the pump to the water pipes and lift off the assembly.

These pumps are easily disassembled by simply removing the cover from the pump housing and when this is done, the internal parts are readily accessible for inspection and repairs.

On the 6GAL and 6GAK engines, take off the fan driving spider and unscrew the packing nut and the bearing clamp nut. Remove the cover from the impeller housing and push the shaft and impeller out of the pump body. The oil retainers and bearings may now be removed from the fan drive housing.


DOTTED ARROWS: INDICATE HOT WATER FLOW
SOLID ARROWS: INDICATE COLD WATER FLOW

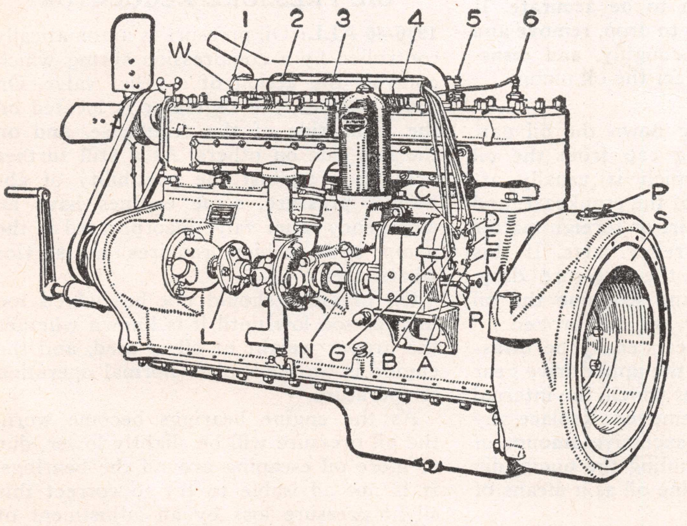
Showing thermostat by-pass as used on six-cylinder truck engines.

Examine the parts and replace any which show evidence of wear, then assemble the pump in the reverse order.

ENGINE WATER THERMOSTAT

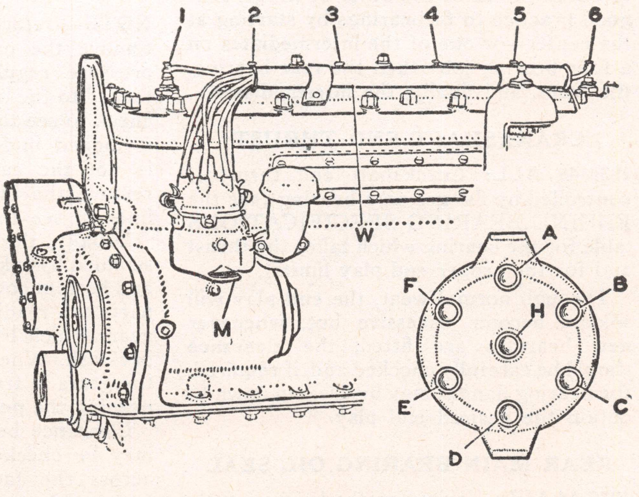
1936-46: If the thermostat is not functioning properly, remove the assembly from the water outlet and see if the bellows and valve are in good condition. If they are, test its operation by completely submerging it in water, heating the water gradually until it reaches the opening temperature of the thermostat, which is approximately 145 degrees. When the water reaches a temperature of about 170 degrees, the thermostat should be fully open.

NOTE—When taking temperature readings, agitate the water thoroughly. And if the unit fails to function properly, it should be replaced rather than attempt to make a repair. Before installing a new unit,



Magneto Ignition and Wiring Scheme.

A-B-C-D-E-F—Wires from magneto to spark plugs. G—Magneto distributor block. L—Flexible coupling between drive shaft and water pump. M—Magneto breaker arm for advancing spark. N—Adjustable coupling and impulse starter on magneto. Coupling provides means for adjusting ignition timing. P—Cover over flywheel inspection opening through which the timing marks on the flywheel may be observed when timing ignition or valves. R—Cover over magneto circuit breaker. S—Flywheel.



Battery Ignition and Wiring Scheme.

A-B-C-D-E-F are wires from distributor to spark plugs. H—High tension wire which carries current to distributor head from outside coil. M—Distributor arm for advancing or retarding ignition. W—Wiring manifold. 1-2-3-4-5-6—Spark plugs.

it is good practice to give it a test as directed above.

FUEL SYSTEM

NOTE—For service information on Carburetors, Automatic Chokes, Governors, Fuel Pumps, Air Cleaners and Gasoline Gauges, see the Table of Contents on page 1.

ELECTRIC SYSTEM

NOTE—For service information on Distributors, Magnetos, Generators, Generator Controls, Starting Motors and Starting Switches, see the Table of Contents on page 1.

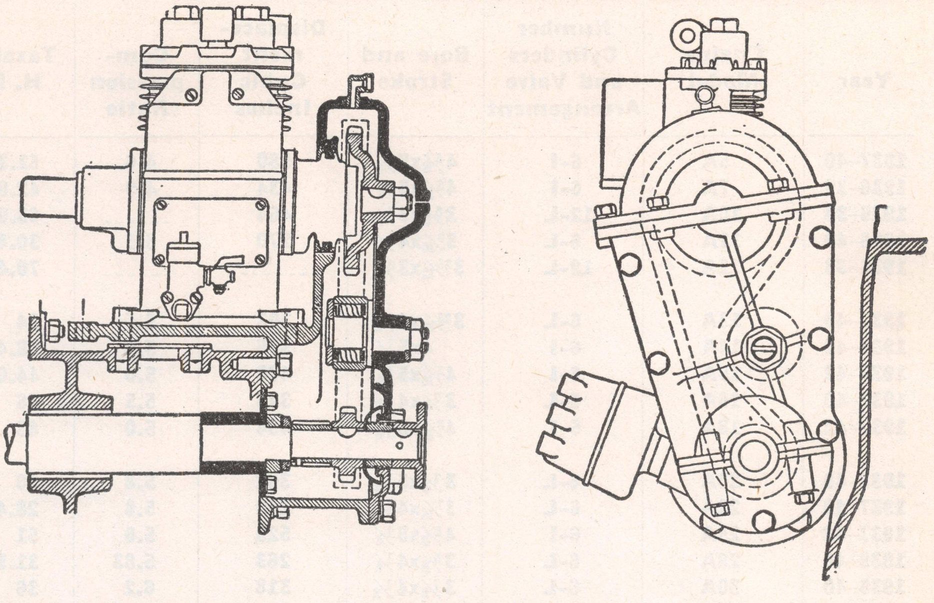


Diagram of chain drive air compressor mounting of early design. Later designs have no idler.

IGNITION TIMING

1936-46: NOTE—Instructions for ignition timing will differ slightly with different makes of electrical equipment, and the following instructions are to be considered general. Firing order on all six-cylinder engines is 1-5-3-6-2-4. On series XAH and XAK, the firing order is 1-2-4-3, while on engines FS, FCS, FL, FC and FCL, the order of firing is 1-3-4-2.

With battery ignition, crank the engine to bring No. 1 piston up on its compression stroke and stop when the "DC" mark on the flywheel is in line with the indicator on the flywheel housing. In this position, the points should just be beginning to open, with the spark retarded and the distributor rotor in the No. 1 firing position.

If equipped with a magneto, crank the engine to bring No. 1 piston up on its compression stroke and stop when the "DC" mark on the flywheel is in line with the indicator on the flywheel housing. Loosen the coupling connection between the magneto shaft and the engine shaft. Remove the breaker cover and the distributor cover. Move the advance arm to the retarded position—which is when the arm is moved as far as it will go in the direction of rotation. Then turn the magneto in the direction of rotation, until the points just begin to open, being sure the rotor is in line with the proper segment to distribute spark to No. 1 cylinder. With the magneto in this position, connect the coupling flanges and replace the breaker and distributor covers.

NOTE—If the magneto is equipped with an impulse coupling, turn the magneto until the impulse coupling trips, then turn it back until the points close, then forward again until the points just open.

The spark may be advanced or retarded to compensate for the grade of fuel being used. Likewise, certain operating conditions may require either more or less spark advance. For best performance and fuel economy, the spark setting should be one which will provide smooth engine performance with a slight "ping" on wide-open throttle at comparatively low vehicle speed

NOTE—For Waukesha engines developed since 1942, see page 915.

Year	Engine Model	Number Cylinders and Valve Arrangement	Bore and Stroke	Displacement Cubic Inches	Compression Ratio	Taxable H. P.	Brake H. P. at R. P. M.	Maximum Torque at R. P. M. Pounds Feet	Oil Capacity Quarts
1937-40	5A	6-I	4⅝x5¾	580	4.6	51.3	130	385	22
1936-38	7A	6-I	4 3/16x5¼	434	4.9	42.08	108@2400	285	22
1936-38	10A	12-L	3⅝x3¾	464	------	63.08	128@2600	---------	16
1936-40	11A	6-L	3 9/16x4½	270	5.5	30.4	77@3000	181½	12
1936-38	12A	12-L	3 25/32x3¾	---------	------	70.42	143@2800	---------	16
1937-40	13A	6-L	3 25/32x4½	303	5.5	34	85	218	12
1937-40	14A	6-I	4x5¼	396	5.0	38.4	105	260	18
1937-42	15A	6-I	4 5/16x5¼	460	5.0	44.6	124@2400	320@1000	18
1937-40	16A	6-L	3⅞x4½	318	5.5	36	94	232	12
1937-42	18A	6-I	4 3/16x5¼	434	5.0	45	108	285	18
1937-40	20A	6-L	3⅞x5½	362	5.8	36	116	280	12½
1937-40	21A	6-L	3 7/16x4½	250	5.8	28.4	68@2600	175@800	12
1937-42	25A	6-I	4⅝x5¼	529	5.0	51	126@2400	365@1000	18
1939-40	29A	6-L	3⅝x4¼	263	5.83	31.54	79@2600	183@1000	6
1938-40	30A	6-L	3⅞x4½	318	6.2	36	110	245	12½
1939-40	33A	6-L	4x4¼	320	5.78	38.4	95	224	6
1941-46	100A	6-L	3 7/16x4½	250	6.75	28.4	90@2600	185@1200	12
1941-46	110A	6-L	3 9/16x4½	270	6.5	30.5	100@2600	200@1100	12
1941-46	120A	6-L	3⅞x4½	318	6.4	36.0	110@2600	250@1000	12
1941-46	140A	6-L	3⅞x5⅛	362	6.28	36.0	125@2600	285@1100	12
1938-40	205	6-L	3¼x4⅛	205	5.85	25.35	50@2100	143@1000	6
1939-40	221	6-L	3⅜x4⅛	221	5.85	27.34	68½@3000	154@1000	6

TUNE UP CHART

Year	Engine Model	Firing Order	Spark Plug Gap	Breaker Gap	Cam Angle, Degrees	Timing Mark Location	Spark Timing, Degrees	Tappet Clearance For Running, Hot Int.	Tappet Clearance For Running, Hot Exh.	Tappet Clearance For Timing, Intake ①	Battery Terminal Grounded
1937-40	5A	153624	.022	.016-.018	35	Flywheel	TDC	.020	.025	.020	Positive
1936-38	7A	153624	.022	.016-.018	35	Flywheel	TDC	.020	.025	.020	Positive
1936-38	10A	③	.025	.018-.024	37④	Flywheel	---------	.000	.000	.000	Positive
1936-40	11A	153624	.022	.018-.024	35	Flywheel	12 BTDC	.012	.016	.012	Positive
1936-38	12A	③	.025	.018-.024	37④	Flywheel	---------	.000	.000	.000	Positive
1937-40	13A	153624	.022	.018-.024	35	Flywheel	12 BTDC	.012	.020	.012	Positive
1937-40	14A	153624	.022	.018-.024	35	Flywheel	TDC	.020	.025	.020	Positive
1937-42	15A	153624	.025	.018-.024	35	Flywheel	TDC	.020	.025	.020	Positive
1937-40	16A	153624	.022	.018-.024	35	Flywheel	12 BTDC	.012	.020	.012	Positive
1937-42	18A	153624	.025	.018-.024	35	Flywheel	TDC	.020	.025	.020	Positive
1937-40	20A	153624	.025-.028	.018-.024	35	Flywheel	7 BTDC	.000	.000	.000	Positive
1937-40	21A	153624	.025-.028	.018	36	Flywheel	7 BTDC	.010	.012	.010	Positive
1937-42	25A	153624	.025-.028	.018	35	Flywheel	TDC	.020	.025	.020	Positive
1939-40	29A	153624	.030	.020	35	Flywheel	TDC	.006	.006	.010②	Positive
1938-40	30A	153624	.025-.028	.018-.024	35	Flywheel	1½ BTDC	.000	.000	.000	Positive
1939-40	33A	153624	.030	.020	35	Flywheel	TDC	.006	.006	.010②	Positive
1941-46	100A	153624	.025-.028	.018	35	Flywheel	7 BTDC	.000	.000	.000	Positive
1941-46	110A	153624	.025-.028	.018	35	Flywheel	7 BTDC	.000	.000	.000	Positive
1941-46	120A	153624	.025-.028	.018	35	Flywheel	7 BTDC	.000	.000	.000	Positive
1941-46	140A	153624	.025-.028	.018	35	Flywheel	7 BTDC	.000	.000	.000	Positive

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TUNE UP CHART

Year	Engine Model	Firing Order	Spark Plug Gap	Breaker Gap	Cam Angle, Degrees	Timing Mark Location	Spark Timing, Degrees	Tappet Clearance			Battery Terminal Grounded
								For Running, Hot		For Timing, Intake①	
								Int.	Exh.		
1938-40	205	153624	.030	.018	35	Flywheel	TDC	.008	.010	.010②	Positive
1939-40	221	153624	.030	.018	35	Flywheel	TDC	.008	.010	.010②	Positive

① Set when engine is at operating temperature.
② Set with engine cold.
③ Firing order: 1R, 2L, 5R, 6L, 3R, 4L, 6R, 1L, 2R, 3L, 4R, 5L.
④ Firing interval 30-30 cam degrees.

VALVE SYSTEM

Year	Engine Model	Stem Clearance		Tappet Guide Clearance	Tappet Clearance				Valve Spring Pressure Test②		Valve Seat Angle Degrees
					Running, Hot		Timing①				
		Intake	Exhaust		In-take	Ex-haust	In-take	Ex-haust	Free Length, Inches	Pounds at Inches, Length	
1937-40	5A	.004-.0059	.006-.009	.001	.020	.025	.020	.025	3 15/16	86-94@2 3/8	45
1936-38	7A	.004-.0059	.005-.0069	.001	.020	.025	.020	.025	③2 1/2 ④3	③68-72@1 3/4 ④58-62@2 1/8	45
1936-38	10A	.0015-.0025	.003-.004	.001	.015	.022	.015	.022	3	------------	--
1936-40	11A	.001-.002	.004-.005	.001	.012	.016	.012	.016	3 1/32	99-107@2 1/32	45
1936-38	12A	.0015-.0025	.003-.004	.001	.015	.022	.015	.022	3	------------	--
1937-40	13A	.0035-.004	.004-.005	.001	.012	.020	.012	.020	3 1/32	99-107@2 1/32	45
1937-40	14A	.004-.0059	.005-.0069	.001	.020	.025	.020	.025	③2 1/2 ④3	③68-72@1 3/4 ④58-62@2 1/8	45
1937-42	15A	.004-.0059	.005-.0069	.001	.020	.025	.020	.025	③2 1/2 ④3	③68-72@1 3/4 ④58-62@2 1/8	45
1937-40	16A	.0035-.004	.004-.005	.001	.012	.020	.012	.020	3 1/32	99-107@2 1/32	45
1937-42	18A	.004-.0059	.005-.0069	.001	.020	.025	.020	.025	③2 1/2 ④3	③68-72@1 3/4 ④58-62@2 1/8	45
1937-40	20A	.0015-.0025	.0015-.0025	.001	.000	.000	.000	.000	3 3/16	119-127@2	45
1937-40	21A	.0015-.0025	.0015-.0025	.001	.010	.012	.010	.012	3 1/32	99-107@2 1/32	45
1937-42	25A	.004-.0059	.005-.0069	.001	.020	.025	.020	.025	③2 1/2 ④3	③68-72@1 3/4 ④58-62@2 1/8	45
1939-40	29A	.001-.0015	.001-.0015	.001	.006	.006	.010⑤	.016⑤	2 13/16	59-62@1 19/32	45
1938-40	30A	.0015-.0025	.0015-.0025	.001	.000	.000	.000	.000	3 3/16	119-127@2	45
1939-40	33A	.001-.0015	.001-.0015	.001	.006	.006	.006	.006	2 13/16	59-62@1 19/32	45
1941-46	100A	.0015-.0025	.003-.004	.001	.000	.000	.000	.000	3 1/32	99-107@2 1/32	45
1941-46	110A	.0015-.0025	.003-.004	.001	.000	.000	.000	.000	3 1/32	99-107@2 1/32	45
1941-46	120A	.0015-.0025	.003-.004	.001	.000	.000	.000	.000	3 1/32	99-107@2 1/32	45
1941-46	140A	.0015-.0025	.003-.004	.001	.000	.000	.000	.000	3 1/32	99-107@2 1/32	45
1938-40	205	.001-.0015	.001-.0015	.001	.008	.010	.008	.010	2 1/16	37@1 9/32	45
1939-40	221	-------	-------	.001	.008	.010	.008	.010	2 1/16	37@1 9/32	30

① Set when engine is at operating temperature.
② 15 percent loss permissible before spring replacement is required.
③ Inner spring.
④ Outer spring.
⑤ Set with engine cold.

PISTON AND RING CLEARANCES

Year	Engine Model	Piston Skirt, Inches		Fitting Pistons with Shim and Spring Scale		Ring End Gap, Inch		Ring and Groove, Inch	
		Top	Bottom	Shim Thickness	Pounds Pull on Scale	Compression	Oil	Compression	Oil
1937–40	5A	④	.0025①	.004①	5–10	.013–.018⑤ .010–.015⑥	.010–.018	.0015–.002⑤ .001–.0015⑥	.001–.0015
1936–38	7A	④	.0025	③	③	.013–.018	.010–.018	.0015–.002⑤ .001–.0015⑥	.001–.0015
1936–38	10A	④	-------	-------	-------	-------	-------	---------	-------
1936–40	11A	④	.0025①	.004①	5–10	.010–.015	.010–.018	.002–.0025⑤ .0015–.002⑥	.0015–.002
1936–38	12A	④	-------	-------	-------	-------	-----	---------	-------
1937–40	13A	④	.0025①	.004①	5–10	.010–.015	.010–.015⑦ .010–.018⑧	.002–.0025⑤ .0015–.002⑥	.0015–.002
1937–40	14A	④	.003–.0035	.004① .005②	5–10	.010–.015	.010–.018	.0015–.002⑤ .001–.0015⑥	.001–.0015
1937–42	15A	④	.003–.0035	.004① .005②	5–10	.010–.020	.010–.020	.0015–.002⑤ .001–.0015⑥	.001–.0015
1937–40	16A	④	.0025	.004	6–11	.010–.015	.010–.015⑦ .010–.018⑧	.002–.0025⑤ .0015–.002⑥	.0015–.002
1937–42	18A	④	.003–.0035	.004① .005②	5–10	.010–.020	.010–.020	.0015–.002⑤ .001–.0015⑥	.001–.0015
1937–40	20A	④	.003–.0035	.004① .005②	6–11① 5–10②	.010–.020	.010–.020	.0015–.002⑤ .001–.0015⑥	.001–.0015
1937–40	21A	④	.0015	-------	-------	.010–.015	.010–.018	.0015–.002⑤ .001–.0015⑥	.001–.0015
1937–42	25A	④	.003–.0035	.004① .005②	5–10	.010–.020	.010–.020	.0015–.002⑤ .001–.0015⑥	.001–.0015
1939–40	29A	④	.003–.0035	-------	-------	.015–.020	.015–.020	.0015–.003	.0015–.003
1938–40	30A	④	.003–.0035	.004① .005②	6–11① 5–10②	.010–.020	.010–.020	.0015–.002⑤ .001–.0015⑥	.001–.0015
1939–40	33A	④	.003–.0035	-------	-------	.015–.020	.015–.020	.0015–.003	.0015–.003
1941–46	100A	④	.002①	.002① .005②	10–15① 5–10②	.007–.017	.007–.017	.0015–.002⑤ .001–.0015⑥	.001–.0015
1941–46	110A	④	.002①	.002① .005②	10–15① 5–10②	.007–.017	.007–.017	.0015–.002⑧ .001–.0015⑥	.001–.0015
1941–46	120A	④	.004① .005②	.004① .005②	7–12① 5–10②	.010–.020	.010–.020	.0015–.002⑤ .001–.0015⑥	.001–.0015
1941–46	140A	④	.004① .005②	.004① .005②	7–12① 5–10②	.010–.020	.010–.020	.0015–.002⑥ .001–.0015⑥	.001–.0015
1938–40	205	④	.003	③	③	.015–.020	.015–.020	.0015–.003	.0015–.003
1939–40	221	⑦	.003	③	③	.015–.020	.015–.020	.0015–.003	.0015–.003

① "Lo-Ex" pistons.
② "X-113" pistons.
③ Pass on .003″; lock on .004″.
④ Measure at bottom of skirt.
⑤ Top ring.
⑥ Lower compression rings.
⑦ No. 3 ring.
⑧ No. 4 ring.

ENGINE BEARING SPECIFICATIONS

Year	Engine Model	Camshaft		Connecting Rod			Mains				
		Journal Diameter	Clearance	Journal Diameter	Clearance	Bearing Bolt Tension Lb. Ft.	Journal Diameter	Clearance	Bearing Bolt Tension Lb. Ft.	Thrust on No.	End-play
1937-40	5A	③	.001-.003	2.6245-2.625	.002-.0035	---	2.9995-3.000	.0035-.0045	---	---	-----
1936-38	7A	②	.001-.003	2.3745-2.375	.002-.0035	28-32	2.7495-2.750	.002-.0035	---	4	.005-.007
1936-38	10A	----------	--------	2.437-2.438	.0025-.0045	---	2.8745-2.8755	.002	---	---	-----
1936-40	11A	2.2495	.001-.003	2.187-2.188	.002	48-52	2.8745-2.8755	.002	70-75	4	.008
1936-38	12A	----------	--------	2.437-2.438	.0025-.0045	---	2.8745-2.8755	.002	---	---	-----
1937-40	13A	2.2495	.001-.003	2.187-2.188	.002	48-52	2.8745-2.8755	.002	70-75	4	.008
1937-40	14A	②	.001-.003	2.3745-2.3755	.002	28-32	2.7495-2.7505	.002	⑤	4	.005-.007
1937-42	15A	②	.001-.003	2.3745-2.3755	.002	28-32	2.7495-2.7505	.002	⑤	4	.007-.010
1937-40	16A	2.2495	.001-.003	2.187-2.188	.002	48-52	2.8745-2.8755	.002	70-75	4	.008
1937-42	18A	②	.001-.003	2.3745-2.3755	.002	28-32	2.7495-27.505	.002	⑤	4	.003-.009
1937-40	20A	2.249-2.250	.001-.003	2.187-2.188	.002-.004	48-52	2.9995-3.0005	.0025-.0045	70-75	4	.008
1937-40	21A	2.2495	.001-.003	2.187-2.188	.002-.0035	28-32	2.8745-2.8755	.002-.0035	70-75	4	.008
1937-42	25A	②	.001-.003	2.3745-2.3755	.002-.004	28-32	2.7495-2.7505	.002	⑤	4	.007-.010
1939-40	29A	2.053-2.054	.0015-.0025	1.987-1.988	.0015-.002	56	2.497-2.498	.002-.0025	④	7	.002-.004
1938-40	30A	2.249-2.250	.001-.003	2.187-2.188	.0025-.0035	48-52	2.8745-2.8755	.0035-.0045	70-75	4	.008
1939-40	33A	2.053-2.054	.0015-.0025	1.987-1.988	.0015-.002	56	2.497-2.498	.002-.0025	④	7	.002-.004
1941-46	100A	2.249-2.250	.001-.003	2.187-2.188	.0025-.0035	48-52	2.9995-3.0005	.0035-.0045	70-75	4	.008
1941-46	110A	2.249-2.250	.001-.003	2.187-2.188	.0025-.0035	48-52	2.9995-3.0005	.0035-.0045	70-75	4	.008
1941-46	120A	2.249-2.250	.001-.003	2.187-2.188	.0025-.0035	48-52	2.9995-3.0005	.0035-.0045	70-75	4	.008
1941-46	140A	2.249-2.250	.001-.003	2.187-2.188	.0025-.0035	48-52	2.9995-3.0005	.0035-.0045	70-75	4	.008
1938-40	205	1.750-1.751	.0015-.0025	1.987-1.988	.0015-.002	38½	2.497-2.498	.002-.003	④	7	.002-.004
1939-40	221	1.750-1.751	.0015-.0025	1.987-1.988	.0015-.002	38½	2.497-2.498	.002-.003	④	7	.002-.004

① For 7/16" bolts, 48 to 52 lbs. ft.; ½" bolts, 70 to 75 lbs. ft.

② No. 1, 2.1535". No. 2, 2.1435". No. 3, 2.1335". No. 4, 2.1235". No. 5, 2.1135". No. 6, 2.1035". No. 7, 1.7487".

③ No. 1, 2.123". No. 2, 2.113". No. 3, 2.103". No. 4, 2.093". No. 5, 2.083". No. 6, 2.073". No. 7, 1.498".

④ 7/16" bolts, 59½ lbs. ft.; ½" bolts, 70 lbs. ft.

⑤ ½" bolts, 70 to 75 lbs. ft.; ⅝" bolts, 140 to 150 lbs. ft.

ENGINE

CYLINDER HEAD

1936-46 All: Cylinder head nuts should be tightened down by starting from the center and working in a criss-cross fashion toward the sides and to the ends. Draw down the nuts evenly and repeat the operation until all are normally tight. After the engine has been run sufficiently long to bring all the parts to normal operating temperature, a final tightening should be made.

NOTE—When using a torque indicating wrench, the final tightening should be within the torque values recommended by the wrench manufacturer. If two torque values are shown, use the lower limit for clean and oily threads, and the high limit for clean and dry threads. In any case, the threads should be free from rust or dirt, otherwise a false reading will be obtained due to the increased friction. When the final tightening is made on overhead valve engines, check the valve clearances according to the recommendations given in the VALVE SYSTEM table.

ROCKER ARMS & PUSH RODS

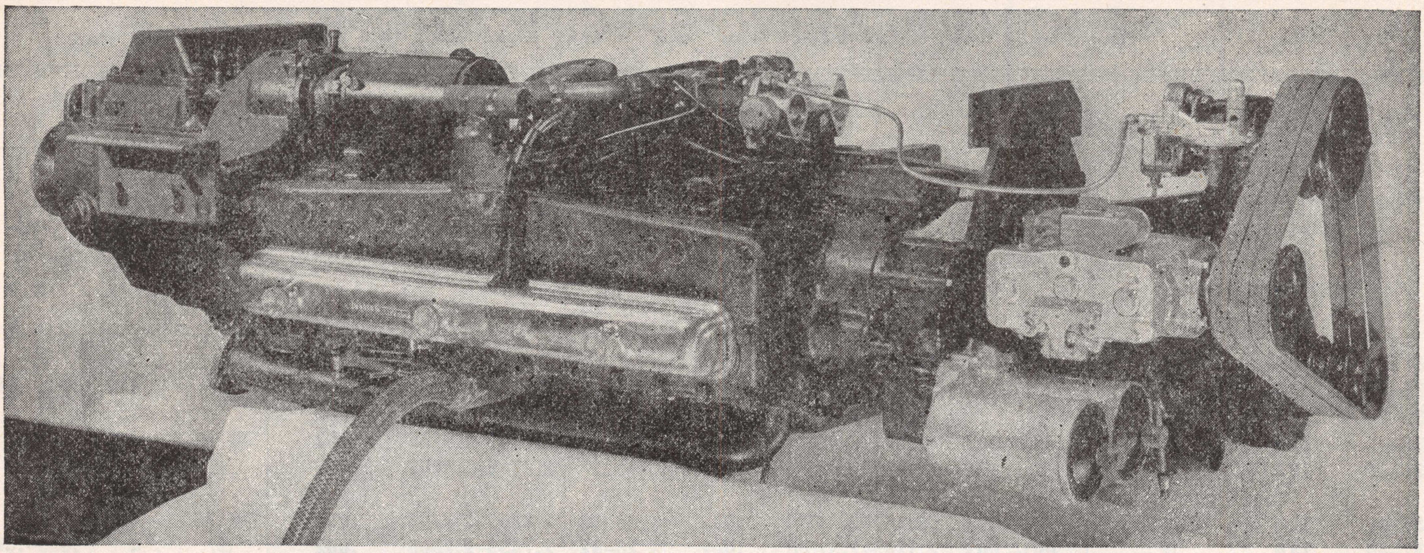
Overhead Valve Engines: When disassembling the rocker shaft assembly, place all parts on the bench in their proper relationship to assure correct assembly. To prevent the possibility of bending or twisting push rods, they should always be removed before taking off the cylinder head, and replaced after the head is installed.

NOTE—Due to the wear on the balls, push rods should always be replaced in their original position. Before assembling rocker arms, be sure the faces are free from pits or rough spots, otherwise it will be difficult to maintain the proper valve clearance.

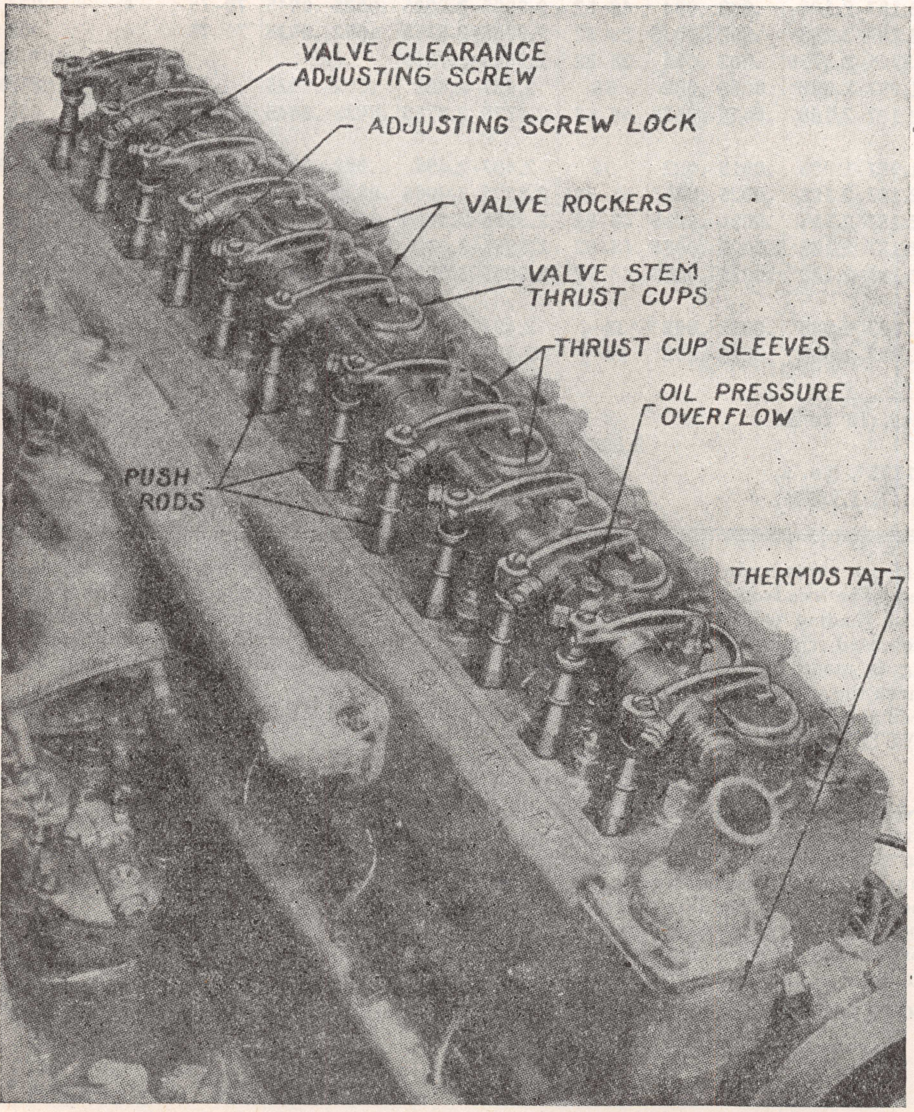
VALVE SEAT INSERTS

1936-46: Some of these engines are equipped with inserts which are screwed into the cylinder block while others are of the pressed-in type. Since it requires special equipment to install the screwed-in type no attempt should be made to remove this type insert unless this equipment is at hand.

If the engine being serviced is equipped with the pressed-in type insert, and if replacement is necessary, special puller and driver equipment is available to perform this operation. However, if this equipment



12-Cylinder Engine. Three-quarter right front view. Bus application. Truck engine similar except for some accessories.



Overhead valve mechanism.

is not at hand, the following method may be used:

Use a drill which is smaller in diameter than the width of the insert and drill two holes at opposite sides, but not all the way through. Cut through the undrilled portion of the insert with a sharp chisel and remove the two pieces.

To install this type insert, pack in "dry ice" for at least fifteen minutes to allow the metal to contract, and heat the exhaust valve port area gradually, if necessary, to permit this material to expand. Then press or drive the insert into the cylinder head or block, as the case may be, using extreme care to see that it is not cocked or misaligned. When installed, the seats should be finished in a manner described in the following paragraph.

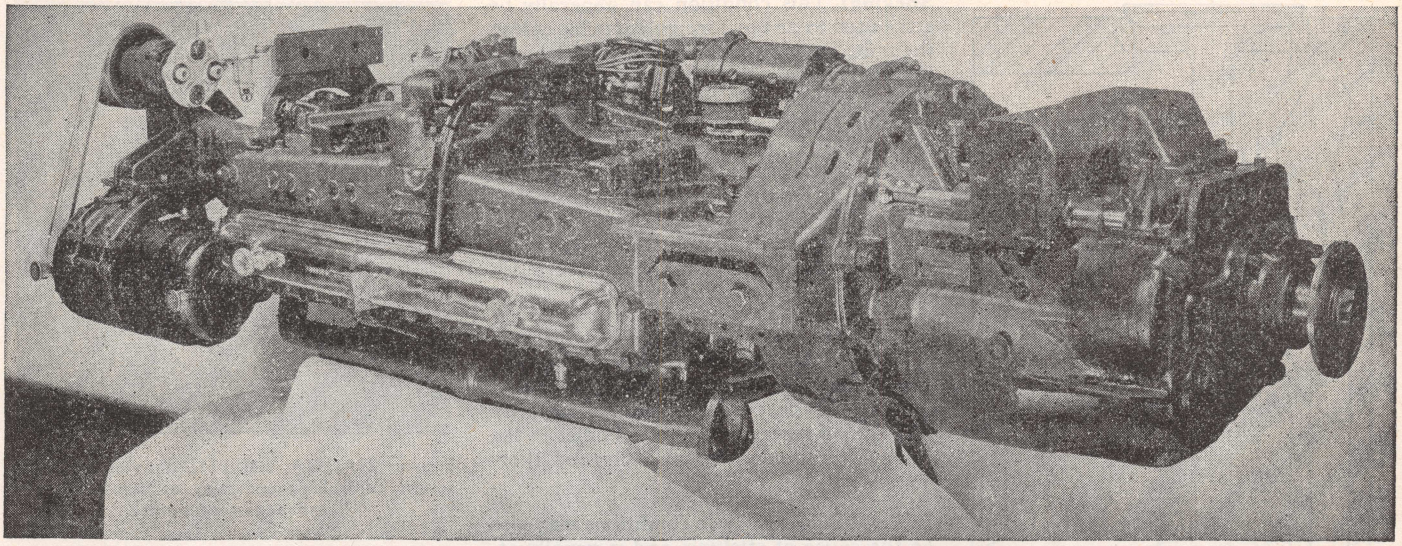
Since these inserts are too hard to reface by the ordinary grinding methods, a high-speed grinding stone or a special lapping tool should be used to perform this operation. When using this equipment, be sure valve guides are clean and the valve guide pilot is a snug fit in order to assure a concentric finish. Finished seats should be checked with a dial indicator and run-out should not exceed .0005".

VALVE SPRING CUP PLUNGERS

Overhead Valve Engines: An inverted cup plunger operates in a small cast iron cylinder and surrounds each outer valve spring. The purpose of this arrangement is to prevent excessive oil from the rocker arm reaching the valve stem, and also prevents any side thrust from the rocker arm being transmitted to the valve stem.

VALVE SPRINGS

1936-46: Whenever valve springs are removed, they should be examined and tested. See the VALVE SYSTEM table for the correct free length and for pressure test recommendations.



12-Cylinder Engine. Three-quarter left rear view. Bus application. Truck engine similar except for some accessories.

NOTE—On overhead valve engines, valve springs can be removed without taking off the cylinder head. When removing any spring, be sure to bring the piston for that cylinder up on top center to prevent the valve from dropping into the cylinder. Depress the end of the rocker arm over the valve until the push rod can be removed from its socket. Then compress the valve spring, remove the spring retainer and lift off the spring.

VALVE STEM GUIDES

1936-46: When necessary to replace guides on L-head engines, remove the tappet and guide cluster assemblies (if equipped), take out the valves and use a suitable puller to remove the guides.

On L-head engines which do not have removable tappet guide clusters, run the tappet adjusting screw all the way down and crank the engine to bring the tappet on the low point of the cam. If a puller is not at hand, use a suitable drift, preferably one having a pilot the same size as the valve stem, to drive out the guide. If the guide comes in contact with the tappet before it is all the way out, break off the lower part.

On overhead valve engines, remove the cylinder head and take off the rocker shaft assembly, remove the valves and springs and pull, or drive, out the guides.

NOTE—On all engines, it is good practice to remove and install one guide at a time. If the engine being serviced has guides with stop collars or shoulders, install the guide until the shoulder is seated against the guide bore. If the guide has no shoulder, the following procedure should be followed: When installing an intake guide, measure the depth of an intake guide not yet removed in order to determine the correct depth of the guide being installed. Similarly, when installing an exhaust guide, measure the position of an exhaust guide not yet removed. When all guides are installed, they should be reamed to provide a clearance within the limits given in the VALVE SYSTEM table.

VALVE TAPPETS & GUIDES

5A, 7A, 14A, 15A, 25A: Tappets must be a free fit in their guides without excessive side play. If the fit is too loose, the guides should be reamed and oversize tappets fitted to provide a clearance within the limits given in the VALVE SYSTEM table.

As these tappets are assembled directly into cast-in guide holes, the camshaft will have to be removed in order to take out the tappets. If the available reaming equipment requires the removal of the valve stem guides, be sure to install new stem guides rather than attempt to use the old ones.

11A, 13A, 16A, 21A: Tappets must be a free fit in their guides without excessive side play. If the fit is too loose, remove the guide cluster from the engine, take out the loose tappet, ream the guide hole and install an oversize tappet, being sure the tappet is provided with a clearance within the limits given in the VALVE SYSTEM table.

NOTE—If all or most of the tappets are too loose a fit, install a new cluster and standard size tappets.

20A, 30A, 100A, 110A, 120A, 140A: These engines are equipped with hydraulic valve lifters, the service of which is fully described in the following chapter.

29A, 33A, 205, 221: Tappet guides in these engines are removable bushings pressed in the block. When necessary to replace, the camshaft will have to be removed and the old bushings pressed out and new ones installed. Then ream the bushings to provide a clearance within the limits given in the VALVE SYSTEM table.

HYDRAULIC VALVE LIFTERS

20A, 30A, 100A, 110A, 120A, 140A: The purpose of the hydraulic lifter is to take up the clearance between the parts making up the valve operating train from the camshaft to the valve stem, under every condition of engine speed, load or temperature. This is accomplished by introducing between the cam and the valve stem, a confined column of oil, the length of which is adjusted automatically every revolution of the camshaft.

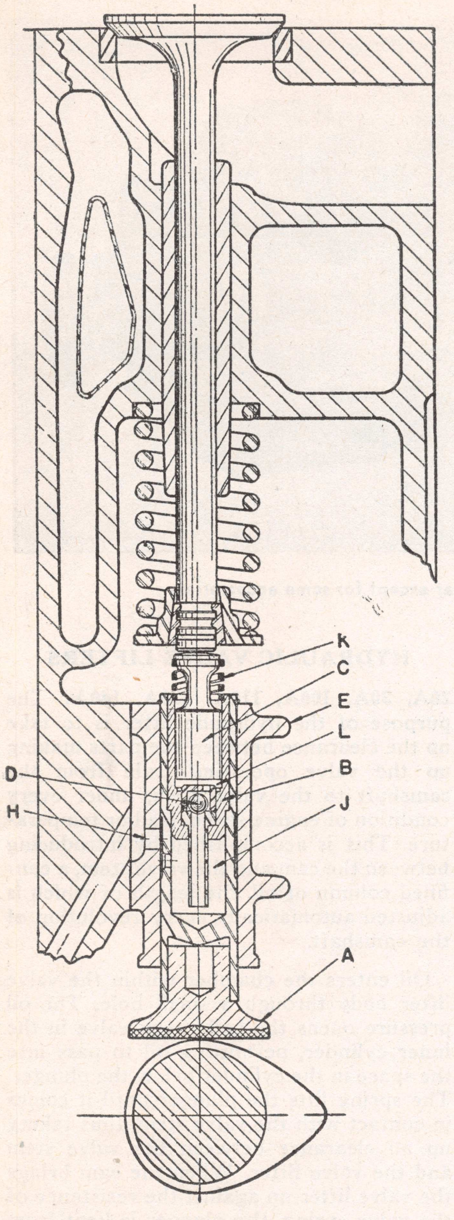
Oil enters the chamber within the valve lifter body through a small hole. The oil pressure opens the ball check valve in the inner cylinder, permitting oil to pass into the space in the cylinder below the plunger. The spring lifts the plunger until it comes in contact with the valve stem, thus taking up all clearance between the valve stem and the valve lifter. When the cam brings the valve lifter up against the resistance of the valve spring, the plunger is kept from sliding down into the cylinder by the oil in the space below the plunger, which is trapped by the closing of the ball check valve.

Noisy Operation can be attributed to any of the following:

1. Incorrect oil level or oil pressure.
2. Dirty, scored or worn plunger parts.
3. A general clatter, affecting all or most of the valves, generally indicates difficulty with the oil supply.

NOTE—Any of the above causes can be corrected without removing the entire valve lifter assemblies.

Oil Level: Oil level should always be maintained according to the markings on the oil level dipstick. If the level is too high, foaming may result, while if the level is too low, air will very likely enter the pump inlet.



Hydraulic valve lifter.
A—Body. B—Cylinder. C—Plunger. D—Ball check valve. H—Inlet hole. J—Supply chamber. K—Plunger return spring. L—Pressure chamber.

Oil Pressure: Extremely high oil pressure may lift the entire hydraulic unit against the plunger spring, permitting excessive plunger movement and wear. Low pressure permits oil relief leakage between the plunger and the cylinder to exceed the oil feed through the ball check.

Noise In One Lifter: A recurring tap or click which is synchronized with the valve action indicates a faulty lifter unit. When this occurs, the plunger unit should be disassembled and inspected for the following:

1. Sticking mechanism.
2. Dirt, pitting or incorrect clearance between the plunger and the cylinder.
3. Operating clearance between the plunger and the valve stem—which should be zero.

Sticking: This condition can generally be attributed to dirt or foreign particles within the unit. To correct this condition, clean all the parts thoroughly after disassembly by wiping with a soft cloth and washing in gasoline. A stuck ball check valve may be unseated by using a blunt tool, after which, be sure to wash the cylinder thoroughly in gasoline. After the parts have been washed thoroughly, blow dry with compressed air, holding the air hose nozzle far enough away to prevent the possibility of moisture adhering to the parts.

NOTE—If sticking was caused by dirt, the oil pan should be removed and cleaned, otherwise the condition may repeat itself in a short time, or perhaps, immediately. Be sure the oil reservoir and bleed holes in the valve lifter guides are also cleaned thoroughly.

Pits and Scores: These conditions may also be the cause of sticking, and is usually attributed to gritty particles, excessive wear, or damage during installation. The remedy for either of these conditions requires the replacement of the cylinder and plunger only, as it is not necessary to replace the valve lifter body. Slight scratches on the valve lifter body will not effect the operation of either the engine or the hydraulic lifters.

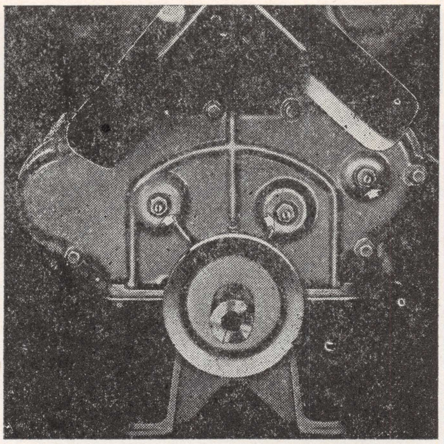
Operating Clearance: Incorrect clearance between the cylinder and the plunger can usually be attributed to mismating of parts. The cylinder and plunger are carefully fitted in production and are **not interchangeable.**

Assembling Hydraulic Unit: When reassembling, the following points should be checked.

1. When the cylinder unit is shaken, the ball check should rattle.
2. The plunger should bounce back when pressed quickly into the cylinder and released.
3. The plunger spring should be locked into the cylinder by a twist of the plunger.
4. When the tappet body is free of oil, the cylinder should slide smoothly within the body.

Checking Valve Clearance: With no oil in the hydraulic unit and with the plunger and plunger spring fully depressed, there must always be from .040" to .080" clearance between the valve stem and the top of the plunger. If the clearance is less than .040", grind a few thousandths off the end of the valve stem. This clearance must be measured with a feeler gauge whenever new parts are installed; if the location of parts has been changed, and whenever the valves have been reseated.

Installing Hydraulic Lifters: After the lifters have been installed and the engine is ready for operation, run the engine for a sufficient length of time to allow the hydraulic lifters to become filled with oil—which is indicated by the quiet operation of the lifters.



Engines 29A, 33A, 205, 221. Showing adjusting screws controlling end play of camshaft, idler and accessory shafts.

VALVE TIMING, CHECK

1936-42: With the engine at normal room temperature and No. 1 intake valve tappet set to the clearance for timing as given in the VALVE SYSTEM table, crank the engine until the flywheel mark (given below) is in line with the center of the opening in the flywheel housing. In this position, No. 1 intake valve should be just starting to open.

NOTE—Check valve timing according to the following flywheel marks for No. 1 cylinder, and see the following chapters for correct settings.

5A, 7A, 14A, 15A, 25A, 29A, 33A, 205, 221 . . . "TDC" or "DC".

11A, 13A, 16A, 21A. . . "IN-OP" or "Top DC".

10A, 12A. . . "Top Dead Center Right Hand Bank."

20A, 30A, 100A, 110A, 120A, 140A. . . "TOP-X-DC".

TIMING CHAIN

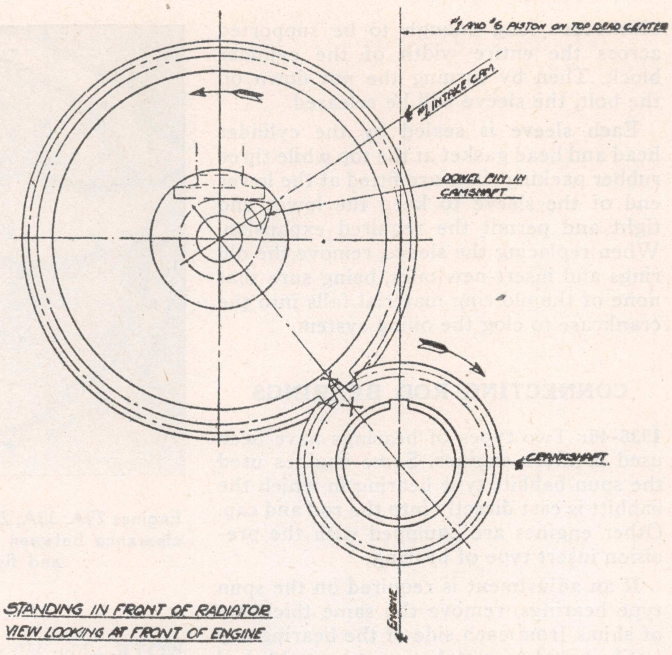
5A, 7A, 14A, 15A, 25A: The tension of the camshaft drive chain is controlled by a spring-loaded, eccentrically-mounted idler sprocket. To install the chain for correct valve timing, rotate the **camshaft** so as to bring the punchmark on its front face to the top position. Then set the **camshaft sprocket** so that there will be **8 spaces or 9 chain link rivets** between the punchmarks on the camshaft and crankshaft sprockets.

Wind up the idler sprocket spring 1½ turns in a clockwise direction to remove all slack in the chain, after which, slip the tongue of the spring into the nearest of the six slots in the stationary stud.

NOTE—Be sure to check and, if necessary adjust the valve clearances to the recommendations given in the VALVE SYSTEM table.

TIMING GEARS

11A, 13A, 16A, 21A: Valve timing is automatically established because the camshaft


#1 AND #6 PISTON ON TOP DEAD CENTER
#1 INTAKE CAM
DOWEL PIN IN CAMSHAFT
CRANKSHAFT
ENGINE
STANDING IN FRONT OF RADIATOR
VIEW LOOKING AT FRONT OF ENGINE

Engines 11A, 13A, 16A.
Timing gear setting.

gear is doweled and held in place with a special notched screw in the end of the shaft. All that is necessary to set the gears correctly is to rotate the crankshaft and camshaft so that when the camshaft gear is installed, the "X" marks on both gears will be meshed.

10A, 12A: Correct valve timing is automatically established on these engines because the camshaft gear is located on the end of the shaft by two pins—one of which is offset. To install the camshaft gear correctly, rotate the crankshaft and camshaft so that when the camshaft gear is installed, the "X" marks on both gears will be meshed.

20A, 30A, 100A, 110A, 120A, 140A: When installing the camshaft gear, rotate the crankshaft and camshaft so that when the camshaft gear is installed, the "X" marks on both gears are meshed.

29A, 33A, 205, 221: On these engines, the camshaft must be removed in order to install a new camshaft gear. This is done by removing the gear cover, crankshaft oil slinger, oil pan, valves, and lift the tappets up out of the way to prevent interference as the camshaft is being withdrawn.

On engines 29A and 33A, the camshaft gear is pressed on from the front and retained by a nut. Since no provision is made to pull the gear from the camshaft with the camshaft in place, the shaft and gear will have to be removed from the engine, and the gear pressed off and on in an arbor press.

For correct valve timing, turn the crankshaft and camshaft so that when the gears are installed, the punchmarks on both gears will be meshed.

NOTE—On 205 and 221 engines, the camshaft gear can only be pressed on from the rear against the flange on the front of the shaft.

CAMSHAFT & BEARINGS

1936-46: On all engines **except 29A, 33A, 205 and 221,** camshaft end play is automatically controlled by a spring-loaded thrust button at the front end of the shaft, requiring no adjustment.

On 29A, 33A, 205 and 221 engines, camshaft end play is controlled by a special screw through the gear cover. At long intervals, or when the engine has been disassembled for repairs, the end play should be checked. If an adjustment is necessary, loosen the lock nut and tighten the screw until the fibre plug in its inner end contacts the steel plug in the front end of the camshaft. Then back off the screw ⅛ turn before tightening the lock nut.

Camshaft Bearings: Two types of bearings are used in these engines. Early production engines used the conventional bushing type bearing which requires line-reaming after installation, while later production engines are equipped with the thin shelled precision type bearings which do not require reaming after installation. An examination of the engine being serviced will readily show which type is used.

When new bearings are installed (regardless of type), be sure the oil holes in the bearings register with the oil holes in the crankcase.

NOTE—When necessary to replace camshaft bearings, they should be installed in sets (particularly those of the shell type).

PISTONS & RODS, REMOVE

1936-46: On all engines, the piston and rod assemblies are removed from the top of the block. Although regular production rods are generally marked with the cylinder number in which they are installed, replacement rods are not; therefore, unmarked rods should be suitably identified with punchmarks, as they are removed.

PISTON & ROD, ASSEMBLE

1936-46: If the engine is equipped with aluminum pistons of the slotted type, they should be assembled to the rods so that when installed in the cylinder bores, the slotted side of the piston is facing away from the camshaft.

PISTONS, RENEW

1936-46 All: NOTE—A variation of 10 degrees between the temperature of the pistons and cylinder bores is sufficient to produce a difference of .0005". Therefore, both the pistons and cylinder bores should be at normal room temperature (about 70 degrees) when fitting pistons. This is particularly important because the clearances given in the PISTON & RING CLEARANCES table are minimum and pistons must not be fitted with less than specified.

Before any attempt is made to fit new pistons, cylinder bores should be carefully indicated and refinished. If bores do not require refinishing, be sure to remove any ridge at the top of each bore. If refinishing is required, it is good practice to do so in alternate cylinders due to the localized temperature build-up. When refinished, cylinder bores should not be out-of-round or tapered more than .0005".

Before fitting pistons, wipe the cylinder walls and pistons to remove all chips, dirt or other foreign matter. The feeler ribbon used to check piston fit should be about 12" long and ½" wide. Consult the PISTON & RING CLEARANCES table for the thickness of shim to use, as well as the recommended pounds pull on a spring scale required to withdraw the feeler ribbon past the piston.

Insert the piston in the bore upside down and in its running position. Place the feeler ribbon between the cylinder wall and the thrust side of the piston (opposite slotted side on aluminum pistons) in a position at right angles to the piston pin hole.

After assembling the piston to the connecting rod, check the assembly for alignment on a suitable jig.

PISTON RINGS, RENEW

1936-46 All: NOTE—To prevent the possibility of bending or breaking the second ring land—thus ruining the piston—the ridge at the top of the cylinder bore should be cut away before removing the piston and rod assemblies. If the available ridge reamer has no provision to control the depth of the cut, it is good practice to bring the piston far enough up into the cylinder to allow the reamer to rest on top of the piston. This will serve to prevent cutting down into the ring travel area.

CAUTION—Never cut down into the ring travel area more than half the depth of the top ring.

New rings should be fitted with end gaps and groove clearances as given in the PISTON & RING CLEARANCES table. Ring grooves must be clean and free from carbon, and must show no perceptible wear

NOTE—Ring end gaps given in the PISTON & RING CLEARANCES table are for cylinder bores without taper. If rings other than standard are being installed, pay particular attention to the installation instructions which are usually included in the ring package. This applies to clearances, position in grooves, etc.

When rings are properly fitted to the pistons, be sure to stagger the ring gaps so they are spaced equal distances around the circumference of the piston. However, see that no gaps are over the piston pins.

PISTON PINS, RENEW

1936-46 All: The correct fit of piston pins in cast iron pistons should be one which requires a light push with the palm of the hand to insert the pin. For aluminum pistons, at normal room temperature, it should require a hard push with the palm of the hand to install the pin. However, to facilitate fitting pins in aluminum pistons, heat the piston in boiling water for a few minutes, after which the pin should enter the piston easily.

To check the fit of pins after installation, hold the piston in both hands and, for aluminum pistons, the weight of the rod should not be sufficient to allow it to fall. When using the same method on cast iron pistons, the rod should drop easily by its own weight.

These pins are of the full-floating type, being held in place by snap rings in the grooves of the piston bosses.

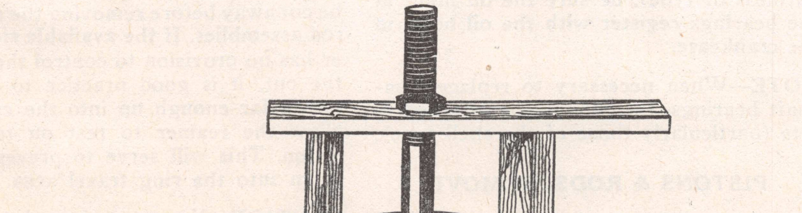
PISTON PIN BUSHINGS

1936-46: New bushings should be pressed in the pistons or connecting rods, as the case may be, and reamed to provide a light push fit of the pins with the parts at normal room temperature. When installed, be sure the oil holes in the bushings are in line with the oil holes in the connecting rods.

CYLINDER SLEEVES

10A, 12A: These engines are equipped with wet type sleeves which can be removed by inserting a long bolt through the sleeve and attach a cross bar at the bottom and at the top, supporting the top cross bar on two wooden blocks, being sure the blocks are long enough to be supported across the entire width of the cylinder block. Then by turning the nut down on the bolt, the sleeve will be released.

Each sleeve is sealed by the cylinder head and head gasket at the top while three rubber packing rings are fitted at the lower end of the sleeve to keep the lower end tight and permit the required expansion. When replacing the sleeve, remove the old rings and insert new ones, being sure that none of the old ring material falls into the crankcase to clog the oiling system.



Method of Removing Wet Type Sleeves.

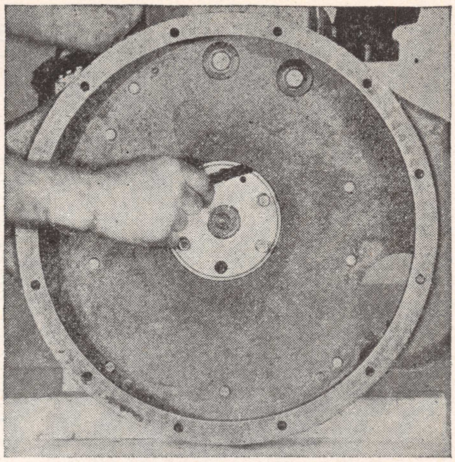
CONNECTING ROD BEARINGS

1936-46: Two types of bearings have been used in these engines. Some engines used the spun babbitt type bearing in which the babbitt is cast directly into the rod and cap. Other engines are equipped with the precision insert type of bearing.

If an adjustment is required on the spun type bearings, remove the same thickness of shims from each side of the bearing cap until a metal-to-metal contact is established with the crankpin. The bearing may then be scraped to provide maximum bearing surface, and sufficient shims installed on both sides to provide a clearance within the limits given in the ENGINE BEARING SPECIFICATIONS table.

If the engine being serviced is equipped with the precision insert shell type bearing, they may be replaced by simply taking off the bearing caps and slip the old shells out and the new ones in. Bearings should be replaced in sets and under no circumstances should the rods or caps be filed, altered or mutilated in any way in an attempt to obtain proper bearing fit.

NOTE—Before replacing bearings, make sure that the crankpins are not nicked or scored, and that all parts are thoroughly clean. This is particularly important because the presence of one small particle of metal, carbon or other foreign matter, lodged between the back of the bearing and the rod, or between the face of the bearing and the crankpin, will very likely cause a hot spot due to the elimination of the oil clearance at that point, eventually resulting in a bearing failure or a scored crankpin.



Engines 29A, 33A, 205, 221. Method of checking clearance between crankshaft oil slinger flange and flywheel housing.

NOTE—The White Company recommends the use of lead wire to check the fit of bearings. With this method, apply a coat of 20 SAE oil to the bearing to be checked and place a short length of wire, about ⅜" long, on each end of the rod bearing of the crank, parallel to the center line of the crankshaft. Then install the connecting rod and cap, rotating the crank about 15 degrees as the bearing cap nuts are being tightened. When the bearing caps have been tightened to the recommended torque tension, free up the bearing by rotating the crank in the 15-degree arc as described above and remove the cap and checking wire. When the wire is "miked", it will give the clearance of the new bearing. If the clearance is too great, the crankpins should be turned down and undersize bearings fitted.

CAUTION—In the majority of these engines, the bearings are designed for use without shims and under no circumstances should they be used in an attempt to obtain proper bearing fit. The use of shims with this type bearing will prevent the proper "crush" fit of the bearings in the connecting rod bores. On engines **29A and 33A**, a .009" shim pack is used between the bearing cap and rod **only on the side opposite the bearing lock notch.** When new bearings are installed, never use more than .009" of shims at this point; nor should these shims be left out as by so doing, the bearings will buckle when the cap bolts are tightened.

MAIN BEARINGS

1936-46: When replacing bearings, make sure the crankshaft journals are not nicked or scored. Use care also, to see that all parts are thoroughly clean and that all oil passages are open. The importance of cleanliness cannot be over-stressed as the presence of one small particle of metal, carbon or other foreign matter, lodged between the back of the bearing and the cap or saddle, or between the bearing face and the crankshaft journal, will very likely cause a hot spot due to the elimination of the oil clearance at that point, eventually resulting in a bearing failure or a scored journal.

IMPORTANT—When necessary to replace bearings in 12-cylinder engines (10A and 12A), they must be line-bored in order to obtain an even contact on all bearings, should any of the bearing saddles or caps be distorted. It is good practice to fit bearings in any engine in this manner, and for the same reason.

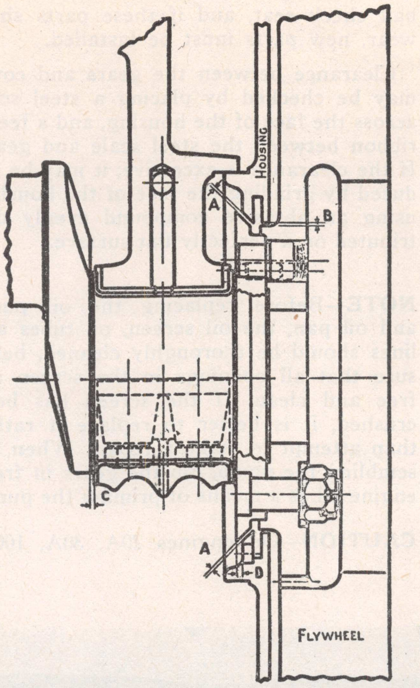
However, when bearings become worn, and the line-boring operation is not to be performed (on 12's it must be), they can be replaced without removing the crankshaft in the following manner: Remove the bearing cap and take out the worn lower shell. A suitable tool can be made to remove the upper shell by using a cotter pin with the rounded end flattened to form a T-shape. Insert the long end of the pin in the oil passage hole in the crankshaft journal and, by rotating the crankshaft in the reverse direction, the T-shaped head will contact the bearing and force it out.

To install, place a new upper shell on the crankshaft journal with the locating notch in the correct position and rotate the shaft to turn the shell in place. Then install the lower shell in the cap and replace the cap, being sure the proper thickness shim pack (if used) is placed between the cap and support. Then tighten the cap bolts to the recommended torque tension.

CAUTION—On all engines except 29A, 33A, 205 and 221, no shims are used between the bearing cap and support. Under no circumstances should shims be used in this installation because the proper "crush" fit will not be obtained. On engines 29A, 33A, 205 and 221, a .009" shim pack is used on both sides between the cap and support. When installing bearings of this design, be sure to install the correct thickness of shims. If the shims are eliminated the bearings will buckle when the cap bolts are tightened. This "buckling" condition will also result if the shims are permitted to project between the bearing shells.

To check the fit of new bearings, follow the same procedure as described for checking the fit of connecting rod bearings except that, with the checking wire in place and the cap bolts tightened to the recommended torque tension, the bearings may be considered fitted properly if the crankshaft is movable with a fairly heavy drag when the shaft is rocked through an arc of 2"—not more than 1" in either direction.

NOTE—On engines 29A, 33A, 205 and 221, bearing clearance may be reduced .001" at a time by removing a .003" shim from each side and substituting a .002" shim on each side. To increase clearance .001" at a time, remove a .002" shim and install a .003" shim on each side.

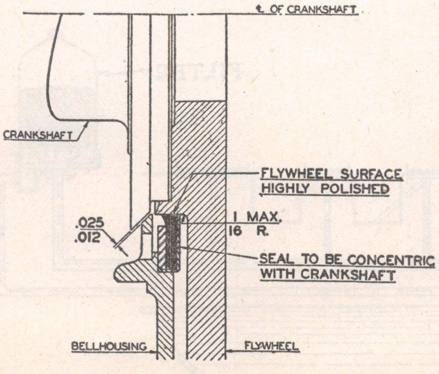


Engines 29A, 33A, 205, 221. Clearance between crankshaft oil slinger and flywheel housing chamfer ("A" in cut) must be from .012" to .025".

On all engines, if the bearing fit is satisfactory, remove the checking shim and replace the cap, but do not tighten the cap bolts, as this bearing must remain loose in order to check the fit of the other bearings. It is good practice to fit bearings by starting from the center, then the rear, the front, and finally, the intermediates.

CRANKSHAFT END THRUST

1936-46: Crankshaft end thrust is controlled by thrust washers or flanges on either side of a bearing (see the ENGINE BEARING SPECIFICATIONS table for the bearing which takes the thrust and for the proper end play limits).


℄ OF CRANKSHAFT
CRANKSHAFT
FLYWHEEL SURFACE HIGHLY POLISHED
.025
.012
1/16 MAX. R.
SEAL TO BE CONCENTRIC WITH CRANKSHAFT
BELLHOUSING
FLYWHEEL

Engines 29A, 33A, 205, 221. Special oil seal installation.

Through normal wear, the end play will seldom become excessive but whenever new bearings are fitted, the clearance should be carefully checked and, if required, thicker thrust washers may be installed to obtain the desired end play.

CRANKSHAFT OIL SEALS

1936-46: On all engines except 29A, 33A, 205, 221 and the 12-cylinder engines, oil sealing at the rear main bearing is controlled by an oil slinger, integral with the crankshaft, running in a groove having a cored hole leading into the oil sump.

On the 12-cylinder engines, the engine oil supplies the wet clutch with oil for its operation.

NOTE—On engines 29A, 33A, 205 and 221, if a new flywheel housing is being installed or if the engine has been disassembled for repairs, the clearance between the crankshaft oil slinger flange and the flywheel housing must be carefully controlled when assembling the engine, to prevent oil leaks.

To measure the clearance, force the crankshaft back to the limit of its end play and insert a feeler gauge between the oil slinger flange and the flywheel housing chamfer. The clearance should not be less than .012" nor more than .025". If necessary to increase clearance, scrape the flywheel housing chamfer and install an additional gasket between the housing and the crankcase. To prevent oil leaks, all possible chance of interference or rubbing should be eliminated at this point.

NOTE—Flywheel housings on some of these engines are equipped with a special type oil seal, and when this type is used, it is important that the seal be concentric with the crankshaft. To prevent rapid wear of this seal, the external pilot of the flywheel hub should be polished with a fine emery or crocus cloth to remove all nicks or rough spots.

FLYWHEEL

1936-46: Whenever replacing the flywheel, it should be checked for wobble or excessive run-out. If a dial indicator is available, mount it on the flywheel housing and allow its stem to contact the flywheel as the engine is being turned slowly. Make a note of the high and low sides of the flywheel through one complete revolution and if run-out exceeds .010", it should be removed and the crankshaft flange recess inspected for burrs, dirt or other foreign matter.

NOTE—Whenever the flywheel is to be removed, always mark the clutch cover and flywheel so that when the flywheel is re-installed, the original balance will be maintained.

ENGINE OILING

OIL PUMP

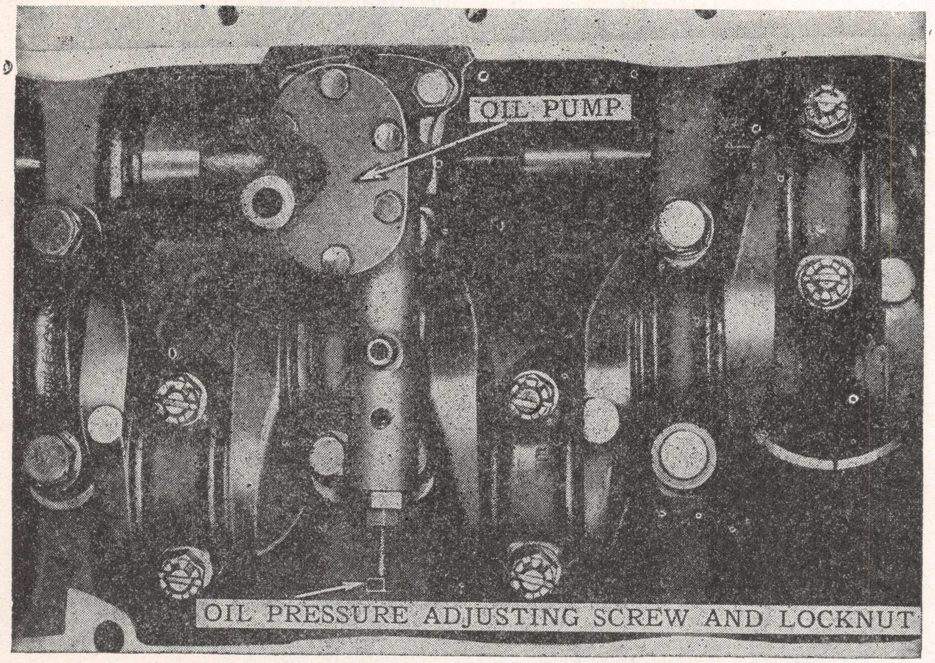
1936-46: On all engines, if the oil pressure drops below normal, do not remove the oil pump until the oil gauge is checked with another gauge known to be accurate. Check the oil level and examine the condition of the oil. If these items are correct and the pressure continues to drop, remove and clean the oil pan thoroughly, and disassemble, clean and inspect the pump and oil pressure regulator.

The pump is easily removed for inspection or repairs after the oil pan is removed. To disassemble the pump, drive the pin out of the hub of the upper spiral drive gear and pull the gear from the shaft. Remove the oil pump bottom cover and withdraw the gears and shaft. Be sure to examine the pump pressure ball check, spring and ball check seat, and if these parts show wear, new parts must be installed.

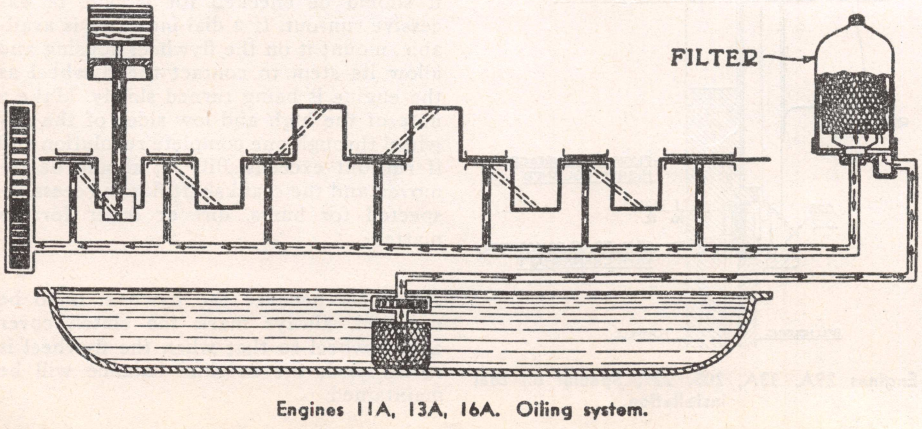
Clearance between the gears and cover may be checked by placing a steel scale across the face of the housing, and a feeler ribbon between the steel scale and gears. If the clearance is excessive, it may be reduced by grinding the face of the housing, using an abrasive compound evenly distributed on a perfectly flat surface.

NOTE—Before replacing the oil pump and oil pan, the oil screen, oil tubes and lines should be thoroughly cleaned, being sure that all openings in the screen are free and clean. If the screen has been crushed, it is better to replace it rather than attempt to make a repair. When assembling the pump, dip the gears in fresh engine oil as a means of priming the pump.

CAUTION—On engines 20A, 30A, 100A, 110A, 120A and 140A, whenever it is necessary to remove the oil pump from the engine, it is advisable to remove the ignition distributor as well, since it is driven directly from an extension of the oil pump shaft. When re-installing the oil pump, crank the engine to bring No. 1 piston up on its compression stroke and stop when the steel ball in the flywheel is in the center of the inspection hole in the flywheel housing. With the engine in this position, assemble the oil pump to the crankcase and install the oil pump extension shaft that drives the distributor. With the tongue on the lower end of this shaft in mesh with the groove in the end of the oil pump main drive shaft, check the position of the groove in the upper, or distributor, end of the extension shaft. This groove should be set at a 45 degree angle to the centerline of the crankshaft with the heavy side toward the front of the engine as shown in the illustration. The location of the oil pump drive gears may not permit exact positioning of the groove; however, make sure that the pump gear is not meshing one or more teeth off the described position.



Engines 29A, 33A, 205, 221.



Engines 11A, 13A, 16A. Oiling system.

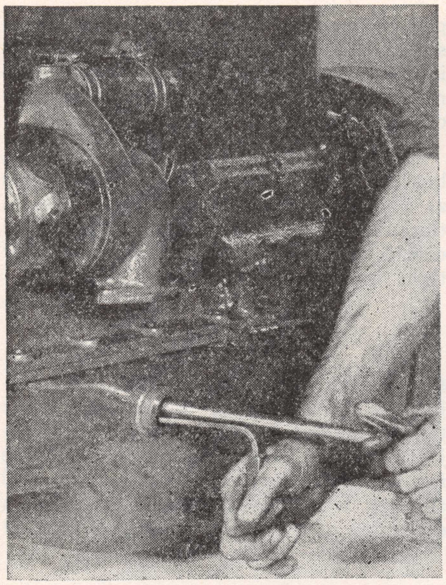
OIL PRESSURE REGULATOR

NOTE—On all engines, oil pressure is automatically controlled by a compression spring which controls the action of a relief or by-pass valve. Oil pressure should not be judged to be too high or too low until it is known whether the proper weight of oil is being used, and the engine is warmed up to normal operating temperature. As the engine bearings become worn, the oil pressure will be slightly lower due to more oil escaping around the bearings. It is not advisable to try to correct this slight pressure loss by an adjustment of the pressure regulator, because the extra amount of oil being thrown off by the worn bearings is already overoiling the cylinder walls.

5A, 7A, 11A, 13A, 14A, 15A, 16A, 21A, 25A: The oil pressure relief valve is located at the forward end of the crankcase on the generator side of the engine. The pressure is regulated by turning the adjusting screw in (clockwise) to increase pressure, and out to decrease it.

10A, 12A, 20A, 30A, 100A, 110A, 120A, 140A: The pressure regulator is incorporated within the oil pump and is not adjustable.

29A, 33A, 205, 221: In these engines, the pressure regulator is incorporated within the oil pump and can be adjusted without taking off the oil pan. If an adjustment is required, remove the pipe plug from the side of the oil pan (opposite camshaft side) and, with the use of special wrenches, an adjustment can be made. Using a special "crow foot" wrench through the oil plug hole, loosen the lock nut and then, with a T-handle socket, turn the adjusting screw clockwise to increase pressure and counter-clockwise to decrease the pressure. Be sure to tighten the lock nut when the adjustment is satisfactory.



Engines 29A, 33A, 205, 221. Method of adjusting oil pressure with T-handle socket and "crow foot" wrench.

OIL TEMPERATURE REGULATOR

Some of these engines are equipped with an oil temperature regulator which consists of a radiator type core enclosed in a housing, connected with both the cooling and oiling systems. Oil and water flows through passages at right angles to each other and are separated by thin copper walls. As the oil passes through the regulator, the water temperature raises or lowers the oil temperature, maintaining proper oil temperature under all operating conditions.

NOTE—If the lubricating oil filter is allowed to remain in a dirty condition, sludge and foreign matter will clog up the oil passage in the regulator core. If the oil filter is cleaned at regular intervals, the temperature regulator may be cleaned at 10,000 mile intervals.

To clean the regulator, remove it from the engine, take off the covers and withdraw the core. Use a small grease gun with pipe fittings brazed to the end to blow out the passages. Immerse the core in a good grade of benzol or coal tar naphtha for at least five minutes. Connect the grease gun to the oil inlet and pump for several minutes to remove the dissolved sludge. Then blow out the water and oil passages in both directions, applying from 50 to 60 pounds air pressure. However, do not connect the air hose to the fitting, but hold it a short distance away. Assemble the unit and install it on the engine.

OIL FILTER

1936-46: Several types of filters are used with these engines and usually complete service instructions accompany each filter in the form of a sticker pasted on the filter itself. If additional information is required, see the chapter devoted to OIL FILTERS elsewhere in this book.

At frequent intervals, the filter should be drained to get rid of any solid matter which may have settled in the filter sump. Whenever this is done, be sure to add sufficient oil to the crankcase to compensate for the oil which was drained.

Filters should be cleaned thoroughly every time the oil is changed and after every 1,000 miles of operation. If the dipstick shows that the oil is thick and very dirty, it indicates that the filter requires service.

CRANKCASE VENTILATOR

1936-46: The crankcase ventilator breather should be inspected at least every 2,000 miles, and if a sludge formation is evident, remove the breather and clean it thoroughly in kerosene. Allow it to soak in the kerosene for about 30 minutes, then blow it out with compressed air, and at the same time, tap it lightly to dislodge any solid particles of sludge.

If the breather is fitted with an air cleaner, it should be removed and washed every 1,000 miles. After the element is washed, blow it dry with compressed air and, if the cleaner is of the oil-wetted type, dip the element in fresh engine oil before assembling. If it is of the oil-bath type, wipe out the oil reservoir with a clean cloth and fill it to the proper level with fresh engine oil.

NOTE—The interval at which the ventilator and air cleaner should be cleaned can only be determined by the type of service to which the vehicle is subjected. Vehicles operating in dusty or sandy areas require more frequent service than vehicles operating under more favorable conditions.

IMPORTANT—For vehicles operating in dust storm areas, the cleaner should be cleaned immediately after such storms occur.

COOLING SYSTEM

WATER PUMP

5A, 7A, 10A, 11A, 12A, 13A, 14A, 15A, 16A, 21A, 25A: The pump used on these engines is of the single stuffing box type. An outboard ball bearing relieves the stuffing box and packing of any whip in the pump shaft.

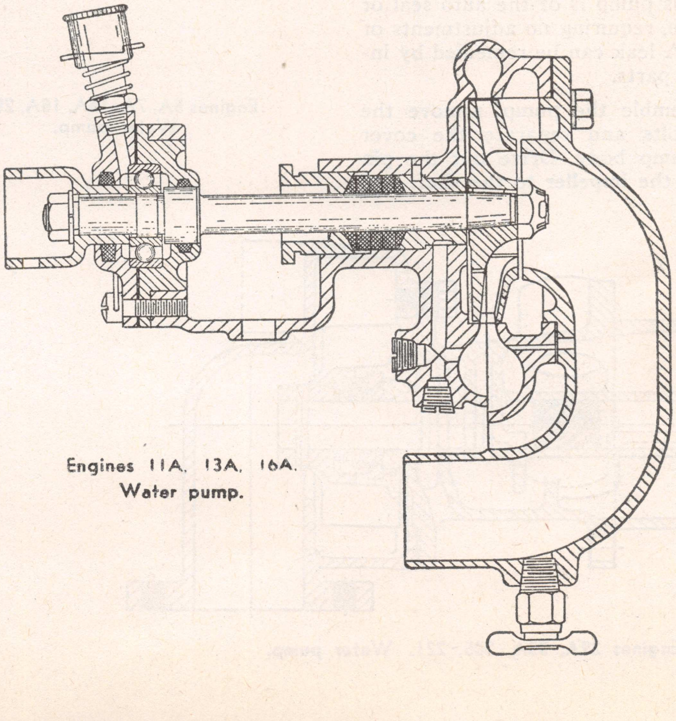
If the pump leaks, turn the gland nut in a counter-clockwise direction until the leak stops and then back the nut off about ¾ of a turn. Always make this adjustment with the engine running.

This type pump is easily disassembled for repairs and the sectional drawing shows clearly the arrangement of all parts. If repacking is required, make sure that the pump shaft is not scored or deeply cut, otherwise premature wear of the new packing will result.

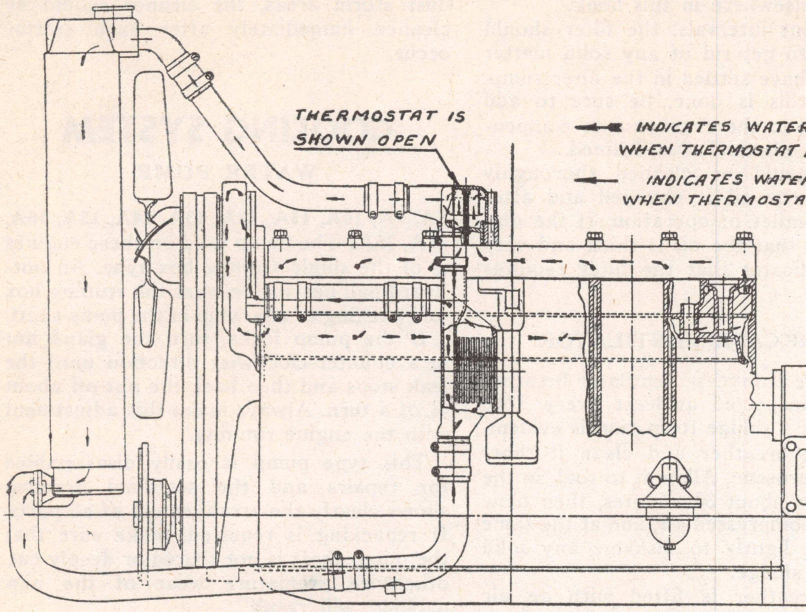
20A, 30A, 100A, 110A, 120A, 140A: This pump is of the packless type having a carbon seal which requires no adjustment. The shaft is mounted in two ball bearings. If the oil seal in this pump is to be replaced, the impeller should also be replaced.

The bearing housing is filled with a special ball bearing lubricant when the pump is assembled at the factory, and the ball bearings are packed with lubricant at the same time. The unit should therefore require no additional lubricant for the life of the pump.

This type pump is easily disassembled for inspection and repairs but particular attention should be given to the relative position of the seal parts when disas-



Engines 11A, 13A, 16A. Water pump.


THERMOSTAT IS SHOWN OPEN
◄◄ INDICATES WATER FLOW WHEN THERMOSTAT IS CLOSED
◄ INDICATES WATER FLOW WHEN THERMOSTAT IS OPEN

Engines 20A, 30A, 100A, 110A, 120A, 140A. Cooling system diagram.

sembling in order to assure correct installation. When the pump has been reassembled, pack the bearing housing with an approved water pump grease.

29A, 33A: This pump is of the regular packing type and can be removed from the engine without taking off the timing gear cover; it will be necessary, however, to remove the ignition distributor.

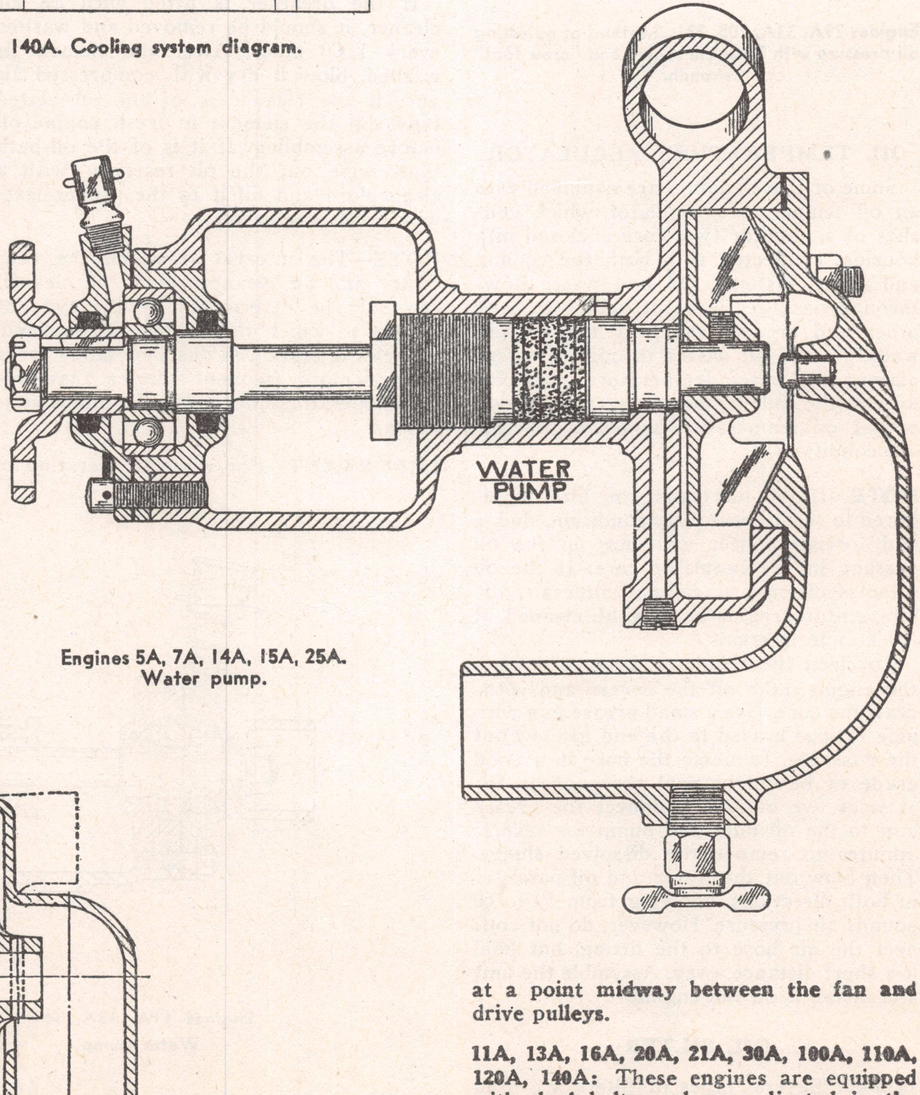
To disassemble the pump, remove the pump body and impeller from the shaft and push the shaft through the sleeve, after which, the water pump drive gear may be pressed from the shaft.

Examine the parts and replace where necessary, then assemble the pump in the reverse order.

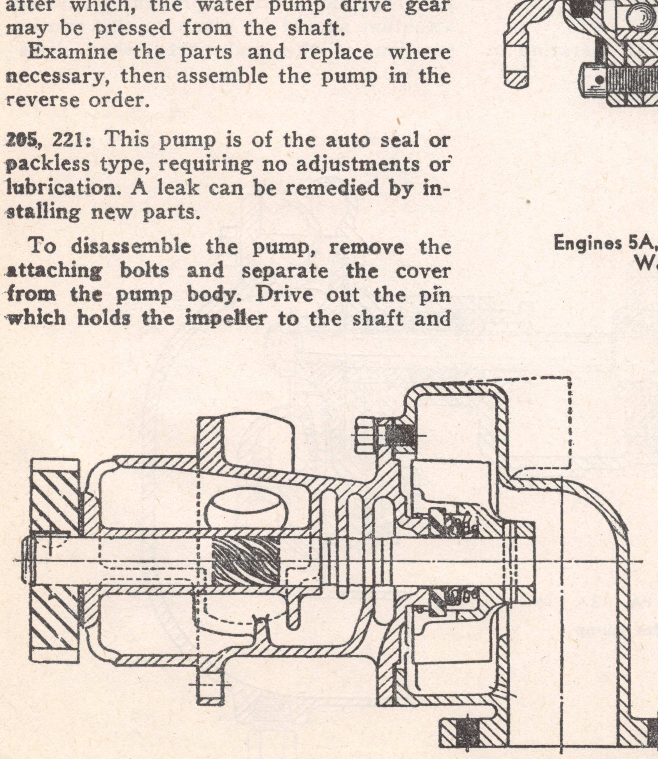
205, 221: This pump is of the auto seal or packless type, requiring no adjustments or lubrication. A leak can be remedied by installing new parts.

To disassemble the pump, remove the attaching bolts and separate the cover from the pump body. Drive out the pin which holds the impeller to the shaft and pull the impeller from the shaft. Insert a screw driver through one of the four slots in the impeller hub and press the snap ring out of the groove, after which, take out the seal parts.

Assemble the pump in the reverse order, bearing in mind that the metal ring acts as a seat for the seal spring and presses the rubber seal squarely against the carbon disc. The clamping ring keeps the rubber tight around the shaft.



Engines 5A, 7A, 14A, 15A, 25A. Water pump.

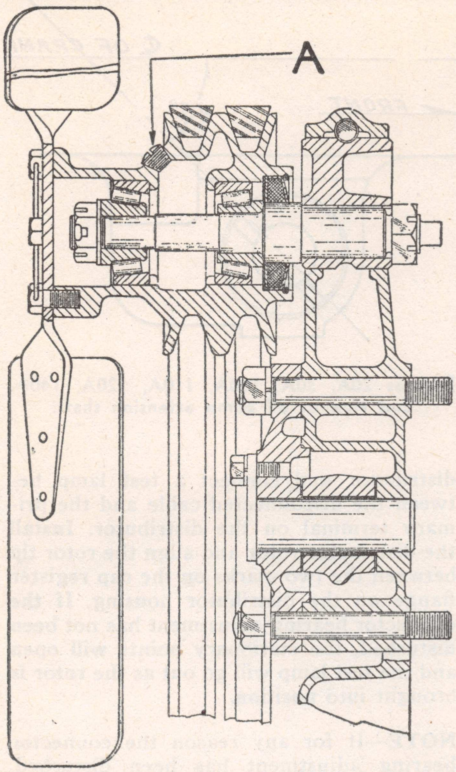


Engines 29A, 33A, 205, 221. Water pump.

FAN BELTS

5A, 7A, 14A, 15A, 25A: The fan belt is adjustable by means of an eccentric type take-up mounted on the fan shaft. To adjust the belt, loosen the lock bolt in the fan bracket and turn the eccentric until the belt is tightened enough to permit a deflection of 1" when pressing on the belt at a point midway between the fan and drive pulleys.

11A, 13A, 16A, 20A, 21A, 30A, 100A, 110A, 120A, 140A: These engines are equipped with dual belts and are adjusted in the same manner as described above. However, the adjustment is correct when it is possible to turn the fan by hand without applying undue force.



Engines 11A, 13A, 16A. Fan assembly.

NOTE—Always replace fan belts in pairs after matching them for length.

10A, 12A: The fan is driven through triple belts from a pulley on the end of the fan drive shaft. Three accessory drive belts are driven from a pulley on the end of the air compressor shaft to drive the generator and the fan drive shaft.

Accessory Belt Adjustment: Adjustment for the accessory drive belts is accomplished by means of a sliding generator bracket. To make the adjustment, loosen the generator bracket capscrews, loosen the lock nut and adjust the belts by turning the adjusting screw in or out until the belts have the desired tension. When the adjustment is satisfactory, tighten the adjusting screw lock nut and the generator bracket screws securely.

To make a fan belt adjustment, loosen the lock bolt and turn the eccentric until the belts have the desired tension, after which, tighten the lock bolt.

NOTE—For best results, fan belts should be replaced in sets, being sure they are matched for correct length.

29A, 33A, 205, 221: Adjustment of fan belts used with these engines is accomplished in the same manner as described for the 5A series except that the tension is controlled by the position of the fan in a slotted bracket. To adjust fan belt tension, loosen the lock nut and shift the position of the fan until the desired result is obtained, and lock the adjustment.

ENGINE WATER THERMOSTAT

1936-46: If the thermostat is not functioning properly, remove the assembly from the water outlet and see if the bellows and valve are in good condition. If they are, test its operation by completely submerging the assembly in water, heating the water gradually until it reaches the opening temperature of the thermostat. If the thermostat starts to open at the correct temperature, continue to heat the water until it reaches the temperature at which the thermostat should be fully open. When taking temperature readings, agitate the water thoroughly, and if the unit fails to function properly, it should be replaced rather than attempt to make a repair. However, before installing a new unit, it is good practice to give it a test as directed above.

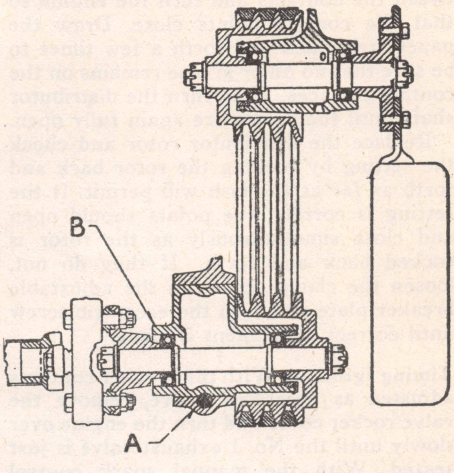
NOTE—Thermostats used in the majority of these engines are provided with a small by-pass hole to prevent any difficulty in the event of steam formation. Its design is such that thermostat failure will only occur while in the open position, permitting free circulation of water through the engine.

CAUTION—Engines 20A, 30A, 100A, 110A, 120A, and 140A should never be operated without the thermostat because by so doing, the cooling system will be short-circuited, causing over-heating.

NOTE—Thermostats are available which have lower, as well as higher opening temperatures than that which the engine was originally equipped. Due to climatic or unusual operating conditions, it may be desirable to install a thermostat having a higher or lower temperature range.

FUEL SYSTEM

NOTE—For service information on Carburetors, Automatic Chokes, Governors, Fuel Pumps, Air Cleaners and Gasoline Gauges, See the Table of Contents on page 1.



12-Cylinder Engines. Fan belt adjustment. A—Binder bolt. B—Eccentric.

ELECTRIC SYSTEM

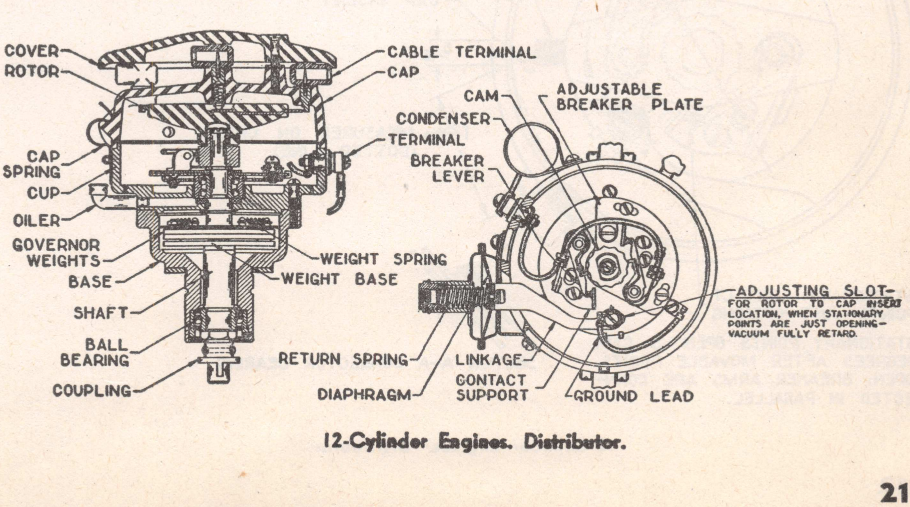
NOTE—For service information on Distributors, Magnetos, Generators, Generator Regulators, Starting Motors and Starter Switches, see the Table of Contents on page 1.

IGNITION TIMING

5A, 7A, 14A, 15A, 25A: On these engines, both manual and automatic spark advance are provided. The breaker mechanism consists of two pairs of contacts and a six-lobe cam which rotates in a clockwise direction when viewed from above.

Adjusting Breaker Contacts: Turn the distributor shaft until the rubbing block of the stationary breaker arm is on the lobe of the cam—points separated. Loosen the clamp screw and turn the eccentric adjusting screw to increase or decrease point gap. When properly adjusted, the gap should be from .016" to .018". Now tighten the clamp screw and recheck the gap to be sure the setting has not changed during the tightening process. Follow the above procedure and adjust the movable breaker arm.

Insert a narrow strip of soft paper be-



12-Cylinder Engines. Distributor.

tween the contacts and turn the engine so that the contact points close. Draw the paper strip back and forth a few times to be sure that no oil or grease remains on the contact surfaces. Then turn the distributor shaft until the points are again fully open.

Replace the distributor rotor and check the setting by rocking the rotor back and forth as far as the lash will permit. If the setting is correct, the points should open and close simultaneously as the rotor is rocked back and forth. If they do not, loosen the clamp screws in the adjustable breaker plate and turn the eccentric screw until correct adjustment is made.

Timing Ignition: With the breaker contacts adjusted as described above, remove the valve rocker cover and turn the engine over slowly until the No. 1 exhaust valve is just seated. With the manual spark control pulled out to the fully retarded position, continue to turn the engine until the "Full Retard" mark on the flywheel (top center) is in line with the indicator on the flywheel housing. In this position, the points should just begin to open—this being the firing position for **No. 6 cylinder.**

NOTE—The point of opening of the contacts can be checked by the ammeter on the instrument panel when the switch is on, or by connecting a 6-volt timing light from the distributor primary terminal to ground. When the points begin to open, the light will burn. If the contacts do not separate or the opening is greater than a slight drag on a feeler, loosen the cam locking screw and turn the cam in the desired direction until the points just begin to open. Then tighten the cam locking screw and recheck the adjustments.

11A, 13A, 16A: A manual spark control and an octane selector are fitted. Spot the flywheel with a chalk mark at a point 1 39/64" ahead of the "X" mark on the flywheel which denotes top center position.

With the octane selector set at "O" and the manual spark control in the fully retarded position, crank the engine until No. 1 piston is coming up on its compression stroke and stop when the chalk mark on the flywheel is in line with the indicator on the flywheel housing.

Loosen the distributor clamp screw and turn the housing until the points just break. Then set the octane selector so that a slight "ping" is heard on wide-open throttle at comparatively low vehicle speed—about 15 mph.

10A, 12A: On these engines, both vacuum and automatic spark advance are provided. The breaker mechanism consists of two pairs of contacts and a 12-lobe cam which rotates in a clockwise direction when viewed from the drive end.

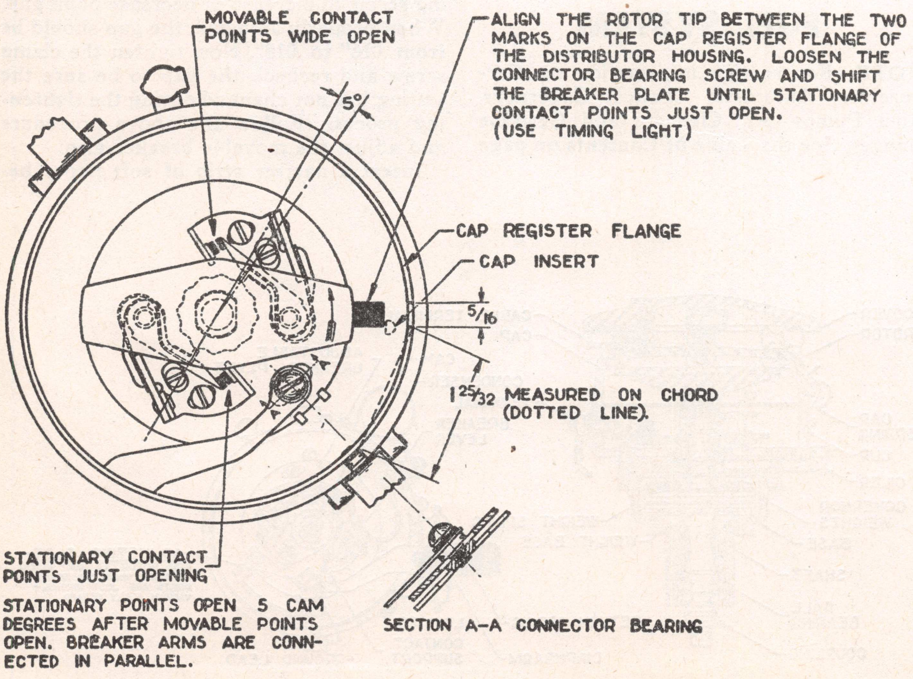
Synchronizing Contacts: With the points adjusted to the gap given in the TUNE UP CHART, turn the engine until No. 1 piston of the right-hand bank is coming up on its compression stroke and continue until the ignition mark, which is ¾" or 8° BTDC, in the flywheel is in line with the pointer on the flywheel housing.

NOTE—Two marks are definitely located on the flywheel, the first is a steel ball spotted before TDC, and the second is an "X" mark located after TDC.

With the steel ball in line with the pointer, disconnect the primary terminal at the distributor and connect a test lamp between the disconnected cable and the primary terminal on the distributor. Install the distributor rotor and align the rotor tip between the two marks on the cap register flange on the distributor housing. If the connector bearing adjustment has not been disturbed, the stationary points will open and the test lamp will go out as the rotor is brought into position.

NOTE—If for any reason the connector bearing adjustment has been disturbed, loosen the connector bearing screw and rotate the breaker plate in the "Adjusting Slot", to the point where the stationary points break and the test lamp goes out.

Now rotate the engine further until the "X" mark on the flywheel is in line with the pointer. Loosen the adjustable breaker plate hold-down screws, and turn the eccentric adjusting screw until the movable points close and the test lamp lights.

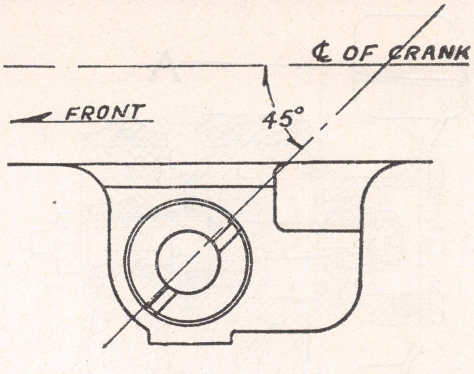

MOVABLE CONTACT POINTS WIDE OPEN
ALIGN THE ROTOR TIP BETWEEN THE TWO MARKS ON THE CAP REGISTER FLANGE OF THE DISTRIBUTOR HOUSING. LOOSEN THE CONNECTOR BEARING SCREW AND SHIFT THE BREAKER PLATE UNTIL STATIONARY CONTACT POINTS JUST OPEN. (USE TIMING LIGHT)
5°
CAP REGISTER FLANGE
CAP INSERT
5/16
1 25/32 MEASURED ON CHORD (DOTTED LINE).
A
A
STATIONARY CONTACT POINTS JUST OPENING
STATIONARY POINTS OPEN 5 CAM DEGREES AFTER MOVABLE POINTS OPEN. BREAKER ARMS ARE CONNECTED IN PARALLEL.
SECTION A-A CONNECTOR BEARING

12-Cylinder Engines. Distributor.

Checking Ignition Timing: If the above operations have been performed correctly, the distributor points will be properly synchronized and the distributor accurately timed to the engine. To check the result proceed as follows:

Remove the spark plug wire from the No. 1 plug of the right bank. Connect one lead of a Neon Timing Light to the No. 1 spark plug and the other to the disconnected wire terminal. Start the engine and allow it to run at idling speed. Then direct the flash of the Timing Light at the opening in the flywheel housing and check the position of the ignition mark on the flywheel in relation to the pointer in the housing. Should the position of the mark vary in either direction, timing may be advanced or retarded by loosening the breaker cam retaining screw and rotating the cam in the direction for proper timing. Check to make sure the vacuum advance unit is inoperative and that the vacuum plunger is not drawn into the vacuum unit.

20A, 30A, 100A, 110A, 120A, 130A, 140A: Both automatic and vacuum spark advance are provided with these distributors. The breaker mechanism consists of a single set of contacts and a 6-lobe cam which rotates in a clockwise direction when viewed from the top.



Engines 20A, 30A, 100A, 110A, 120A, 140A. End view of oil pump extension shaft.

NOTE—If the distributor unit has been removed from the engine, it may be installed in the following manner: Rotate the engine until No. 1 piston is on the compression stroke, and the flywheel timing mark (7 degrees before TDC) is in line with the pointer on the flywheel housing. Install the vacuum unit on the engine, lining up the centerline on the graduation with the line on the engine and tighten the lock screw. Insert the distributor shaft with the groove in the oil pump extension shaft. See the paragraph describing the method of installing the oil pump on these engines.

Timing Ignition: With the flywheel and distributor located as directed above, rotate the distributor body so as to bring the grease cup nearly parallel to the block and towards the front, and the breaker points just opening. When this position has been established, tighten the binder screw in the distributor clamp plate. Make sure the distributor rotates freely in its well as the vacuum unit operates.

If the above directions have been followed, the ignition timing should be correct. However, it may be checked in the same manner as described for the 10A and 12A engines with a neon timing light except that the timing line (7 degrees before TDC) before the "X" mark, should be chalk-marked

29A, 33A, 205, 221: On 29A and 33A engines, the flywheel should be spotted at a point 1⅞" before the "DC" mark; on 205 and 221 engines, spot the flywheel 1⅝" before the "DC" mark.

To check the timing, crank the engine to bring No. 1 piston on its compression stroke and stop when the spotted mark (see above) is in line with the pointer on the flywheel housing. In this position, the points should just begin to open—with the spark retarded and the distributor rotor in the No. 1 firing position.

ENGINES GASOLINE WHITE HORSE

Year	Engine Model	Number Cylinders and Valve Arrangement	Bore and Stroke	Displacement Cubic Inches	Compression Ratio	Taxable H. P.	Brake H. P. at R. P. M.	Maximum Torque at R. P. M. Pounds Feet	Oil Capacity Quarts
1939–41	32A	4-I	3⅝x3⅝	150	5.5	21	37@2500	100@1200	4
1941–42	35A	4-I	3⅝x3½	145	5.7	21	40@2600	88@1200	5

TUNE UP CHART

Year	Engine Model	Firing Order	Spark Plug Gap	Breaker Gap	Cam Angle, Degrees	Timing Mark Location	Spark Timing, Degrees	Tappet Clearance		Battery Terminal Grounded
								For Running, Hot	For Timing, Intake	
1939–43	32A	1423	.030	.020	41	Flywheel	TDC	Zero	Zero	Positive
1941–42	35A	1423	.030	.020	41	Flywheel	11¼ BTDC	Zero	Zero	Positive

VALVE SYSTEM

Year	Engine Model	Stem Clearance		Tappet Guide Clearance	Tappet Clearance				Valve Spring Pressure Test		Valve Seat Angle Degrees
					Running, Hot		Timing				
		Intake	Exhaust		Intake	Exhaust	Intake	Exhaust	Free Length, Inches	Pounds at Inches, Length	
1939–41	32A	.002–.0038	.002–.0038	.001–.003	Zero	Zero	Zero	Zero	2⅜	-----------	①
1941–42	35A	.0025–.0043	.0025–.0043	.001–.003	Zero	Zero	Zero	Zero	2⅜	-----------	①

① Intake 30 degrees: exhaust 45 degrees.

PISTON AND RING CLEARANCES

Year	Engine Model	Piston Skirt, Inches		Fitting Pistons with Shim and Spring Scale		Ring End Gap, Inch		Ring and Groove, Inch	
		Top	Bottom	Shim Thickness	Pounds Pull on Scale	Compression	Oil	Compression	Oil
1939–41	32A	.002	.002	.002	6–9	.010–.020	.010–.020	.002–.0025	.0015–.002
1941–42	35A	.002	.002	.002	6–9	.025–.035①	.020–.030①	.002–.0025	.0015–.002

① Measured at bottom of cylinder.

ENGINE BEARING SPECIFICATIONS

Year	Engine Model	Camshaft		Connecting Rod			Mains				
		Journal Diameter	Clearance	Journal Diameter	Clearance	Bearing Bolt Tension Lb. Ft.	Journal Diameter	Clearance	Bearing Bolt Tension Lb. Ft.	Thrust on No.	End-play
1939–41	32A	----	-------	1.9365–1.9375	.0015–.0035	28–30	2.249–2.250	.0015–.0035	47-49	3	.002–.012
1941–42	35A	----	-------	1.9365–1.9375	.002–.0025	28–32	2.249–2.250	.0025–.003	50①	3	.003–.006

① Crankcase through bolt tension.

ENGINE

32A, 35A: These engines are of the four-cycle, four-cylinder, valve-in-head, horizontally opposed, air-cooled type and mounted integrally with the clutch and transmission on the rear axle.

The entire power plant, including the engine, clutch, transmission and rear axle assembly, is readily accessible for inspection and complete replacement purposes. Inspection can best be accomplished by removing the cover over the engine on the inside of the body, which gives access to the top of the unit. The side panels are of the hinged type and can be swung up, giving all-around access.

If the entire power plant is to be removed, it is better to remove these panels entirely. The rear of the chassis should then be raised, the controls and units disconnected, and the complete unit can be removed.

CYLINDER HEADS

32A, 35A: The cylinder heads are made of aluminum alloy with alloy iron valve guides and valve seat inserts shrunk in place. In production, the head is heated to 580 degrees F. (500 on 32A) and screwed to the cylinder barrel with a .004" to .008" shrink fit, thus making a permanent assembly, resulting in the top of the cylinder bore being pulled in to a slightly smaller diameter for a length of approximately 1¼" with the cylinder at normal room temperature. When the engine reaches operating temperature, the head and upper part of the cylinder barrel expand, resulting in a straight cylinder bore.

CYLINDER BARRELS

32A, 35A: The cylinders are cast and machined individually. The base of each cylinder pilots in a bore in the crankcase.

NOTE—When re-installing cylinders, the exhaust manifold to cylinder connection in each bank should be tightened before the anchor stud nuts at the base of the cylinder are permanently tightened, to assure proper alignment.

ROCKER ARMS & PUSH RODS

32A, 35A: Whenever the push rods are removed, they should be tagged or otherwise marked so that each rod may be replaced in its original location. Examine each rod to make sure it is straight, and replace any that are bent. If any of the balls and sockets show wear beyond the case hardening, they should be replaced also.

VALVE SPRINGS

32A, 35A: Valve springs can be changed on these engines without removing the cylinder and head assembly. When removing any spring, be sure to bring that piston up on top center to prevent the valve from dropping into the cylinder.

Whenever valve springs are removed, they should be cleaned and examined carefully for any signs of weakness.

VALVE GRINDING

32A, 35A: When necessary to grind valves, remove the cylinder assembly from the crankcase and reseat the valves without disturbing the cylinder head.

NOTE—When re-installing the cylinders, be sure to tighten the exhaust manifold to cylinder connections before the anchor stud nuts at the base of the cylinder are permanently tightened, to assure proper alignment.

VALVE SEAT INSERTS

32A, 35A: Since these inserts are too hard to reface by the ordinary grinding methods, a high-speed grinding stone or a special lapping tool is required to perform this operation. When using this equipment, be sure valve guides are clean and the valve guide pilot is a snug fit in order to assure a concentric finish. Finished seats should be checked with a dial indicator and run-out should not exceed .0005".

VALVE STEM GUIDES

32A, 35A: When necessary to replace valve stem guides, remove the cylinder assembly, take off the cylinder head cover, remove the rocker arms and push rods and remove the valves and springs. Then use a suitable puller to remove and replace the guides.

NOTE—Be sure to tighten the manifold flange connections on each bank before tightening the cylinders down permanently.

HYDRAULIC VALVE LIFTERS

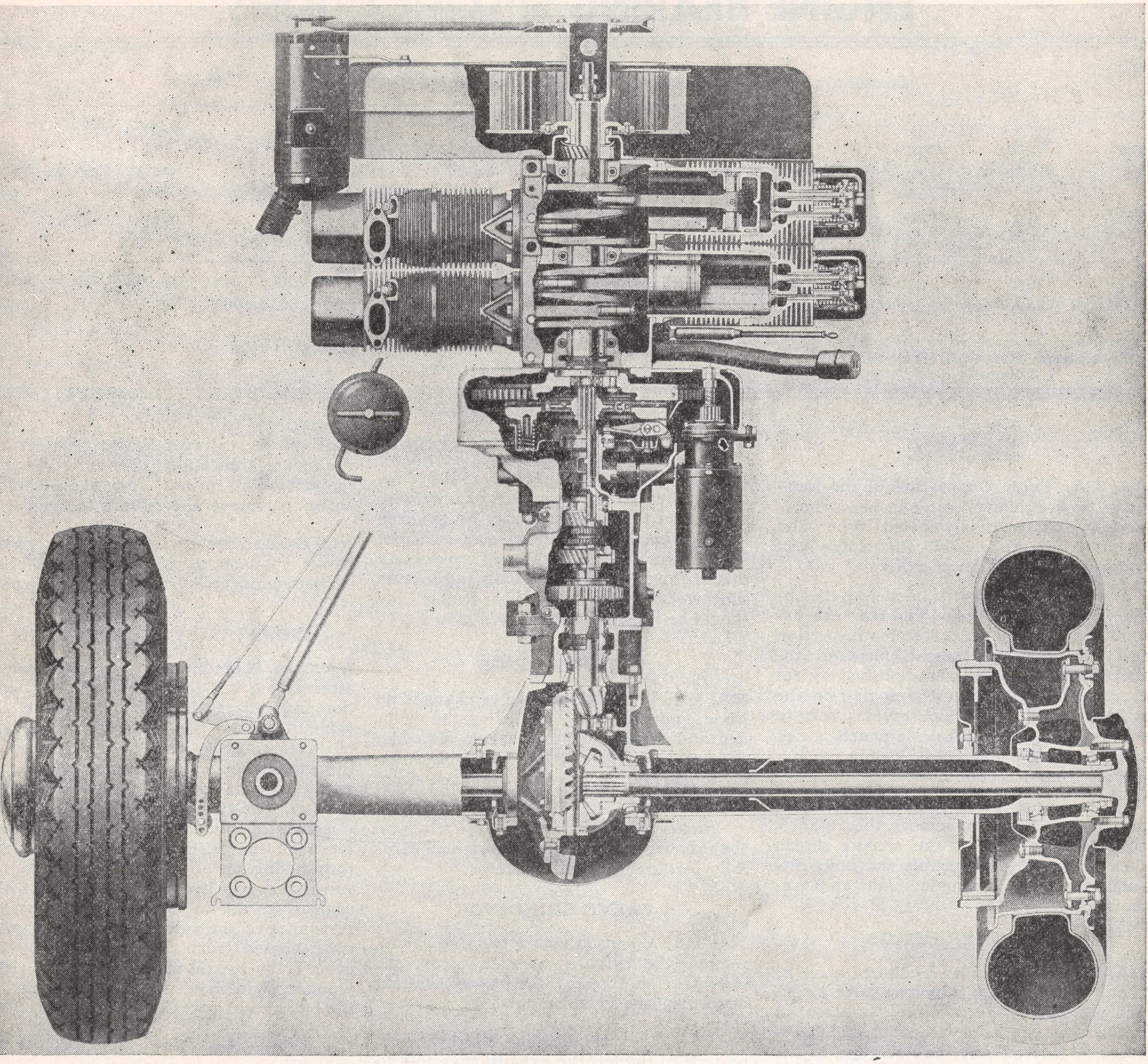
32A, 35A: These lifters are readily removed after taking out the push rods. In operation, oil enters the chamber within the valve lifter body through a small hole. The oil pressure opens the ball check valve in the inner cylinder, permitting oil to pass into the space in the cylinder below the plunger. The spring lifts the plunger until it comes in contact with the valve stem (through the push rod and rocker arm), thus taking up all clearance between the valve stem and hydraulic lifter. When the cam brings the valve lifter up against the resistance of the valve spring, the plunger is prevented from sliding down into the cylinder by the oil in the space below the plunger, which is trapped by the closing of the ball check valve.

Noisy Operation: Noisy operation of the valve lifters may be attributed to:

1. Incorrect oil level or oil pressure.
2. Dirty, scored or worn lifter parts.
3. A general clatter, affecting all or most of the valves, generally indicates difficulty with the oil supply.

Oil Level: Correct oil level is essential to quiet operation of the lifters, and should be maintained always to the level of the mark indicated on the dipstick. If the level is too high, foaming will likely be the result; if too low, air will enter the pump inlet. In either case, the air in the oil will cause noisy valve action.

Oil Pressure: Oil must always be maintained at the correct pressure. Extremely high pressure may lift the entire hydraulic unit against the plunger spring, permitting excessive plunger movement and wear. Low oil pressure permits oil relief leakage



Sectional view of power plant. Typical of all 1939-42.

between the plunger and cylinder to exceed the oil feed through the ball check.

Single Noise: A recurring tap or click synchronized with the valve action indicates a faulty hydraulic unit, which should be removed, disassembled and inspected for:

1. Sticking mechanism.
2. Dirt, pitting or incorrect clearance between plunger and cylinder.
3. Operating clearance between valve stem and rocker arm—which should be zero.

Sticking: The most likely cause of this condition is dirt or other foreign matter. It can be corrected by a thorough cleaning of all parts after disassembly, by washing in clean gasoline. A stuck ball check may be dislodged by using a small blunt tool, after which the cylinder should be washed thoroughly in gasoline. If air pressure is used to dry the parts, hold the hose nozzle a few inches away to prevent the admission of any moisture.

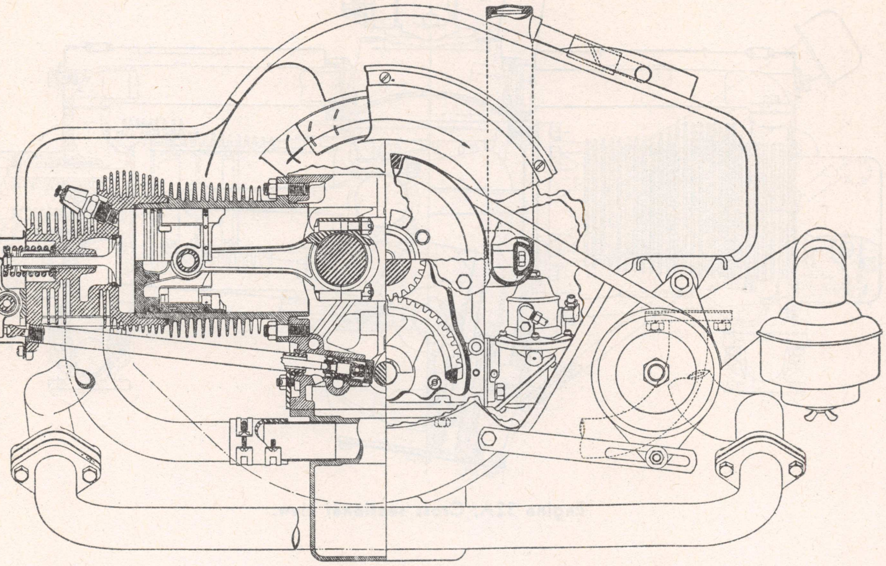
NOTE—When dirt has been the cause of the sticking condition, the engine oil pan should be removed, cleaned and the engine flushed, otherwise the condition may recur almost immediately. The oil reservoir and the bleed holes in the lifter bores should also be thoroughly cleaned.

Pits and Scores: Sticking may also be caused by pitting and scoring of the surfaces, which may result from gritty particles, excessive wear, or damage during installation. The remedy is to replace the hydraulic cylinder and plunger—but not the lifter body. Slight scratches on the lifter body have no effect on the operation of the engine or the valve mechanism.

Incorrect Clearance between the cylinder and plunger is usually caused by mismating of parts. During production, cylinders and plungers are carefully fitted and are not interchangeable.

Assembling Lifters: When assembling the lifter parts, pay attention to the following:

1. The ball check should rattle when the cylinder unit is shaken.
2. The plunger should bounce back when pressed quickly into the cylinder and released.
3. Lock the plunger spring into the cylinder by a twist of the plunger.



Engine 35A. Front sectional view.

4. When free of oil, the cylinder should slide smoothly into the tappet body.

Checking Valve Clearance: Valve tappet adjustment is provided at the push rod end of the rocker arm. Adjustment is necessary after the valves have been ground or if the valve lifter mechanism has been disassembled. With the **engine cold and no oil in the lifters,** the proper clearance should be from .040" to .060". When making adjustments, rotate the crankshaft to bring the piston at top dead center of the compression stroke.

NOTE—When the assembly and adjustments have been completed, the hydraulic units will be filled with oil, which will be indicated by quiet valve action after the engine has been run for a while.

VALVE TIMING

32A, 35A: The position of the camshaft and crankshaft gears is definitely established on their respective shafts by a Woodruff key and are held in place by a tight press fit.

To set the gears for correct timing, turn the crankshaft to bring No. 1 piston on top dead center which is indicated by a "C" mark on the flywheel ("TDC" on 32A) being visible in the flywheel inspection hole. Then turn the camshaft and install the gear so that the punch marks on both gears are meshed.

CAMSHAFT & BEARINGS

32A, 35A: The camshaft is supported in three precision finished steel-backed, copper lead lined bearings (two steel-backed, babbitt lined bearings on 32A engine). These bearings are replaceable but need not be reamed. Be sure, however, that the oil holes in the bearings are in line with the oil holes in the crankcase.

PISTONS & RODS, REMOVE

32A, 35A: Piston and rod assemblies are removed by taking off the cylinders, removing the crankcase pan, disconnecting the rods from the crankshaft and lifting them out.

Although regular production rods are generally marked with the cylinder number in which they are installed, replacement rods are not; therefore, unmarked rods should be suitably identified with punch marks, as they are removed.

PISTONS, RENEW

32A, 35A: NOTE—A variation of 10 degrees between the temperature of the pistons and cylinder bores is sufficient to produce a difference of .0005". Therefore, both the pistons and cylinders should be at normal room temperature (about 70 degrees) when fitting pistons.

Before any attempt is made to fit new pistons, cylinder bores should be carefully indicated and refinished, if necessary. If reboring is not required, a special reamer is available to remove any ridge at the top and bottom of the ring travel area. When refinished, cylinder bores should not be out-of-round or tapered more than .0005".

Before fitting pistons, wipe the cylinder walls and pistons to remove all chips, dirt or other foreign matter. The feeler ribbon used to check piston fit may be about 12" long and ½" wide. Consult the PISTON & RING CLEARANCES table for the thickness of shim to use, as well as the recommended pounds pull on a spring scale required to withdraw the feeler ribbon past the piston.

Insert the piston in the bore upside down and in its running position. Place the feeler ribbon between the cylinder wall and the thrust side of the piston, in a position at right angles to the piston pin hole.

After assembling the piston to the connecting rod, check the assembly for alignment on a suitable jig.

PISTON RINGS, RENEW

32A, 35A: New rings should be fitted with end gaps and groove clearances as given in the PISTON & RING CLEARANCES table. Ring grooves must be clean and free from carbon, and must show no perceptible wear. Always abide by the installation instructions which are usually included in the ring package.

When rings are properly fitted to the pistons, be sure to stagger the ring gaps so they are spaced equal distances around the circumference of the piston, yet having no gaps over the piston pins.

NOTE—Before installing new rings, and to prevent the possibility of bending or breaking the second ring land—thus ruining the piston—the ridge at the top (and bottom) of the cylinder bore should be removed by running a hone through each cylinder bore. Since the cylinder heads are a shrink fit on the cylinders, and cannot be removed and replaced successfully in the field, the conventional ridge reamer is not suitable for this operation.

PISTONS PINS, RENEW

32A, 35A: The piston pins are of the "full floating" type, being retained by snap ring keepers which fit into grooves in the piston bosses. The correct fit of piston pins should be one which requires a thumb push fit in both the piston and rod, with the parts at normal room temperature.

PISTON PIN BUSHINGS, RENEW

32A, 35A: When required, new bushings should be pressed in place and reamed to provide a thumb push fit of the pin. When installed, be sure the oil hole in the bushing lines up with the oil hole in the connecting rod.

CONNECTING ROD BEARINGS

32A, 35A: These bearings may be replaced by simply taking off the bearing cap and slipping old shells out and new ones in.

Bearings should be replaced in sets and under no circumstances should rods or caps be filed, altered or mutilated in any way in an attempt to obtain proper bearing fit.

NOTE—Before replacing bearings, make sure that the crankpins are not nicked or scored, and that all parts are thoroughly clean. This is particularly important because the presence of one small particle of metal, carbon or other foreign matter, lodged between the back of the bearing and the rod, or between the face of the bearing and the crankpin, will very likely cause a hot spot due to the elimination of the oil clearance at that point, eventually resulting in a bearing failure or a scored crankpin.

CAUTION—These bearings are designed for use without shims and under no circumstances should shims be used in an attempt to obtain a bearing fit, because the proper "crush" fit of the bearings in the connecting rod bores will not be obtained.

NOTE—The White Company recommends the use of a piece of lead wire to check the fit of bearings. With this method, apply a coat of SAE 20 oil to the bearing to be checked and place a short length of wire, ⅛" long on each end of the rod bearing of the crank, parallel to the center line of the crankshaft. Then install the connecting rod and cap, rotating the crank approximately 15 degrees as the bearing cap nuts are being tightened. When the bearing caps have been tightened to the proper torque tension, free up the bearing by moving the crank in the 15-degree arc as described above and remove the cap and checking wire. When the wire is "miked", it will give the clearance of the bearing. If the clearance is too great, the crankpins should be turned down and undersize bearings fitted.

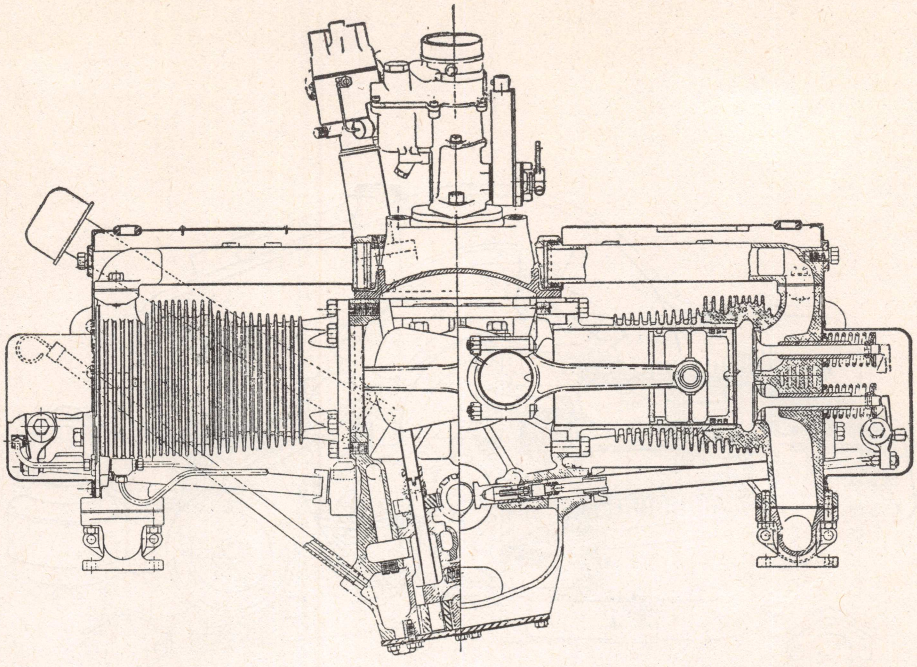
MAIN BEARINGS, RENEW

32A, 35A: The crankshaft is mounted in three steel-backed, copper lead lined bearings of the precision type. These bearings should be replaced in sets and under no circumstances should any attempt be made to file, shim, alter or otherwise mutilate the caps or saddles in order to obtain a bearing fit.

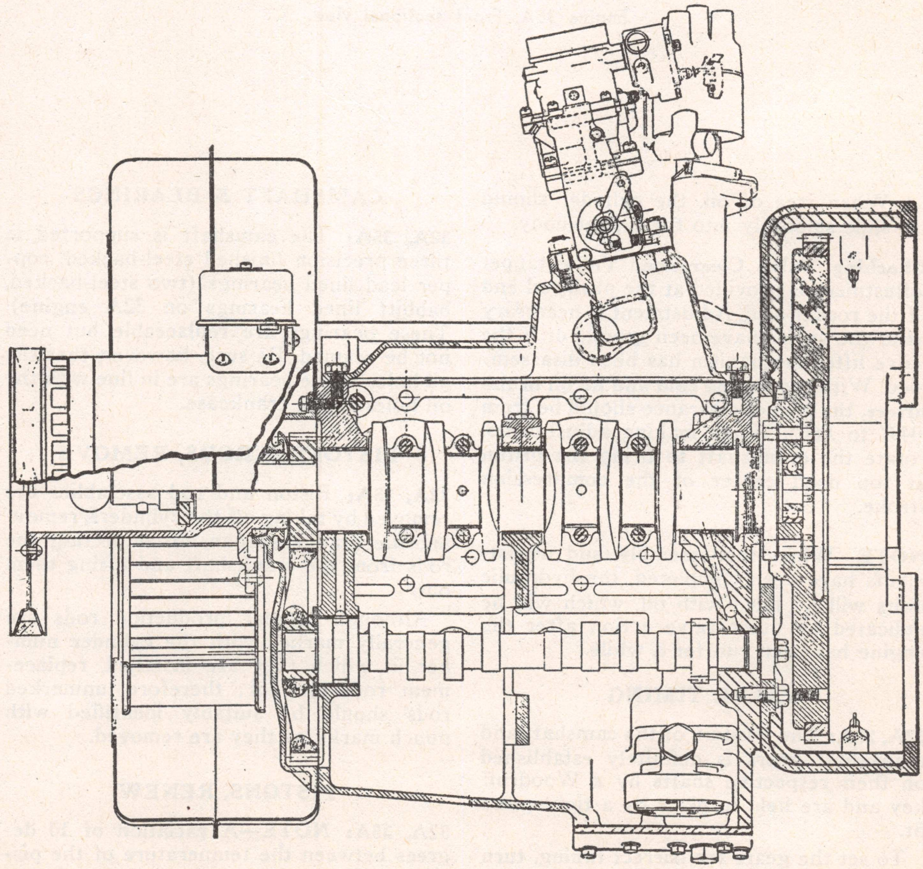
Before replacing bearings, make sure that the crankshaft journals are not nicked or scored. Use care also, to see that all parts are thoroughly clean, and that oil holes are free and clear.

NOTE—On the 35A engines, the crankcase is made in two sections, being separated at the camshaft and crankshaft center line. The two sections are held in place by means of heat-treated through studs. This construction eliminates the necessity of the conventional main bearing caps—as used on 32A engines—and provides for utmost rigidity within a small space.

To check the fit of new bearings, follow the same procedure as described for checking the fit of connecting rod bearings except that, with the checking wire in place and the cap bolts (or through studs on 35A engines) tightened to the recommended torque tension, the bearings may be considered fitted properly if the crankshaft is movable with a fairly heavy drag when the shaft is rocked through an arc of 2 inches—not more than 1 inch in either direction.



Engine 32A. Cross sectional view.



Engine 32A. Longitudinal cross sectional view.

CRANKSHAFT END THRUST

32A, 35A: Crankshaft end thrust is controlled by thrust washers at the rear main bearing (center on 32A). Through normal wear, the end play will seldom become excessive, but whenever new bearings are fitted, the clearance should be carefully checked and, if required, the clearance may be reduced by installing new thrust washers.

REAR MAIN BEARING OIL SEAL

32A, 35A: Oil sealing at the rear main bearing is controlled by a slinger, integral with the crankshaft, running in a groove in the crankcase, through which the excess oil is deflected and returned to the oil pan.

FLYWHEEL

32A, 35A: The flywheel is bolted to the rear end of the crankshaft and is located by means of dowel pins pressed into the end of the crankshaft. Tapped holes are provided in the flywheel for puller screws.

NOTE—If the flywheel should be removed, both the end of the crankshaft and the flywheel are marked with a line to facilitate re-assembly. When installing the flywheel, be sure these two marks are in line with each other, in order to maintain the proper engine balance.

NOTE—Whenever replacing the flywheel, it is good practice to check it for wobble or excessive run-out. If a dial indicator is available, mount it on the flywheel housing and allow its stem to contact the flywheel as the engine is being turned slowly. Make a note of the high and low sides of the flywheel through one complete revolution, and if run-out exceeds about .010", it should be removed and the crankshaft flange recess inspected for burrs, dirt or other foreign matter.

ENGINE OILING

OIL PUMP

32A, 35A: If the oil pressure drops below normal (30 to 40 pounds), do not remove the oil pump until the oil gauge is checked with another gauge known to be accurate. Check the oil level and examine the condition of the oil. If these items are correct and the pressure continues to drop, remove and clean the oil pan thoroughly, and disassemble, clean and inspect the pump.

The pump is easily removed for inspection or repairs after taking down the oil pan. To disassemble the pump, drive the pin out of the hub of the upper spiral drive gear and pull the gear from the shaft. Remove the bottom cover and withdraw the gears and shaft. Be sure to examine the pump pressure ball check, spring and ball check seat, and if these parts show wear, new parts must be installed.

NOTE—Before replacing the oil pump and oil pan, the oil screen, oil lines and passages should be thoroughly cleaned, being sure that all openings in the screen are free and clear. If the screen has been crushed, it should be replaced rather than attempt to make a repair. When assembling the pump, dip the gears in fresh engine oil as a means of priming the pump.

OIL PRESSURE REGULATOR

32A, 35A: Oil pressure is automatically controlled by a compression spring which controls the action of a relief or by-pass valve. Oil pressure should not be judged to be too high or too low until it is known whether the proper weight of oil is used, and the engine is warmed up to normal operating temperature.

As the engine bearings become worn, the oil pressure will be slightly lower due to more oil escaping around the bearings. It is not advisable to try to correct this slight pressure loss, because the extra amount of oil being thrown off by the worn bearings is already over oiling the cylinder walls.

OIL FILTER

32A, 35A: These engines are equipped with oil filters, the service of which is described and illustrated in the OIL FILTERS chapter elsewhere in this book.

Filters should be cleaned thoroughly every time the oil is changed and after every 500 miles of operation, or oftener, if required. If the dip stick shows the oil to be thick and very dirty, it indicates that the filter requires attention. When servicing filters, they should be inspected for leaks, and oil should be added to the proper level each time the filter element is changed, or if the filter is cleaned.

CRANKCASE VENTILATION

32A, 35A: These engines incorporate a sealed crankcase application, making use of a forced ventilation brought about by maintaining crankcase pressures below atmospheric. This is accomplished by means of an air scoop mounted on top of the fan housing and connected to the crankcase breather pipe. A sealed cap is attached to the oil filler pipe. The air stream from the fan through the air scoop keeps the crankcase under constant negative pressure.

With this feature, much of the normal crankcase fumes, which might contain corrosive impurities (and condensation) are completely removed from the engine. Also, by having a sealed oil filler cap, the possibility of dirt getting into the engine at this point is precluded.

At regular intervals, depending upon mileage and operating conditions, the tube in the air scoop should be removed and cleaned. At the same time, blow out any accumulations which may have formed in the scoop.

NOTE—The interval at which the ventilator should be cleaned can only be determined by the type of service to which the vehicle is subjected. Vehicles operating in dusty or sandy areas require more frequent service than those operating under more favorable conditions. Vehicles which are operated in dust storm areas, should have the ventilator cleaned immediately after such storms occur.

COOLING SYSTEM

32A, 35A: These engines are cooled by a multi-bladed fan which is keyed to the front end of the crankshaft. Air is directed from the fan, through the fan housing, to each pair of cylinders in the proper proportion to give uniform temperatures.

FUEL SYSTEM

NOTE—For service information on Carburetors, Automatic Chokes, Fuel Pumps, Governors, Air Cleaners and Gasoline Gauges, see the Table of Contents on page 1.

GOVERNOR

32A, 35A: The engine governor is of the velocity type and is built integral with the carburetor (also see the Stromberg Carburetor Chapter). The throttle valve has full control of the engine speed, which assures the proper mixture ratio being delivered by the carburetor under varying operating conditions.

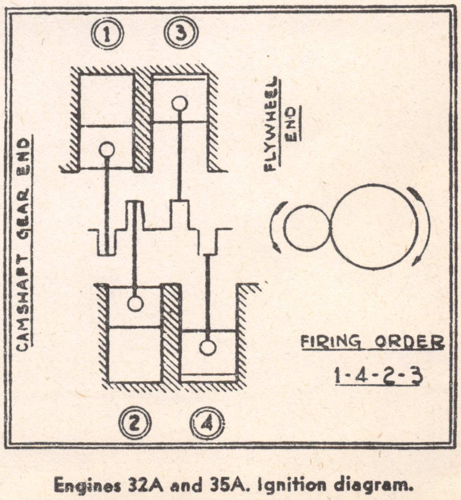
The throttle shaft, which is the main operating part of the governor, is mounted in ball bearings, to eliminate practically all friction and to reduce wear of all the component parts of the unit. The bearings are completely sealed, thereby requiring very little attention during the course of ordinary service.

Adjustments: The idle mixture adjustment and the idle speed (throttle stop screw) are set in the usual manner. After the engine is started, the governor can be set to any desired speed by removing the lock pin and turning the adjusting screw as follows:

To increase the engine speed, turn the adjustment clockwise; to decrease the governed speed, turn the adjustment counterclockwise. **This is the only adjustment that is required for the governor.**

NOTE—When turning the adjusting screw be sure that the screw stops at the bottom of the serration.

If the governor cannot be made to operate satisfactorily by adjusting as described



Engines 32A and 35A. Ignition diagram.

above, the complete carburetor and governor assembly should be removed and serviced.

ELECTRIC SYSTEM

NOTE—For service information on Distributors, Magnetos, Generators, Generator Regulators, Starting Motors and Starter Switches, see the Table of Contents on page 1.

IGNITION TIMING

32A, 35A: The flywheel is marked "C" ("TDC" on 32A) indicating top dead center for No. 1 piston, and is visible through the flywheel inspection hole. A second mark "S" is stamped on the rim of the flywheel 1 5/16 in. before the top dead center mark.

NOTE—If the distributor has been removed from the engine, it may be installed in the following manner: Rotate the engine to bring No. 1 piston up on its compression stroke and stop when the "S" mark on the flywheel is in the center of the inspection hole in the flywheel housing. In this position, install the distributor with the rotor set so that the breaker points are just ready to separate. The rotor should be pointing directly toward the top of No. 1 cylinder.

Checking Ignition Timing: If the distributor is installed as directed above, the timing should be correct. However, it may be checked for accuracy by means of a Neon timing light in the following manner.

Make a chalk mark on the "S" mark on the flywheel. Then remove the No. 1 spark plug cable and connect one lead of the timing light to No. 1 spark plug and the other to the disconnected cable terminal. Start the engine and allow it to run at idling speed. Now with the flash of the timing light directed at the inspection hole in the flywheel housing, check the position of the chalk line in relation to the boss in the inspection hole, as it should line up exactly in the center. If it fails to do so, loosen the distributor clamp screw and advance or retard the unit to obtain the desired result

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Year	Engine Model	Number Cylinders and Valve Arrangement	Bore and Stroke	Displacement Cubic Inches	Compression Ratio	Taxable H. P.	Brake H. P. at R. P. M. ①	Maximum Torque at R. P. M. Pounds Feet	Oil Capacity Quarts ②
1936-40	4DT-196	4-I	3⅝x4¾	195.3	14.5	21.02	49@2000	144@1400	6
1939-42	4DT-212	4-I	3⅝x5⅛	211.6	14.5	21.02	52.5@2300	152@1400	6
1939-46	4DT-226	4-I	3¾x5⅛	226.4	14.5	22.50	55@2300	162@1400	6
1936-39	6LD-275	6-I	3½x4¾	274.2	13.5	29.40	72@2400	776@1300	7
1939-42	6DT-278	6-I	3⅝x4½	278.6	14.5	31.54	72.5@2600	196@1500	7
1939-42	6DT-294	6-I	3⅝x4¾	293.8	14.5	31.54	75@2400	210@1500	7
1939-46	6DT-317	6-I	3⅝x5⅛	317.4	14.5	31.54	79@2300	222@1500	7
1939-42	6DT-389	6-I	3⅞x5½	389.1	14.2	36.04	80@2000	285@1200	10
1936-38	6LD-415	6-I	4x5½	414.6	13.3	38.40	91@2000	308@1100	10
1939-46	6DT-468	6-I	4¼x5½	468.3	14.2	43.35	96@2000	344@1200	10
1936-39	6LD-468	6-I	4¼x5½	468.3	13.0	43.35	96@2000	345@1100	10
1939-42	6DH-691	6-I	4¾x6½	691.4	13.7	54.15	130@1800	508@1000	10
1936-39	6LD-691	6-I	4¾x6½	691.4	12.5	54.15	130@1800	500@1000	10

① Maximum R. P. M. with full load.

② Including filters.

TUNE UP CHART

Year	Engine Model	Firing Order	Injection Timing, Degrees	Nozzle Discharge Pressure, Lbs. Sq. In.	High Idle Speed, R. P. M. ①	Low Idle Speed, R. P. M.	Valve Timing	
							Intake Opens, Deg.	Exhaust Closes, Deg.
1936-40	4DT-196	1342	32 PC	2000	2000	450	20 BTDC	13 ATDC
1939-42	4DT-212	1342	32 PC	2000	2300	450	20 BTDC	13 ATDC
1939-46	4DT-226	1342	32 PC	2000	2300	450	20 BTDC	13 ATDC
1936-39	6LD-275	153624	35 PC	2250②	2400	500	20 BTDC	13 ATDC
1939-42	6DT-278	153624	32 PC	2000	2600	450	20 BTDC	13 ARDC
1939-42	6DT-294	153624	32 PC	2000	2400	450	20 BTDC	13 ATDC
1939-46	6DT-317	153624	32 PC	2000	2300	450	20 BTDC	13 ATDC
1939-42	6DT-389	153624	11 PO	2000	2000	450	20 BTDC	13 ATDC
1936-38	6LD-415	153624	11 PO	2000	2000	500	17 BTDC	10 ATDC
1939-46	6DT-468	153624	5 PO	2000	2000	450	20 BTDC	13 ATDC
1936-39	6LD-468	153624	11 PO	2000	2000	500	17 BTDC	10 ATDC
1939-42	6DH-691	153624	9.5 PO 28 PC	2000	1800	400	15 BTDC	10 ATDC
1936-39	6LD-691	153624	9.5 PO 24 PC	2000	1800	450	15 BTDC	10 ATDC

① Maximum R. P. M. with no load.

② 2000 pounds for speeds over 1800 R. P. M.

PC—Port closing.

PO—Port opening.

VALVE SYSTEM

Year	Engine Model	Stem Clearance		Tappet Guide Clearance	Tappet Clearance				Valve Spring Pressure Test		Valve Seat Angle Degrees
					Running Hot		Timing				
		Intake	Exhaust		In-take	Ex-haust	In-take	Ex-haust	Free Length, Inches	Pounds at Inches, Length	
1936-40	4DT-196	.002-.004	.002-.004	.0005-.001	.009	.012	.009	.012	2 3/8	84-89@1 33/64	45
1939-42	4DT-212	.002-.004	.002-.004	.0005-.001	.009	.012	.009	.012	2 3/8	84-89@1 33/64	45
1939-46	4DT-226	.002-.004	.002-.004	.0005-.001	.009	.012	.009	.012	2 3/8	84-89@1 33/64	45
1936-39	6LD-275	.002-.004	.002-.004	.0005-.001	.009	.012	.009	.012	2 3/8	84-89@1 33/64	45
1939-42	6DT-278	.002-.004	.002-.004	.0005-.001	.009	.012	.009	.012	2 3/8	84-89@1 33/64	45
1939-42	6DT-294	.002-.004	.002-.004	.0005-.001	.009	.012	.009	.012	2 3/8	84-89@1 33/64	45
1939-46	6DT-317	.002-.004	.002-.004	.0005-.001	.009	.012	.009	.012	2 3/8	84-89@1 33/64	45
1939-42	6DT-389	.002-.004	.002-.004	.0005-.001	.009	.012	.009	.012	2 23/32	78-86@1 13/16	45
1936-38	6LD-415	.002-.004	.002-.004	.0005-.001	.009	.012	.009	.012	2 23/32	78-86@1 13/16	45
1939-46	6DT-468	.002-.004	.002-.004	.0005-.001	.009	.012	.009	.012	2 23/32	78-86@1 13/16	45
1936-39	6LD-468	.002-.004	.002-.004	.0005-.001	.009	.012	.009	.012	2 23/32	78-86@1 13/16	45
1939-42	6DH-691	.002-.004	.002-.004	.0005-.001	.010	.016	.010	.016	3 1/8	100-110@2 3/16	45
1936-39	6LD-691	.002-.004	.002-.004	.0005-.001	.010	.016	.010	.016	3 1/8	100-110@2 3/16	45

PISTON AND RING CLEARANCES

Year	Engine Model	Piston Skirt, Inches		Fitting Pistons with Shim and Spring Scale		Ring End Gap, Inch ①		Ring and Groove, Inch	
		Top	Bottom	Shim Thickness ③	Pounds Pull on Scale ④	Com-pression ②	Oil	Com-pression	Oil
1936-40	4DT-196	.006	.006	.006	.0065	.015	.008	.0005-.001	.0005-.001
1939-42	4DT-212	.006	.006	.006	.0065	.015	.008	.0005-.001	.0005-.001
1939-46	4DT-226	.0065	.0065	.0065	.007	.016	.008	.0005-.001	.0005-.001
1936-39	6LD-275	.007	.007	.007	.0075	.014	.007	.0005-.001	.0005-.001
1939-42	6DT-278	.006	.006	.006	.0065	.015	.008	.0005-.001	.0005-.001
1939-42	6DT-294	.006	.006	.006	.0065	.015	.008	.0005-.001	.0005-.001
1939-46	6DT-317	.006	.006	.006	.0065	.015	.008	.0005-.001	.0005-.001
1939-42	6DT-389	.007	.007	.007	.0075	.016	.008	.0005-.001	.0005-.001
1936-38	6LD-415	.008	.008	.008	.0085	.016	.008	.0005-.001	.0005-.001
1939-46	6DT-468	.0075	.0075	.0075	.008	.017	.009	.0005-.001	.0005-.001
1936-39	6LD-468	.008	.008	.008	.0085	.017	.009	.0005-.001	.0005-.001
1939-42	6DH-691	.0085	.0085	.0085	.009	.019	.010	.0005-.001	.0005-.001
1936-39	6LD-691	.0085	.0085	.0085	.009	.019	.010	.0005-.001	.0005-.001

① End gaps are minimum and are for cylinder bores without taper and should be fitted at the narrowest diameter of cylinder.

② For top or fire ring only. Deduct .002" for 2nd ring and .004" for 3rd ring.

③ Piston to pass on shim thickness shown.

④ Piston should lock on shim thickness shown.

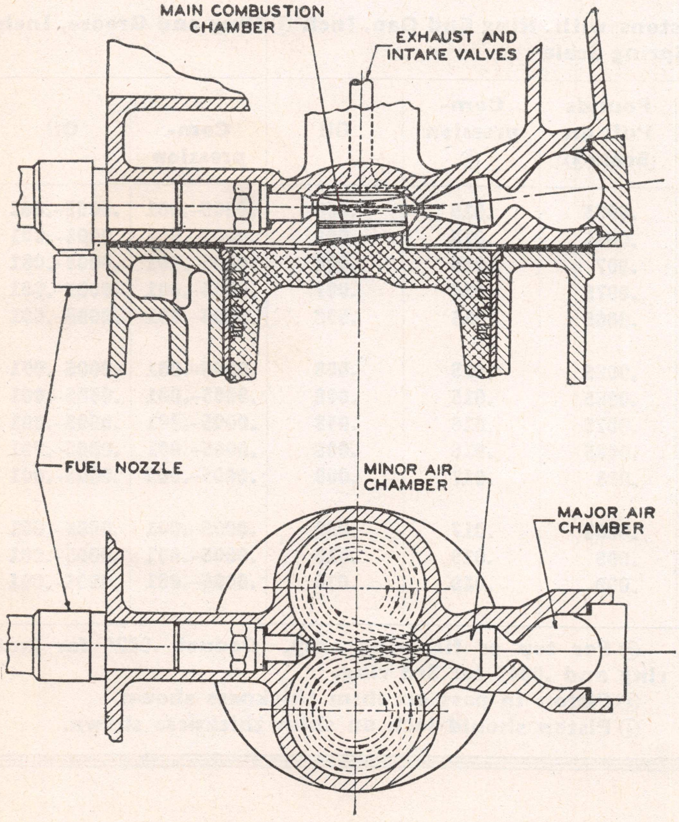
ENGINE BEARING SPECIFICATIONS

Year	Engine Model	Camshaft		Connecting Rod			Mains				
		Journal Diameter	Clearance	Journal Diameter	Clearance	Bearing Bolt Tension Lb. Ft.	Journal Diameter	Clearance	Bearing Bolt Tension Lb. Ft.	Thrust on No.	End-play
1936–40	4DT-196	①	.002–.0035	2.1225–2.1235	.0025	75– 85	2.996–2.997	.003	125–135	5	.004–.008
1939–42	4DT-212	①	.002–.0035	2.1225–2.1235	.0025	75– 85	2.996–2.997	.003	125–135	5	.004–.008
1939–46	4DT-226	①	.002–.0035	2.1225–2.1235	.0025	75– 85	2.996–2.997	.003	125–135	5	.004–.008
1936–39	6LD-275	①	.002–.0035	2.1225–2.1235	.0025	75– 85	2.996–2.997	.003	125–135	7	.004–.008
1939–42	6DT-278	①	.002–.0035	2.1225–2.1235	.0025	75– 85	2.996–2.997	.003	125–135	7	.004–.008
1939–42	6DT-294	①	.002–.0035	2.1225–2.1235	.0025	75– 85	2.996–2.997	.003	125–135	7	.004–.008
1939–46	6DT-317	①	.002–.0035	2.1225–2.1235	.0025	75– 85	2.996–2.997	.003	125–135	7	.004–.008
1939–42	6DT-389	②	.002–.0035	2.3725–2.3735	.0025	95–105	2.996–2.997	.003	150–160	7	.004–.008
1936–38	6LD-415	②	.002–.0035	2.3725–2.3735	.0025	95–105	2.996–2.997	.003	150–160	7	.004–.008
1939–46	6DT-468	②	.002–.0035	2.3725–2.3735	.0025	95–105	2.996–2.997	.003	150–160	7	.004–.008
1936–39	6LD-468	②	.002–.0035	2.3725–2.3735	.0025	95–105	2.996–2.997	.003	150–160	7	.004–.008
1939–42	6DH-691	2½″	.002–.0035	3.246–3.247	.0035	150–160	3.496–3.497	.004	③	4	.004–.008
1936–39	6LD-691	2½″	.002–.0035	3.246–3.247	.0035	150–160	3.496–3.497	.004	③	4	.004–.008

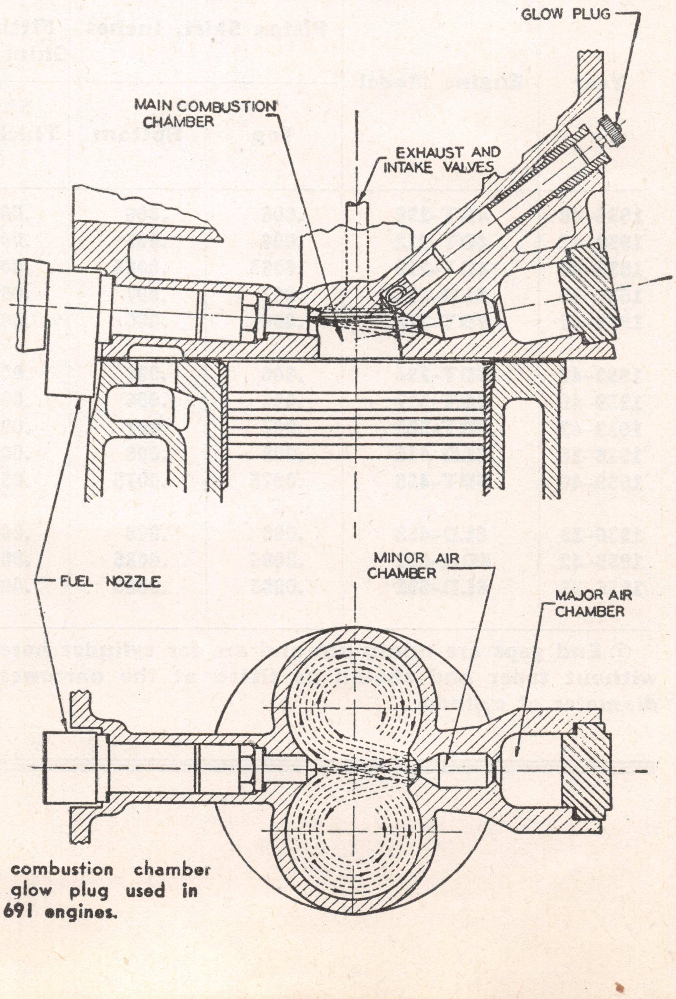
① Rear bearing journal 1½″; all others 2⅛″.

② Rear bearing journal 1½″; all others 2¼″.

③ For Nos. 1, 4 and 7, 150–160 pounds; all others 210–230 pounds.


MAIN COMBUSTION CHAMBER
EXHAUST AND INTAKE VALVES
FUEL NOZZLE
MINOR AIR CHAMBER
MAJOR AIR CHAMBER

Cylinder combustion chamber.


GLOW PLUG
MAIN COMBUSTION CHAMBER
EXHAUST AND INTAKE VALVES
FUEL NOZZLE
MINOR AIR CHAMBER
MAJOR AIR CHAMBER

Cylinder combustion chamber showing glow plug used in 691 engines.

ENGINE

NOTE—For detailed information on Diesel Fuel Injection Systems, see the Table of Contents on page 1.

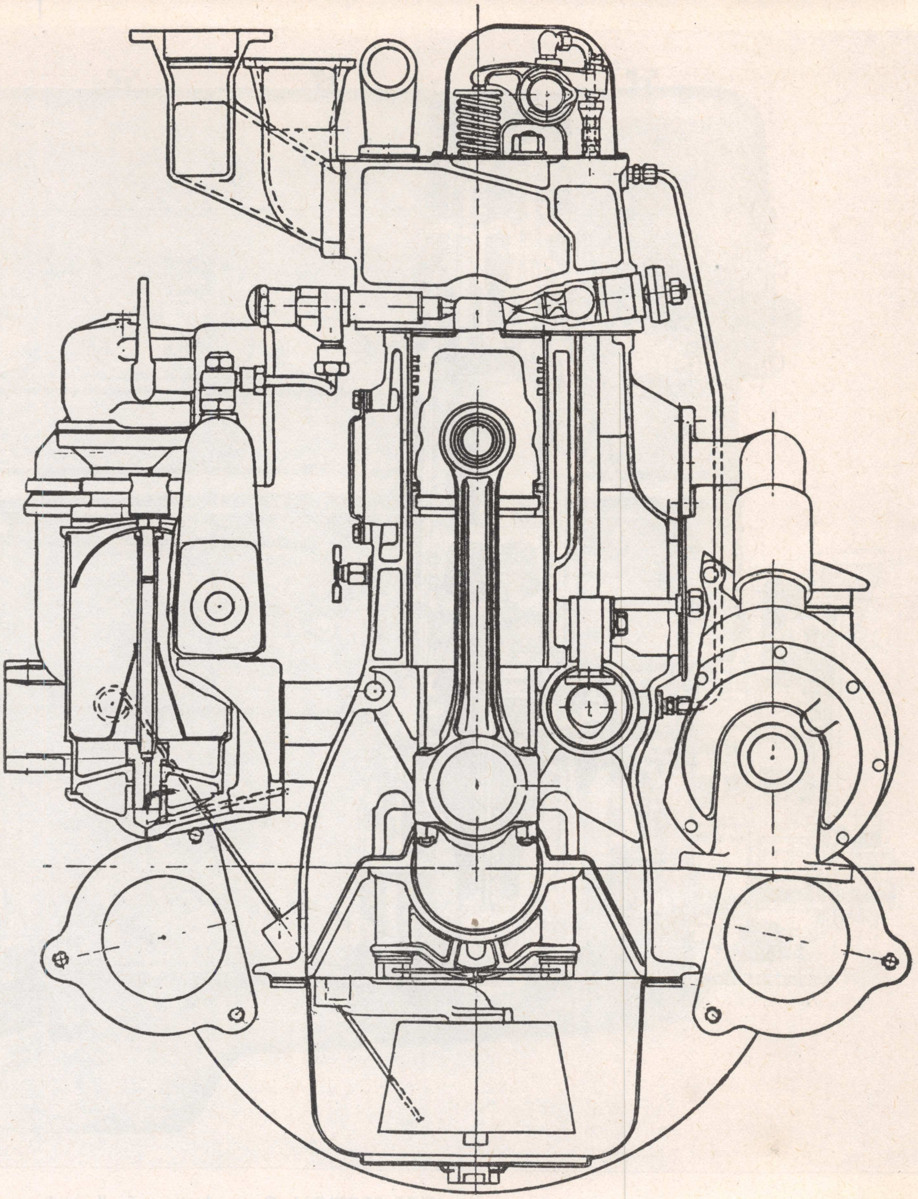
NOTE—See Trouble Diagnosis data at the rear of this chapter.

CYLINDER HEAD

1936-46 All: Cylinder heads should be tightened down by starting from the center, working outward toward the sides and to the ends. Draw down the nuts evenly and repeat the operation until all are normally tight. After the engine has been run sufficiently long to bring all the parts to normal operating temperature, a final tightening should be made.

NOTE—When using a torque indicating wrench, the final tightening should be within the torque values recommended by the wrench manufacturer. If two torque values are shown, use the lower limit for clean and oily threads, and the high limit for clean and dry threads. In any case, the threads should be free from rust or dirt, otherwise a false reading will be obtained due to the increased friction. When the final tightening is made, check the valve tappet clearance according to the recommendations given in the VALVE SYSTEM table.

IMPORTANT—The cylinder head is held down by studs which are installed in the cylinder block so that when the head is removed, the studs may readily be taken out to facilitate further service on the engine. This is particularly important if the head is removed while the engine remains in the chassis, because, besides making the removal operation easier, it will serve to prevent the mating surfaces of the head and block from being marred or scratched.



END SECTION. General view of all engines.

CYLINDER HEAD ENERGY CELLS

1936-46 All: The energy cells are located in the cylinder head directly opposite the fuel injection nozzles. The primary purpose of the cells is to increase turbulence and control combustion. When the energy cell is charged with fuel from the injection nozzle, the initial combustion takes place in the main combustion chamber. The fuel in the inner chamber of the energy cell is partially burned, developing high pressures, which causes the remainder of the fuel to return to the main chamber. This action creates intense turbulence, insuring complete burning of the entire fuel charge. At the same time, the rate of burning is controlled so that high pressures on the piston are avoided.

When the cells are removed for cleaning, or for any other purpose, all parts of the cell, as well as the cavity of the cylinder head, must be thoroughly cleaned of carbon. As there is no gasket used for sealing the joint between the cell and the cylinder head, the cell should be reseated in the head by lightly lapping with a medium valve grinding compound, using the same motion as when grinding poppet valves.

To remove a cell, if a special puller is not available, remove its retaining plug, then take out the injection nozzle. Insert a pointed piece of brass rod through the nozzle opening and drift the cell out of the cylinder head.

NOTE—When an engine has been in service for a considerable length of time, the cells may not drift out easily. In such cases, penentrating oil applied to the outer end of the cell, after its retaining plug is removed, will help to free the cell. Excessive drifting on the inner end of the cell will not only ruin its operation but will make removal still more difficult by expanding the end.

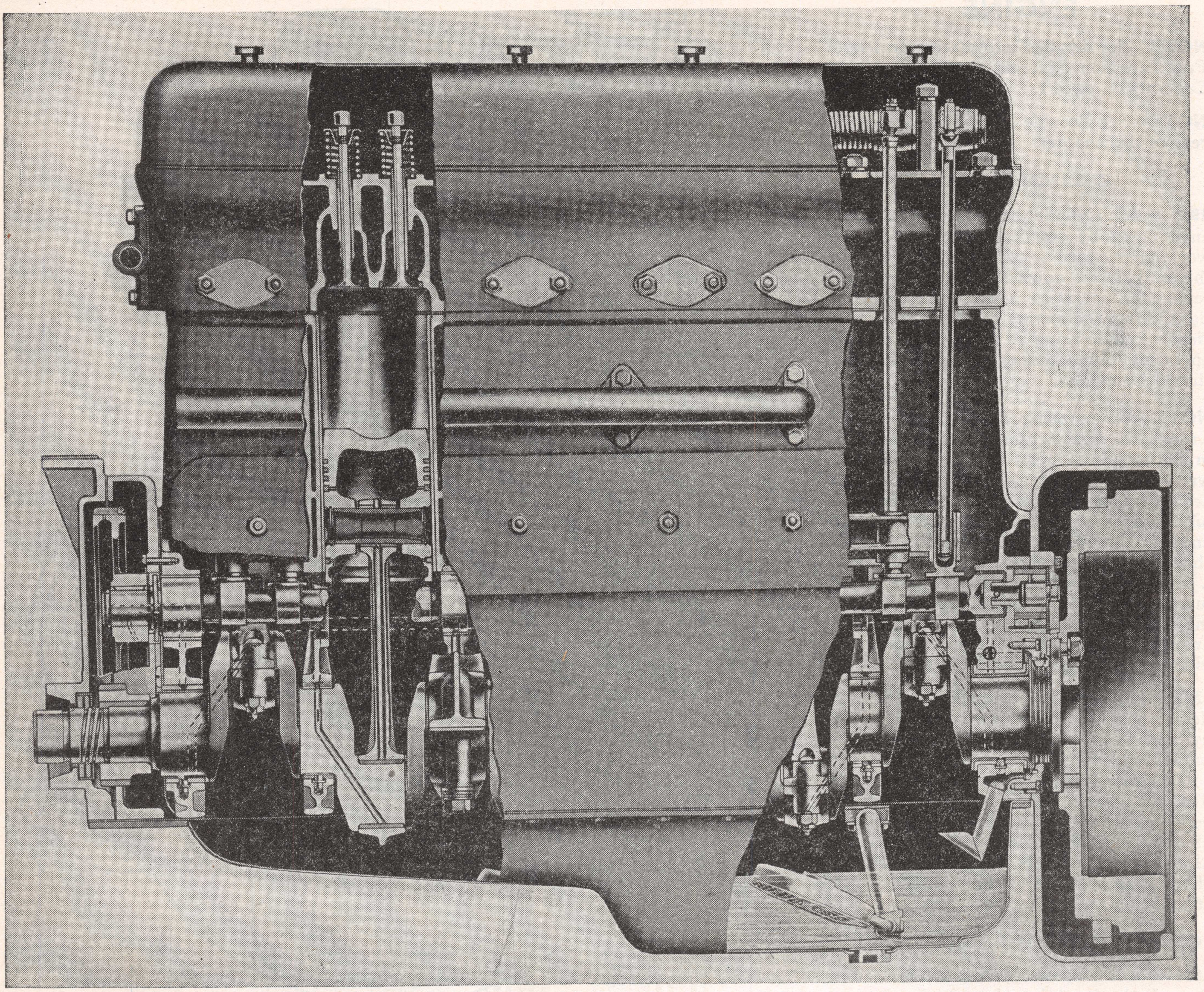
CAUTION—When the cell is replaced, the retaining plug should be properly tightened but **not over tightened.** A leak at the retaining plug would be due to improper seating of the cell joint or at the cell in the cylinder head. This condition could not be remedied by excessive tightening of the retaining plug. The cell will have to be removed and serviced as described below.

When cleaning the cell, a suitable wooden scraper should be used, but by immersing the cell in a carbon solvent such as carbon tetrachloride, the same result will be obtained. When cleaning the small orifice, a tool of soft material and correct diameter should be used. Never use a drill or reamer for this operation.

To provide a gas tight fit between the cell and the cell cap, the mating surfaces of these two parts should be lapped, using a medium grade of valve grinding compound on a perfectly flat lapping plate (cast iron preferably).

ROCKER ARMS & PUSH RODS

1936-46 All: When disassembling the rocker shaft assembly, place all parts on the bench in their proper relationship to assure correct assembly. To prevent the possibility of bending or twisting push rods, they



SIDE SECTION. General view of all engines.

should always be removed before taking off the cylinder head, and replaced after the head is installed.

IMPORTANT—Since it requires some little time to fill the hollow rocker arm shafts with oil after the engine is started, and since the push rod ends and valve caps are lubricated by a relatively low oil flow rate, initial distress of parts will be prevented if —when assembling—the rocker shafts are lubricated thoroughly with oil. As an added precaution, each end of the rocker arms should also be lubricated.

VALVE SEAT INSERTS

1936-46 All: Since these inserts are too hard to reface by the ordinary grinding methods, a high-speed grinding stone or a special lapping tool should be used to perform this operation. When using this equipment, be sure valve guides are clean and the valve guide pilot is a snug fit in order to assure a concentric finish. Finished seats should be checked with a dial indicator and run-out should not exceed .0005".

To remove and install inserts, special puller and driver equipment is available. However, if these tools are not procurable, the following method may be used:

To remove an insert, use a drill which is smaller in diameter than the width of the insert and drill two holes at opposite sides, but not all the way through. Cut through the undrilled portion of the insert with a sharp chisel and remove the two pieces.

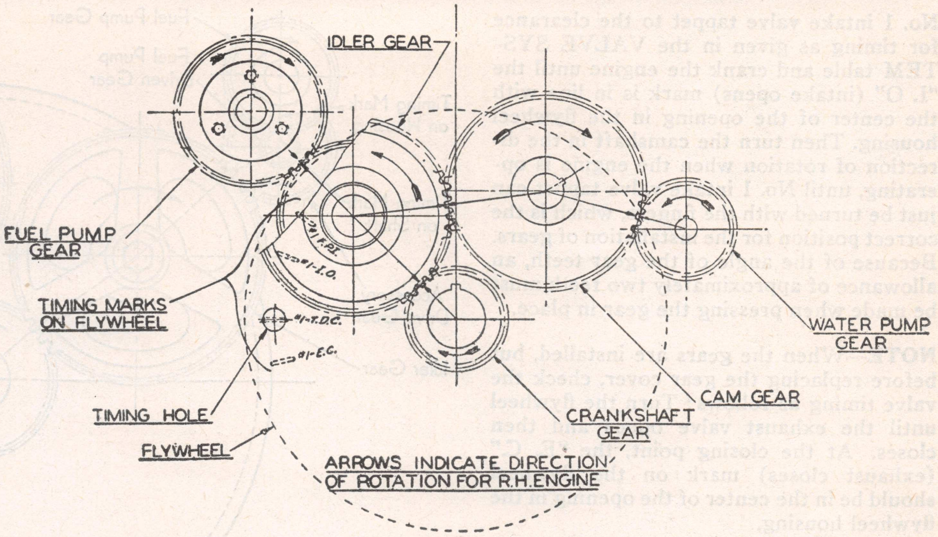
To install an insert, pack in "dry ice" for at least fifteen minutes to allow the metal to contract, and heat the valve port area gradually, if necessary, to permit this material to expand. Then press or drive the insert into the cylinder head, using extreme care to see that it is not cocked or misaligned. When installed, finish the seats with the grinding or lapping equipment already mentioned.

VALVE SPRINGS

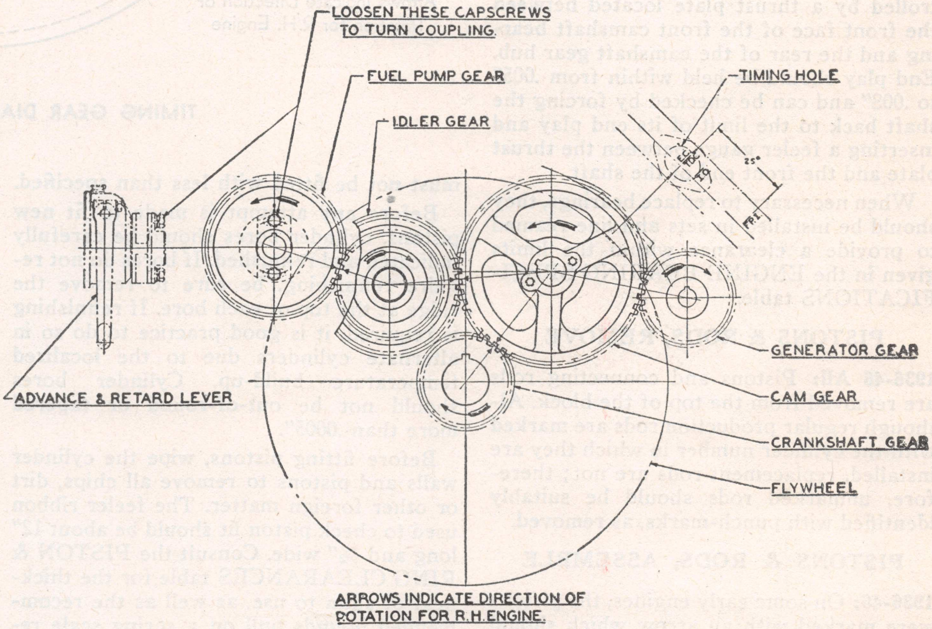
1936-46 All: Valve springs should be tested every time they are removed. See the VALVE SYSTEM table for the correct free length and for test specifications.

Valve springs can be changed on these engines without removing the cylinder head. When removing any spring, be sure to bring that piston up on top center to prevent the valve from dropping into the cylinder. Depress the end of the rocker arm over the valve until the push rod can be removed from its socket. Then compress the valve spring, remove the spring retainer and lift off the spring.

NOTE—To prevent the valve from dropping into the cylinder, as in the case of a broken valve spring or valve stem end, a snap ring is fitted into the groove in the valve stem on late production of these engines.



TIMING GEAR DIAGRAM. Four-cylinder engines and 278, 294 and 317.



TIMING GEAR DIAGRAM. 389 and 468 engines.

VALVE STEM GUIDES

1936-46 All: To remove valve guides, take off the cylinder head and take off the rocker shaft assembly, remove the valves and springs and pull out the guides.

NOTE—On all engines, it is good practice to remove and install one guide at a time. When installing an intake guide, measure the depth of an intake guide not yet removed in order to determine the correct depth of the guide being installed. Similarly, when installing an exhaust guide, measure the depth of an exhaust guide not yet removed. When all guides are installed, they should be reamed to provide a clearance within the limits given in the VALVE SYSTEM table. It is recommended that the guides be drawn in place rather than driven.

VALVE TAPPETS & GUIDES

1936-46 All: Tappets must be a free fit in their guides without excessive side play.

VALVE TIMING, CHECK

1936-46 All: With the engine at normal room temperature and No. 1 intake valve tappet set to the clearance for timing as given in the VALVE SYSTEM table, crank the engine until the "I. O." (intake opens) mark on the flywheel is in line with the center of the opening in the flywheel housing. In this position, No. 1 intake valve should just be starting to open.

TIMING GEARS

1936-46 All: Whenever these gears are removed for any reason, it is important that they be assembled so that the marked teeth on the crankshaft, camshaft and idler gears are meshed at the same time. If the gears are not marked, the correct assembly may be made in the manner described further along in this chapter under "Camshaft Timing".

Replacement Gears: These gears are marked with a number imposed within a circle or a letter U. If marked with a number 2 within a circle, it signifies that the gear is .002" oversize. If marked with a number 3 within a U, it denotes a .003" undersize gear.

Fitting Gears: The crankshaft, camshaft and idler gears should be fitted with .002" backlash. When replacing one gear, use the size marking on the old gear, making allowance for wear on the others. The accessory drive gear may have considerably more lash than .002" and therefore, it need not be replaced as often as the others.

Idler Gear: On all engines, this gear rotates on a stud which is pressed in the crankcase. This stud is secured by means of a lockscrew which is entered into the right side of the case. Since oil is fed to the base of the stud, an acorn lock nut is screwed over the protruding end of the screw and sealed against the crankcase by a gasket.

NOTE—When installing the stud, the setscrew hole in the stud must line up with the corresponding hole in the crankcase. With this arrangement, oil is fed to the base of the hollow stud which supplies a stream to the gear hub.

The idler gear bushing is of the thin wall type and broached in place after being installed and prior to the cutting of the gear teeth. Therefore, if worn excessively, the gear and bushing should be replaced as a unit.

Idler gear end play is controlled by a thrust washer on the end of the shaft and should not exceed .006".

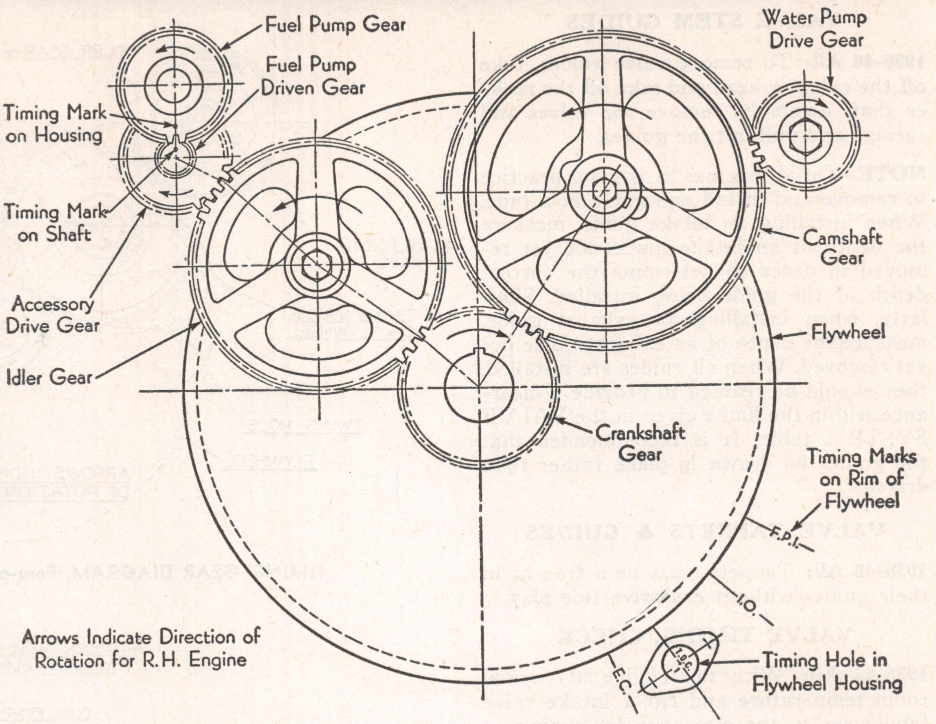
NOTE—The idler gear thrust washer is pinned to the shaft to prevent its turning and secured by a capscrew. This capscrew has either a right or left-hand thread, depending upon the rotation of the gear, to prevent it from working loose.

Camshaft Gear: On all models, the camshaft end thrust is controlled by a thrust plate attached to the front end of the crankcase, between the front face of the front camshaft bearing and the rear of the camshaft gear hub.

The gear is pressed on the shaft and retained by a spring wire lock, which snaps in a groove in the end of the shaft. When installing a gear of the pressed-on type, allow from .004" to .008" end play.

Crank Gear: When installing, heat the gear in boiling water to expand the metal and coat the shaft with white lead in order to make assembly easier.

Camshaft Timing: If the gears are not marked, the correct valve timing may be obtained by proceeding as follows: Adjust



Arrows Indicate Direction of Rotation for R.H. Engine

TIMING GEAR DIAGRAM. 691 engines.

No. 1 intake valve tappet to the clearance for timing as given in the VALVE SYSTEM table and crank the engine until the "I. O" (intake opens) mark is in line with the center of the opening in the flywheel housing. Then turn the camshaft in the direction of rotation when the engine is operating, until No. 1 intake valve tappet can just be turned with the fingers, which is the correct position for the installation of gears. Because of the angle of the gear teeth, an allowance of approximately two teeth must be made when pressing the gear in place.

NOTE—When the gears are installed, but before replacing the gear cover, check the valve timing as follows: Turn the flywheel until the exhaust valve opens and then closes. At the closing point, the "E. C." (exhaust closes) mark on the flywheel should be in the center of the opening in the flywheel housing.

CAMSHAFT & BEARINGS

1936-46 All: Camshaft end thrust is controlled by a thrust plate located between the front face of the front camshaft bearing and the rear of the camshaft gear hub. End play should be held within from .005" to .008" and can be checked by forcing the shaft back to the limit of its end play and inserting a feeler gauge between the thrust plate and the front end of the shaft.

When necessary to replace bearings, they should be installed in sets and line-reamed to provide a clearance within the limits given in the ENGINE BEARING SPECIFICATIONS table.

PISTONS & RODS, REMOVE

1936-46 All: Pistons and connecting rods are removed from the top of the block. Although regular production rods are marked with the cylinder number in which they are installed, replacement rods are not; therefore, unmarked rods should be suitably identified with punch-marks, as removed.

PISTONS & RODS, ASSEMBLE

1936-46: On some early engines, the pistons were marked with an arrow which should point toward the front of the engine when installed. On all engines of later production, the arrow points toward the injection nozzle and should be so installed.

IMPORTANT—If the pistons are not installed in this manner, the piston head will not enter the combustion chamber due to the lobes on the piston head being off-center. This does not apply to the 691 engines with flat top pistons.

PISTONS, RENEW

1936-46 All: NOTE—A variation of 10 degrees between the temperature of the pistons and cylinder bores is sufficient to produce a difference of .0005". Therefore, both the pistons and cylinder bores should be at normal room temperature (about 70 degrees) when fitting pistons. This is particularly important because the clearances given in the PISTON & RING CLEARANCES table are minimum and pistons must not be fitted with less than specified.

Before any attempt is made to fit new pistons, cylinder bores should be carefully indicated and refinished. If bores do not require refinishing, be sure to remove the ridge at the top of each bore. If refinishing is required, it is good practice to do so in alternate cylinders due to the localized temperature build-up. Cylinder bores should not be out-of-round or tapered more than .0005".

Before fitting pistons, wipe the cylinder walls and pistons to remove all chips, dirt or other foreign matter. The feeler ribbon used to check piston fit should be about 12" long and ½" wide. Consult the PISTON & RING CLEARANCES table for the thickness of shim to use, as well as the recommended pounds pull on a spring scale required to withdraw the feeler ribbon past the piston.

Insert the piston in the bore upside down and in its running position (see PISTON & ROD, ASSEMBLE). Place the feeler ribbon between the cylinder wall in a position at right angles to the piston pin hole.

After assembling the piston to the connecting rod, check the assembly for alignment on a suitable jig.

PISTON RINGS, RENEW

1936-46 All: NOTE—To prevent the possibility of bending or breaking the second ring land—thus ruining the piston—the ridge at the top of the cylinder bore should be cut away before removing the piston and rod assemblies. If the available ridge reamer has no provision to control the depth of the cut, it is good practice to bring the piston far enough up into the cylinder to allow the reamer to rest on top of the piston. This will serve to prevent cutting down into the ring travel area. CAUTION—Never cut down into the ring travel area more than 1/32"—or more than half the depth of the top ring.

New rings should be fitted with end gaps and groove clearances as given in the PISTON & RING CLEARANCES table. Ring grooves must be clean and free from carbon, and must show no perceptible wear.

NOTE—Ring end gaps given in the PISTON & RING CLEARANCES table are for cylinder bores without taper. If rings other than standard are being installed, pay particular attention to the installation instructions which are usually included in the ring package. This applies to clearances, position in grooves, etc.

When rings are properly fitted to the pistons, be sure to stagger the ring gaps so they are spaced equal distances around the circumference of the piston. However, see that no gaps are over the piston pins.

PISTON PINS, RENEW

1936-46 All: The correct fit of aluminum pistons, at normal room temperature, should require a light tap fit with a rubber mallet to install the pin. However, to facilitate fitting pins in aluminum pistons, heat the piston in boiling water for a few minutes, after which the pin should enter the piston easily.

These pins are of the full-floating type, being held in place by snap rings in the grooves of the piston bosses.

PISTON PIN BUSHINGS, RENEW

1936-46 All: New bushings should be pressed in place and reamed to provide a light push fit of the pin with the parts at normal room temperature. When installed, be sure the oil hole in the bushing lines up with the hole in the connecting rod.

CONNECTING ROD, BEARINGS, RENEW

1936-46 All: These bearings are of the precision insert type and when worn, they may be replaced by simply taking off the bearing cap and slip the old shells out and the new ones in. Bearings should be replaced in sets and under no circumstances should rods or caps be filed, altered or mutilated in any way in an attempt to obtain proper bearing fit.

NOTE—Before replacing bearings, make sure that the crankpins are not nicked or scored, and that all parts are thoroughly clean. This is particularly important because the presence of one small particle of metal, carbon or other foreign matter, lodged between the back of the bearing and the rod, or between the face of the bearing and the crankpin, will very likely cause a hot spot due to the elimination of the oil clearance at that point, eventually resulting in a bearing failure or a scored crankpin.

CAUTION—These bearings are designed for use without shims and under no circumstances should shims be used in an attempt to obtain a bearing fit, because the proper "crush" fit of the bearings in the connecting rod bores will not be obtained.

To check the fit of new bearings, use a piece of brass shim stock ¼" wide, the length of which should be ¼" less than the length of the bearing, while the thickness should be approximately the same as the minimum allowable clearance.

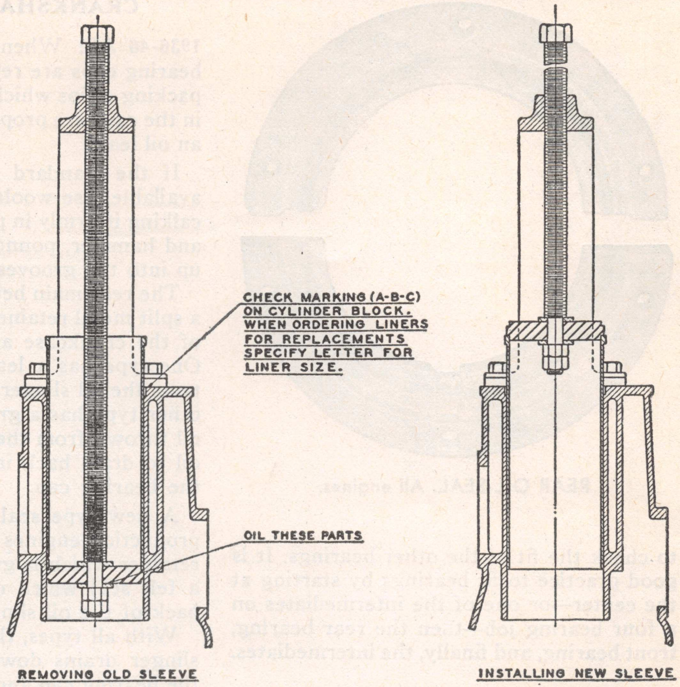
CAUTION—To avoid damaging the bearing material, smooth down the edges of the shim stock on an oil stone so that no sharp edges remain. Install the shim between the bearing and the crankpin, in the center of the bearing, then tighten the cap bolts to the recommended torque tension. When fitted properly, it should not be possible to move the rod endwise by hand, but a light tap with a hammer should cause the rod to move endwise. Then remove the checking shim and re-install the cap, tightening the cap bolts with a torque wrench, after which the rod should move endwise by hand. If the rod is too loose with the checking shim in place, the crankpin should be turned down and undersize bearings fitted.

NOTE—691 engines are equipped with hand hole covers on the side of the crankcase, which, when removed, new inserts may be fitted, without removing the oil pan.

CYLINDER SLEEVES

1936-46 All: These sleeves are of the "dry" type and are obtainable in the original standard sizes only. Since these sleeves are too hard to be bored, new sleeves should be installed with standard size pistons.

To assure maximum heat transfer from the sleeve to the cylinder block and water jackets, the sleeve is a press fit. Sleeves should be coated with machine oil to prevent galling or sticking when being pressed in place. As the sleeve nears the bottom of the block, blow away the oil under the shoulder of the sleeve to permit the shoulder to seat firmly in the counterbore of the block.


CHECK MARKING (A-B-C) ON CYLINDER BLOCK. WHEN ORDERING LINERS FOR REPLACEMENTS SPECIFY LETTER FOR LINER SIZE.
OIL THESE PARTS
REMOVING OLD SLEEVE
INSTALLING NEW SLEEVE

CYLINDER SLEEVE SERVICE TOOL. All engines.

NOTE—Always use a suitable sleeve tool when installing sleeves as they must never be hammered or pounded into position. When properly installed, the sleeve shoulder should be approximately flush with the surface of the block, but never more than .006" above and never below. These limits are required to permit the cylinder head to be clamped evenly with the block, which otherwise would result in leakage across the cored passages. When fitted to the above specifications, the shoulder of the sleeve will be clamped, and the head gasket will be able to take care of the small amount of projection.

MAIN BEARINGS, RENEW

1932-46 All: NOTE—Before replacing bearings, make sure that the crankshaft journals are not nicked or scored. Use care also, to see that all parts are thoroughly clean. This is particularly important because one small particle of metal, carbon, dirt or other foreign matter, lodged between the back of the bearing and the cap or saddle, or between the bearing face and the crankshaft journal, will very likely cause a hot spot due to the elimination of the oil clearance at that point, eventually resulting in a bearing failure or a scored journal.

When bearings become worn, they can be replaced without removing the crankshaft in the following manner: Remove the bearing cap and take out the worn lower shell. A suitable tool can be made to remove the upper shell be using a cotter pin with the rounded end flattened to form a T shape. Insert the T-shaped end of the pin in the oil passage hole in the crankshaft journal and, by rotating the crankshaft in the reverse direction, the T-shaped head will contact the bearing and force it out.

To install, place a new upper shell on the crankshaft journal with the locating notch in the correct position and rotate the shaft to turn the shell in place. Then install the lower shell in the cap and replace the cap, tightening the cap bolts to the recommended torque tension which will be found in the ENGINE BEARING SPECIFICATIONS table.

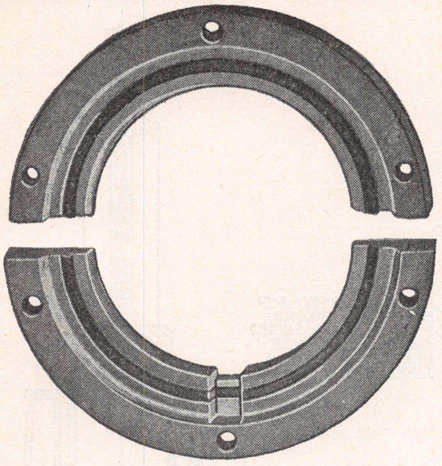
NOTE—Bearings should be replaced in sets and under no circumstances should any attempt be made to shim, file, alter or otherwise mutilate the bearing caps to obtain proper bearing fit.

To check the fit of new bearings, use a piece of brass shim stock ¼" wide, the length of which should be ¼" less than the length of the bearing, while the thickness should be about the same as the minimum allowable clearance.

CAUTION—To avoid damaging the bearing material, smooth down the edges of the shim stock to remove sharp edges or turned over corners. And before inserting it in place, coat the shim on both sides with a light film of engine oil.

Then lay the shim lengthwise in the center of the bearing and install the bearing cap to the crankshaft, tightening the cap bolts to the recommended torque tension. Test the fit of the bearing by rocking the flywheel through an arc of 2"—not more than 1" in either direction. The bearing may be considered fitted properly if the shaft is movable with a fairly heavy drag.

NOTE—Remove the checking shim and replace the cap, but do not tighten the cap bolts, as this bearing must be loose in order



REAR OIL SEAL. All engines.

to check the fit of the other bearings. It is good practice to fit bearings by starting at the center—or one of the intermediates on a four bearing job—then the rear bearing, front bearing, and finally, the intermediates.

CRANKSHAFT END THRUST

1936-46 All: Crankshaft end thrust is controlled by flanges on the rear main bearing. Through normal wear, the end play will seldom become excessive but whenever new bearings are fitted, the clearance should be carefully checked and, if required, the bearing flanges may be dressed down to obtain the desired end play.

CRANKSHAFT OIL SEALS

1936-46 All: Whenever the front or rear bearing caps are replaced, be sure that the packing strips which fit into the milled slots in the caps are properly installed to prevent an oil leak.

If the standard packing strips are not available, use woolen yarn in the grooves, calking it firmly in place, using a small drift and hammer, pounding the yarn gradually up into the grooves until fully packed.

The rear main bearing oil seal consists of a split metal retainer bolted to the rear end of the crankcase and two types are used. One type has a leather insert which contacts the oil slinger on the crankshaft. The other type has a groove which catches the oil thrown from the slinger, permitting the oil to drain back into the oil pan through the bearing cap.

A new type seal is used on all current production engines and consists of a metal retainer which is grooved to accommodate a felt seal which contacts the crankshaft back of the oil slinger.

With all types, the oil thrown off by the slinger drains down into the reservoir in the bearing cap and then through a tube to the oil level in the pan.

NOTE—With all types, if an oil leak occurs, be sure there is no restriction to this oil return. When fitting a new leather insert, the lower portion of the leather should be trimmed flush with the seal to prevent an air lock. In other words, the leather in the lower half of the seal should be trimmed ¾" in either direction of the lowest point of the seal—at the drain tube position. When replacing the leather wiper, apply shellac or gasket cement to hold it securely in place.

FLYWHEEL & HOUSING

1936-46 All: Whenever replacing the flywheel, it should be checked for wobble or excessive run-out. If a dial indicator is available, mount it on the flywheel housing and allow its stem to contact the flywheel as the engine is being turned slowly. Make a note of the high and low sides of the flywheel through one complete revolution and if run-out exceeds .010", it should be removed and the crankshaft flange recess inspected for burrs, dirt or other foreign matter.

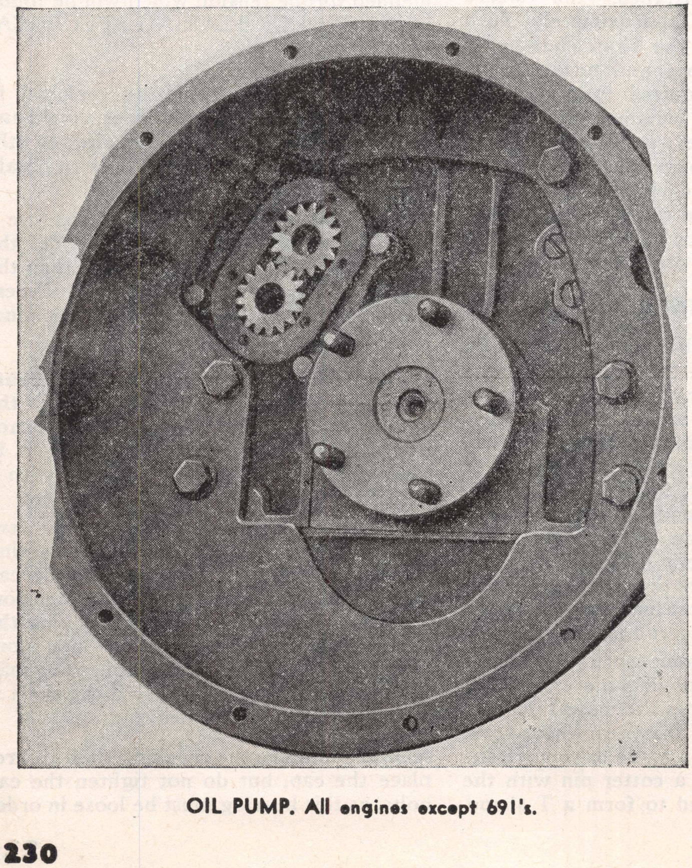
ENGINE OILING

OIL PUMP

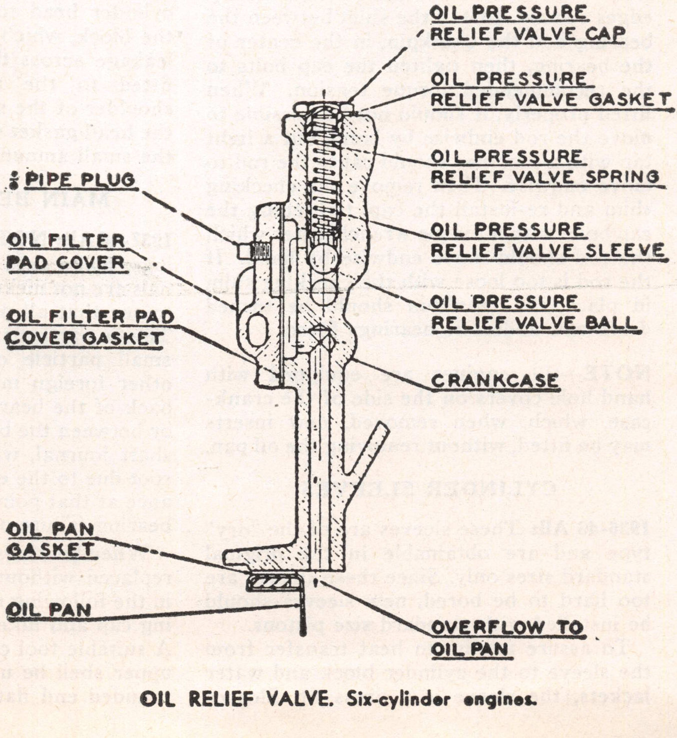
1936-46 All: With the engine operating at normal temperature, oil pressure should be about 30 pounds at normal engine speeds. Clearance between the pump body and the gear on any one side should not exceed .002". Backlash between gears, not more than .002". The face of the gears should be flush with the pump cover.

On all engines, the pump is located in a recess in the flywheel end of the crankcase and is driven by the camshaft. After removing the flywheel, the pump is accessible for inspection by simply removing the cover. If, after inspection, the pump is to be removed, take out the four cap screws which fasten the assembly to the crankcase and withdraw the pump.

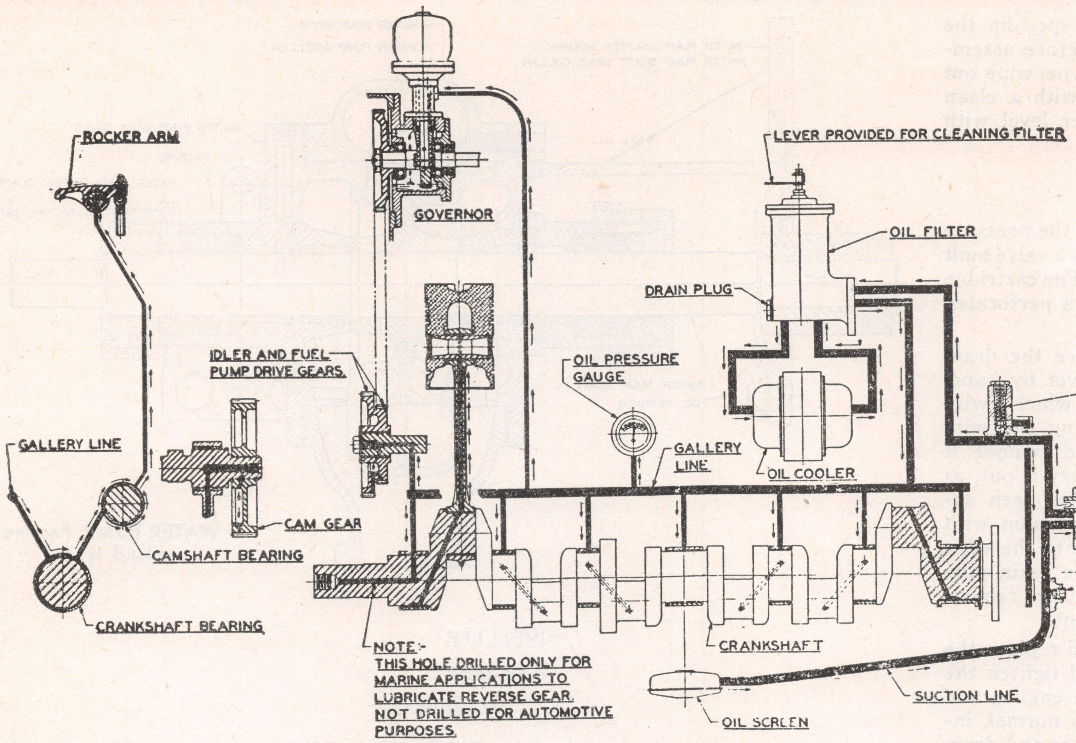
NOTE—On all engines, before replacing the oil pan, the oil float, screen and tube should be thoroughly cleaned, being sure



OIL PUMP. All engines except 691's.


OIL PRESSURE RELIEF VALVE CAP
OIL PRESSURE RELIEF VALVE GASKET
OIL PRESSURE RELIEF VALVE SPRING
OIL PRESSURE RELIEF VALVE SLEEVE
OIL PRESSURE RELIEF VALVE BALL
CRANKCASE
OVERFLOW TO OIL PAN
⅜ PIPE PLUG
OIL FILTER PAD COVER
OIL FILTER PAD COVER GASKET
OIL PAN GASKET
OIL PAN

OIL RELIEF VALVE. Six-cylinder engines.

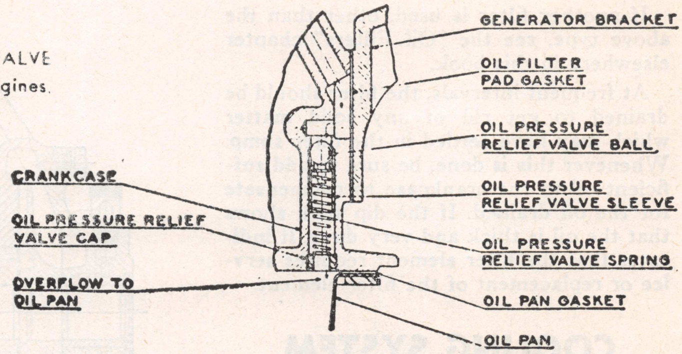

ROCKER ARM
GOVERNOR
LEVER PROVIDED FOR CLEANING FILTER
OIL FILTER
DRAIN PLUG
IDLER AND FUEL PUMP DRIVE GEARS
OIL PRESSURE GAUGE
OIL PRESSURE REGULATING VALVE
GALLERY LINE
GALLERY LINE
OIL COOLER
OIL PUMP
CAM GEAR
CAMSHAFT BEARING
PRIMING HOLE PLUG
CRANKSHAFT BEARING
CRANKSHAFT
NOTE:- THIS HOLE DRILLED ONLY FOR MARINE APPLICATIONS TO LUBRICATE REVERSE GEAR. NOT DRILLED FOR AUTOMOTIVE PURPOSES.
SUCTION LINE
OIL SCREEN

LUBRICATING OIL DIAGRAM. All engines.

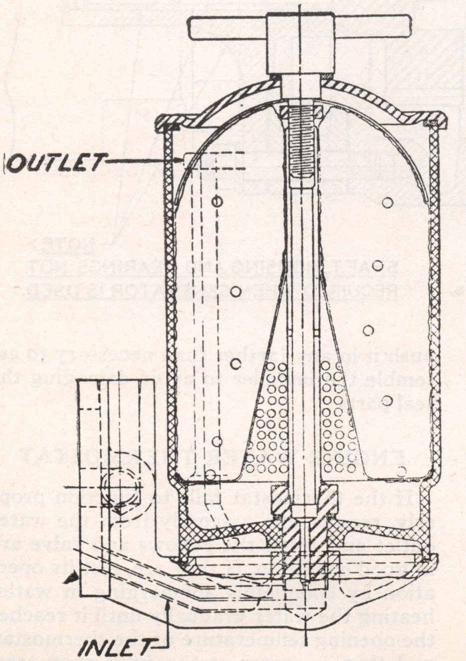
that all openings in the screen are open. If the screen has been crushed, it is better to replace it rather than attempt to make a repair.

If it is necessary to prime the pump, all engines except the 691 have a plug marked "Prime" in the side of the crankcase adjacent to the filter pad.

To prime the pump, take out the plug marked "Prime" from the side of the crankcase adjacent to the oil filter pad which opens into the suction passes. Using an oil gun, start the engine and pump the oil into the suction passes. The engine should not be allowed to run for more than about a half-minute without oil circulation. When the oil is injected into the priming hole, remove the gun and cover the hole with a finger until circulation starts. When started, shut off the engine and replace the priming hole plug.


GENERATOR BRACKET
OIL FILTER PAD GASKET
OIL PRESSURE RELIEF VALVE BALL
OIL PRESSURE RELIEF VALVE SLEEVE
OIL PRESSURE RELIEF VALVE SPRING
CRANKCASE
OIL PRESSURE RELIEF VALVE CAP
OVERFLOW TO OIL PAN
OIL PAN GASKET
OIL PAN

OIL RELIEF VALVE
Four-cylinder engines.


OUTLET
INLET

OIL FILTER. General design on all engines.

OIL PRESSURE REGULATOR

1936-46 Four Cylinder: On these engines, the oil pressure relief valve is accessible from the bottom of the crankcase only. The hollow cap nut which holds the spring in position is located at the inner edge of the crankcase and oil pan flange near the fourth main bearing. If required, the spring may be compressed or lengthened to change oil pressure after removing the cap.

1936-46 Six Cylinder: The oil pressure relief valve spring and ball is accessible after removing the large hexagon cap nut located just back of the oil filter. On the 691 engines, the regulator is located midway on the oil filter side. The only adjustment is by lengthening or compressing the spring.

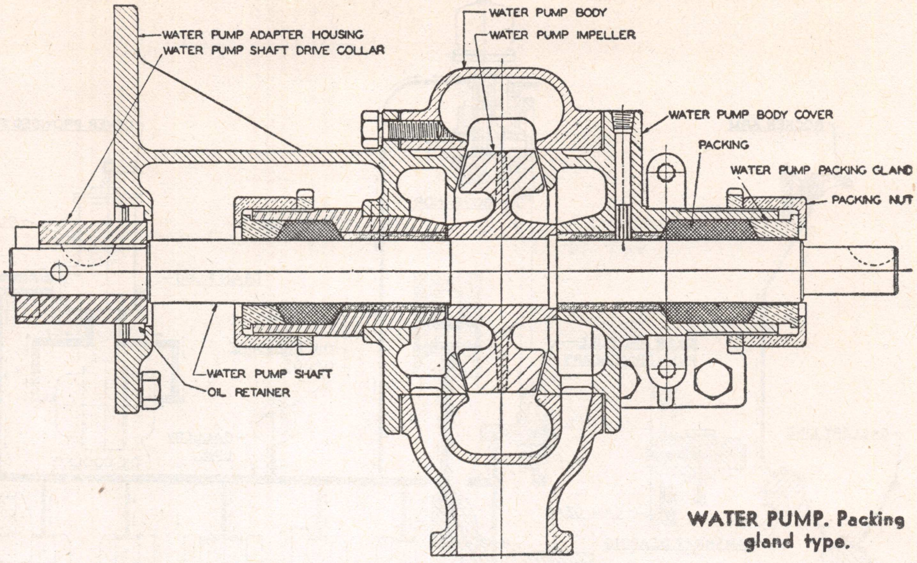
CRANKCASE VENTILATOR

1936-46 All: The interval at which the ventilator and air cleaner should be cleaned can only be determined by the type of service to which the vehicle is subjected. Vehicles operating in dusty or sandy areas require more frequent service than vehicles operating under more favorable conditions.

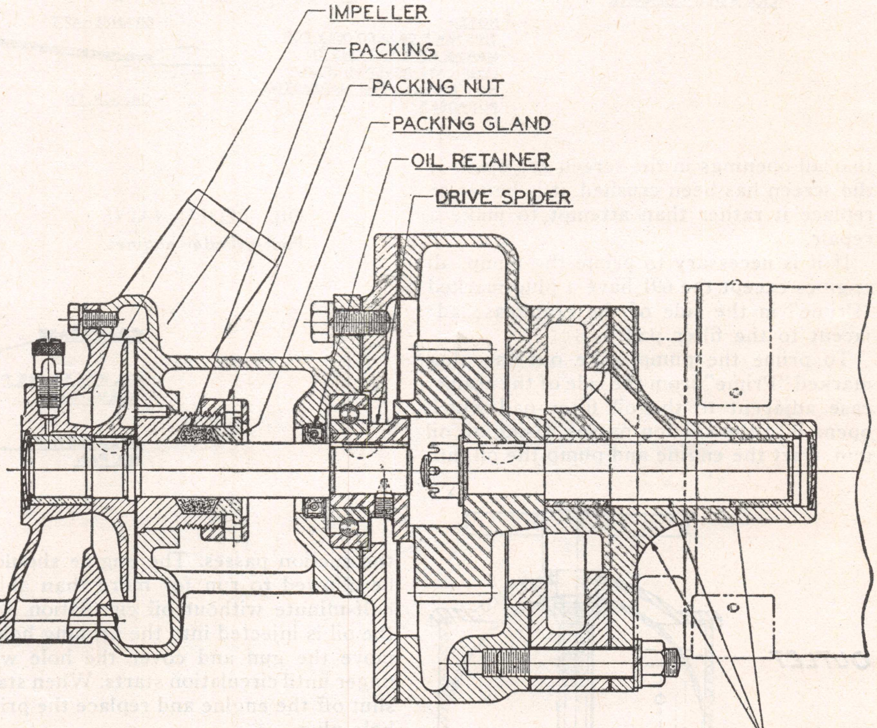
IMPORTANT—For vehicles operating in dust storm areas, the cleaner should be serviced immediately after such storms occur.

For normal service however, the breather should be inspected at least every 2,000 miles, and if a sludge formation is evident, remove the breather and clean it thoroughly in gasoline. Allow the breather to soak in the gasoline for at least 30 minutes, then blow it out with compressed air, while at the same time, tapping it lightly to dislodge any solid particles of sludge.

If the breather is fitted with an air cleaner, it should be removed and washed every 1,000 miles. After the element is washed, blow it dry with compressed air and, if the



WATER PUMP. Packing gland type.



WATER PUMP. Four-cylinder, gear driven type.

NOTE:- SHAFT, HOUSING AND BEARINGS NOT REQUIRED WHEN GENERATOR IS USED.

cleaner is of the oil-wetted type, dip the element in fresh engine oil before assembling. If it is of the oil bath type, wipe out the oil reservoir thoroughly with a clean cloth and fill it to the proper level with fresh engine oil.

OIL FILTER

1936-46 All: On most engines, the pressure within the filter is controlled by a valve built into the base of cover handle. The cartridge is held in a rigid position by a perforated cap fitted to the cover.

To service the filter, remove the drain plug and unscrew the top cover by hand, exposing the filter cartridge to which a wire handle has been welded. Using the wire handle, lift the cartridge and remove it slowly. Do not use a tool to pry it out, as the edge of the filter shell has been accurately machined for a tight union with the cover gasket, and damage to the edge may cause a leak. Remove the drain plug and clean the bottom of the sump, removing all the accumulated sediment.

Insert the new cartridge and replace the cover, using a new gasket and tighten the cover by hand only. Start the engine, and when the oil pressure reaches normal, inspect for leaks around the cover and drain plug.

If another filter is used, other than the above type, see the "Oil Filters" chapter elsewhere in this book.

At frequent intervals, the filter should be drained to get rid of any solid matter which may have settled in the filter sump. Whenever this is done, be sure to add sufficient oil to the crankcase to compensate for the oil drained. If the dip stick shows that the oil is thick and very dirty, it indicates that the filter element requires service or replacement of the filter element.

COOLING SYSTEM

WATER PUMP, OVERHAUL

1936-46 Gear Driven Pump: The pump used on these engines is driven by a gear in the timing case cover and is of the conventional packing gland type. The pump shaft is supported in the body by two bronze bushings and packed with ring packing.

This type pump is easily disassembled by separating the pump housing, and when this is done, the internal parts are accessible and readily removed. If new bushings are to be installed, they should be reamed to provide a shaft clearance of from .002" to .003". When tightening the gland nuts, tighten only sufficiently to stop leakage and back off slightly to relieve the pressure.

Belt Driven Pump: This pump is of the spring gland or packingless type. Water sealing is accomplished by a non-adjustable packless seal, consisting of a carbon disc, flexible seal, seal spring and brass shields.

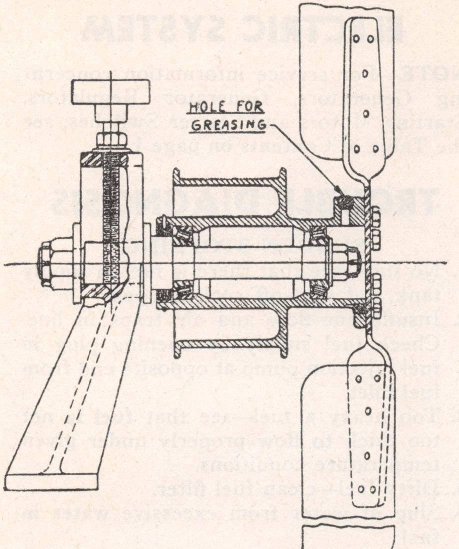
NOTE—The water pump impeller is usually keyed and secured on the shaft by a spring wire retainer in a groove in the end of the shaft while in some cases, the impeller is merely pressed on the shaft over a Woodruff key. Before disassembling the pump, be sure to remove the burrs from the ends of the shaft to prevent damage to the pump bushings.

To disassemble the pump, disconnect the pump body from the drive housing. Use a suitable puller to remove the impeller from the shaft. Insert a screw driver through one of the slots in the impeller hub and press the snap ring out of the groove, after which, take out the seal parts.

When assembling, be sure the oil retainer is in the proper position in the pump housing. When installing the shaft, do not push it in any farther than necessary to assemble the impeller to avoid damaging the seal parts.

ENGINE WATER THERMOSTAT

If the thermostat fails to function properly, remove the assembly from the water outlet and see if the bellows and valve are in good condition. If they are, test its operation by completely submerging in water, heating the water gradually until it reaches the opening temperature of the thermostat, and then in water at the fully open temperature.


HOLE FOR GREASING

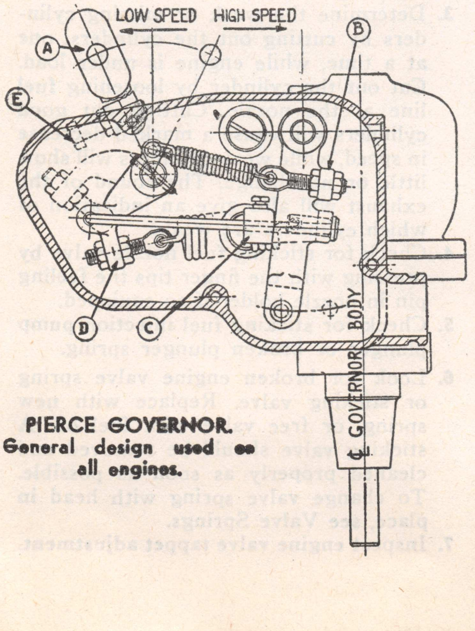
FAN ASSEMBLY. Used with gear-driven water pumps.

When taking temperature readings, agitate the water thoroughly, and if the thermostat fails to function properly, it should be replaced rather than attempt to make a repair. However, before installing a new unit, it is good practice to make a test as directed above.

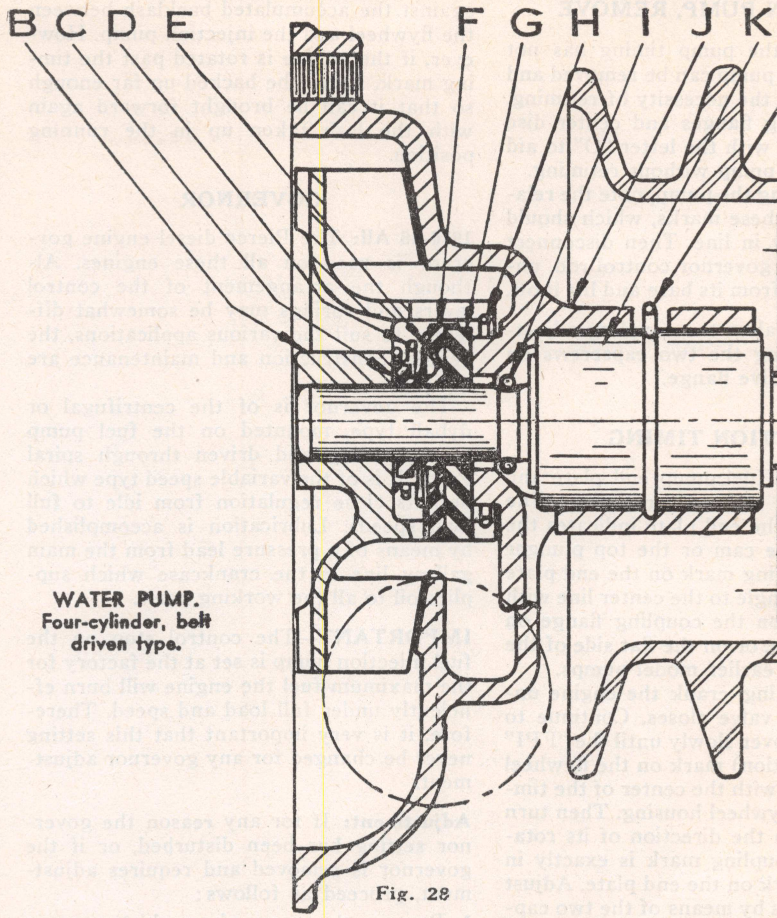
Normally, the thermostat should start to open at from 145 to 150 degrees and be fully open at from 170 to 175 degrees F. However, thermostats are available which have lower, as well as high opening temperatures, depending upon the climatic conditions under which the vehicle is operating.

FUEL SYSTEM

NOTE—For detailed information on Diesel Fuel Injection Pumps, see the Table of Contents on page 1.


LOW SPEED
HIGH SPEED
A
B
E
D
C
GOVERNOR BODY

PIERCE GOVERNOR. General design used on all engines.


B
C
D
E
F
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H
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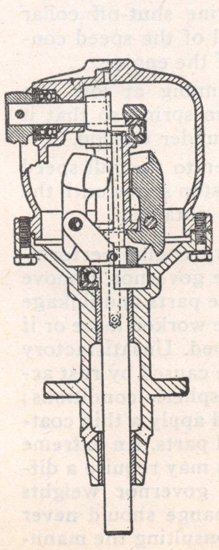
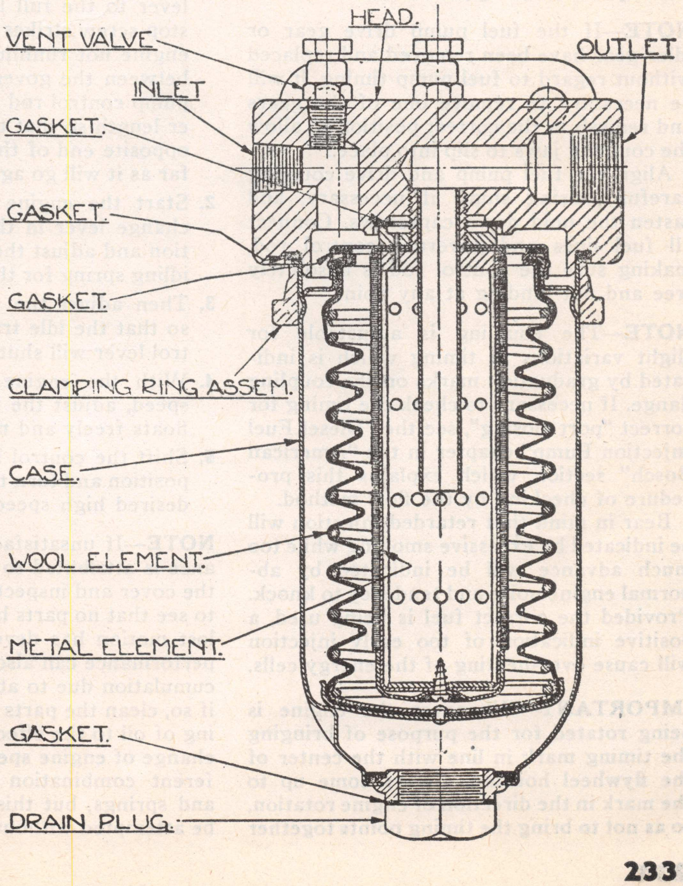
J
K
L
M
N

WATER PUMP. Four-cylinder, belt driven type.

Fig. 28

FUEL FILTER. General design on all engines.




HEAD
VENT VALVE
OUTLET
INLET
GASKET
GASKET
GASKET
CLAMPING RING ASSEM.
CASE
WOOL ELEMENT
METAL ELEMENT
GASKET
DRAIN PLUG

INJECTION PUMP, REMOVE

1936-46 All: If the pump timing has not been altered, the pump can be removed and replaced without the necessity of retiming. The two coupling flanges and center disc are each marked with the letter "O" to aid in replacing the pump without retiming.

Before removing the pump, note the relative position of these marks, which should be approximately in line. Then disconnect all fuel lines and governor control rod, unfasten the pump from its base and lift it off.

NOTE—Do not alter the coupling adjustment by loosening the two capscrews on the side of the drive flange.

INJECTION TIMING

1936-46 All: The fuel pump end plate and the coupling are marked for timing. The center mark on the end plate indicates the center line of the cam or the top plunger position. The timing mark on the end plate is located at an angle to the center line with a mating mark on the coupling flange on late model pumps, or on the flat side of the coupling hub on earlier model pumps.

To set the timing, crank the engine until No. 1 intake valve closes. Continue to turn the engine over slowly until the "FPI" (fuel pump injection) mark on the flywheel is exactly in line with the center of the timing hole in the flywheel housing. Then turn the fuel pump in the direction of its rotation until the coupling mark is exactly in line with the mark on the end plate. Adjust the coupling jaws by means of the two capscrews on the side of the coupling flange and slip the coupling jaws in place.

NOTE—If the fuel pump drive gear or idler gear have been removed and replaced without regard to fuel pump timing, it will be necessary to remove one of the gears and remesh in the correct position to allow the coupling jaws to slip into place.

Align the fuel pump and drive coupling carefully, using shims if necessary, and fasten the hold down capscrews. Connect all fuel lines and governor control rod, making sure the control rod is absolutely free and not binding at any point.

NOTE—The coupling is adjustable for slight variations in timing which is indicated by graduation marks on the coupling flange. If necessary to check the timing for correct "port closing", see the "Diesel Fuel Injection Pump" chapter in the "American Bosch" section which explains this procedure of checking by the flow method.

Bear in mind that retarded injection will be indicated by excessive smoking while too much advance will be indicated by abnormal engine noise and tendency to knock. Provided the correct fuel is being used, a positive indication of too early injection will cause over-heating of the energy cells.

IMPORTANT—Whenever the engine is being rotated for the purpose of bringing the timing mark in line with the center of the flywheel housing, always come up to the mark in the direction of engine rotation, so as not to bring the timing points together against the accumulated backlash between the flywheel and the injection pump. However, if the engine is rotated past the timing mark, it may be backed up far enough so that it can be brought forward again with the lash taken up in the running position.

GOVERNOR

1936-46 All: The Pierce diesel engine governor is used on all these engines. Although the arrangement of the control levers and springs may be somewhat different to suit the various applications, the general construction and maintenance are the same.

The governor is of the centrifugal or flyball type, mounted on the fuel pump drive housing and driven through spiral gears. It is of the variable speed type which permits close regulation from idle to full load speeds. Lubrication is accomplished by means of a pressure lead from the main gallery line in the crankcase which supplies oil to all the working parts.

IMPORTANT—The control stop on the fuel injection pump is set at the factory for the maximum fuel the engine will burn efficiently under full load and speed. Therefore, it is very important that this setting never be changed for any governor adjustment.

Adjustment: If for any reason the governor setting has been disturbed, or if the governor is removed and requires adjustment, proceed as follows:

1. Remove the cover plate which exposes the springs and levers. Shift the control lever to the full load position until the stop screw strikes the housing. With the engine not running, the connecting link between the governor and the injection pump control rod should be of the proper length so that the control stop on the opposite end of the injection pump is as far as it will go against the housing.
2. Start the engine and place the speed change lever in the desired idling position and adjust the spring tension of the idling spring for the desired idling speed.
3. Then adjust the engine shut-off collar so that the idle travel of the speed control lever will shut off the engine.
4. With the engine running at low idle speed, adjust the main spring so that it floats freely and not under tension.
5. Shift the control lever to the full speed position and turn the stop screw until the desired high speed is obtained.

NOTE—If unsatisfactory engine performance is attributed to the governor, remove the cover and inspect the parts and linkage to see that no parts have worked loose or if lost motion has developed. Unsatisfactory performance can also be caused by rust accumulation due to atmospheric conditions; if so, clean the parts and apply a thin coating of oil to the effected parts. An extreme change of engine speeds may require a different combination of governor weights and springs, but this change should never be attempted without consulting the manufacturer to ascertain whether or not the engine will operate properly at such speeds

ELECTRIC SYSTEM

NOTE—For service information concerning Generators, Generator Regulators, Starting Motors and Starter Switches, see the Table of Contents on page 1.

TROUBLE DIAGNOSIS

SUDDEN STOPPING

1. No fuel—see that there is fuel in supply tank and shut-off cock is open.
2. Insufficient flow and air traps in line. Check fuel supply by opening plug in fuel injection pump at opposite end from fuel inlet.
3. Too heavy a fuel—see that fuel is not too thick to flow properly under given temperature conditions.
4. Dirty fuel—clean fuel filter.
5. Slug of water from excessive water in fuel.
6. Plugged fuel line—investigate fuel supply line for obstructions.
7. Turn engine over by hand to make sure that it is free and not stuck from lack of lubrication or other causes.
8. Start engine and check for loss of power.

LOSS OF POWER

It is assumed here that engine has lost power during a running period or that it has failed to give the proper power after being started according to instructions. Conduct investigation in order listed. Engine should be running unless otherwise noted. Each of the following items is a test or a remedy, or both, for possible trouble:

1. Note lubricating oil pressure and level. If pressure is low, check over lubricating system carefully.
2. The most common cause is lack of fuel or air in lines. Vent system thoroughly. If fuel does not flow freely without any signs of air, check for obstruction in fuel supply system. Fuel may be too heavy to flow properly at atmospheric temperature in which engine is operating.
3. Determine the weak or missing cylinders by cutting out the cylinders, one at a time, while engine is under load. Cut out the cylinder by loosening fuel line at the nozzle. Cutting out good cylinders will cause a marked decrease in speed, while weak cylinders will show little or no change. The sound of the exhaust will also give an indication of which cylinders are weak.
4. Check for sticking fuel nozzle valve by pressing with the finger tips the feeling pin in nozzle holder if so equipped.
5. Check for sticking fuel injection pump plunger or broken plunger spring.
6. Look for broken engine valve spring or sticking valve. Replace with new spring, or free valve with fuel oil. A sticking valve should be removed and cleaned properly as soon as possible. To change valve spring with head in place, see Valve Springs.
7. Inspect engine valve tappet adjustment.

8. Check compression of engine cylinders by rocking with hand crank or bar in flywheel. When in good condition engine can be rocked from ten to fifteen times without appreciable loss of rebound. Check each cylinder.
9. Examine the air silencer or cleaner and air intake for obstructions. These often become clogged.
10. Examine exhaust passages and muffler for obstructions.
11. If none of the above tests eliminate the trouble, the cause doubtless lies in the fuel injection pump.

KNOCKING

Knocks in the engine can be divided into fuel knocks and those which cannot be directly assigned to the combustion process. Knocks other than fuel are either from loose bearings, pistons, flywheel, improperly adjusted valve mechanism or blowby due to sticking piston rings.

Excessive fuel knocks are caused by too early injection of the fuel for the speed and load on the engine. This may be due to too great an advance of the injection or improper timing of the fuel pump in servicing.

Trouble from knocking, other than fuel knocks, can usually be found by the nature and location of same by sounding out under different load conditions and by cutting out one cylinder at a time. When the loose or incorrectly adjusted part is found, the remedy is usually obvious and reference to articles under name of part affected will be found helpful in making needed corrections.

OVERHEATING

1. Lack of cooling water.
2. Sediment or salt in water jackets.
3. Obstruction to circulation of cooling water from foreign matter in system or collapse of suction hose.
4. Damage to water pump from ice or other substance.
5. Fuel injection too late.
6. Sheared coupling key on fuel pump drive shaft.
7. Loose connection on timing device on side of fuel pump coupling.
8. Improper lubrication.

EXCESSIVE SMOKING

This may be caused by a sticking or worn nozzle, leaky inlet or exhaust valves, stuck or worn piston rings or scored cylinders. Check inlet and exhaust valve clearance, and make sure that valve is not sticking in guide. Check for a dirty air filter or silencer. As a last resort assume trouble to be in fuel injection pump.

CUMMINS DIESEL

Year	Engine Model	Number Cylinders and Valve Arrangement	Bore and Stroke	Displacement Cubic Inches	Compression Ratio	Taxable H. P.	Brake H. P. at R. P. M.	Maximum Torque at R. P. M. Pounds Feet	Oil Capacity Quarts
1936–46	AA-4	4-I	4x5	251	18	25.60	57@2200	180@1200	10
1936–46	AA-6	6-I	4x5	377	18	38.40	85@2200	275@1200	12
1936–46	HB-4	4-I	$4\frac{7}{8}$x6	448	17	38.02	83@1800	340@800	18
1936–46	HB-6	6-I	$4\frac{7}{8}$x6	672	17	57.04	125@1800	500@800	20
1940–46	HBS-6	6-I	$4\frac{7}{8}$x6	672	14	57.04	175@1800	625@1400	20

TUNE UP CHART

Year	Engine Model	Firing Order①	Injection Timing, Degrees	High Idle Speed, R. P. M.②	Low Idle Speed, R. P. M.	Valve Clearance, Running③		Injector Plunger Clearance	Valve Timing	
						Intake	Exhaust		Intake Opens, Deg.	Exhaust Closes, Deg.
1936–46	AA-4	1243	43½ BTDC	2200	450–500	.015	.025	④	6 BTDC	14 ATDC
1936–46	AA-6	153624	43½ BTDC	2200	450–500	.015	.025	④	6 BTDC	14 ATDC
1936–46	HB-4	1243	49½ BTDC	1800	450–500	.014	.022	④	5 BTDC	13 ATDC
1936–46	HB-6	153624	49½ BTDC	1800	450–500	.014	.022	④	5 BTDC	13 ATDC
1940–46	HBS-6	153624	49½ BTDC	1800	450–500	.016	.028	④	77 BTDC	66 ATDC

① Right-hand rotation engines. Left-hand 4-cylinder, 1342; 6-cylinder, 142635.

② Maximum governed speed—no load.

③ Certain installations require special clearances.

④ With injector plunger firmly in its seat, turn adjusting screw down until it just bottoms and tighten lock nut.

VALVE SYSTEM

Year	Engine Model	Stem Clearance		Tappet Guide Clearance ①	Tappet Clearance				Valve Spring Pressure Test		Valve Seat Angle Degrees
					Running Hot②		Timing④				
		Intake	Exhaust		Intake	Exhaust	Intake	Exhaust	Free Length, Inches	Pounds at Inches, Length	
1936–46	AA-4	.0035–.004	.0035–.004	.0025–.003	.015	.025	.015	.025	$3\frac{1}{16}$	113③	30
1936–46	AA-6	.0035–.004	.0035–.004	.0025–.003	.015	.025	.015	.025	$3\frac{1}{16}$	113③	30
1936–46	HB-4	.004–.0045	.004–.0045	None	.014	.022	.014	.022	$3\frac{19}{32}$	136③	30
1936–46	HB-6	.004–.0045	.004–.0045	None	.014	.022	.014	.022	$3\frac{19}{32}$	136③	30
1940–46	HBS-6	.004–.0045	.004–.0045	None	.016	.028	.014	.022	$3\frac{19}{32}$	136③	30

①Clearance is for both the valve and injector tappets.

② All valve adjustments must be made with Injector Screw loose. Certain installations require special clearances.

③ Spring pressure when valve is open.

④ Adjust with engine hot but allow it to cool before checking timing.

ENGINE

NOTE—For detailed service information on the Cummins Fuel Injection System, see the Table of Contents on page 1.

CYLINDER HEAD

A and H: Cylinder head nuts should be tightened down by starting from the center and working outward in a criss-cross fashion to the ends. Draw down the nuts evenly and repeat the operation until all are normally tight. After the engine has been run sufficiently long to bring all the parts to normal operating temperature, a final tightening should be made.

NOTE—When using a torque indicating wrench, the final tightening should be from 235 to 250 pounds feet on Model A, and from 425 to 450 pounds feet on Model H. Use the lower limit for clean and oily threads, and the high limit for clean and dry threads. In any case, the threads should be free from rust or dirt, otherwise a false reading will be obtained due to the increased friction.

CAUTION—Be sure to check and adjust the valve and injector plungers as de-

NOTE—For Cummins engines developed since 1942, see page 915.

PISTON AND RING CLEARANCES

Year	Engine Model	Piston Skirt, Inches		Fitting Pistons with Shim and Spring Scale		Ring End Gap, Inch ①		Ring and Groove, Inch	
		Top	Bottom	Shim Thickness	Pounds Pull on Scale	Compression	Oil	Compression	Oil
1936–46	AA-4	.0045–.005	.0045–.005	.005②	.0055③	.015–.018	.015–.018	.003–.0035	.004–.0045
1936–46	AA-6	.0045–.005	.0045–.005	.005②	.0055③	.015–.018	.015–.018	.003–.0035	.004–.0045
1936–46	HB-4	.0045④ .0055⑤	.0045④ .0055⑤	.0045⑥ .0055⑦	.0055⑧ .0065⑨	⑩	.015–.018	⑪	⑪
1936–46	HB-6	.0045④ .0055⑤	.0045④ .0055⑤	.0045⑥ .0055⑦	.0055⑧ .0065⑨	⑩	.015–.018	⑪	⑪
1940–46	HBS-6	.0045④ .0055⑤	.0045④ .0055⑤	.0045⑥ .0055⑦	.0055⑧ .0065⑨	⑩	.015–.018	⑪	⑪

① Fit rings in tapered bores with not less than the maximum clearance.
② Piston to pass on shim thickness shown.
③ Piston to lock on shim thickness shown.
④ Cast iron pistons, plus or minus .0005″.
⑤ Aluminum pistons, plus or minus .0005″.
⑥ Cast iron piston to pass on shim thickness shown.
⑦ Aluminum piston to pass on shim thickness shown.
⑧ Cast iron piston to lock on shim thickness shown.
⑨ Aluminum piston to lock on shim thickness shown.
⑩ Two-lap joint .015″–.020″; butt joint .015″–.018″.
⑪ Two-lap joint .0025″–.0035″; butt joint .002″–.003″.

ENGINE BEARING SPECIFICATIONS

Year	Engine Model	Camshaft		Connecting Rod			Mains				
		Journal Diameter	Clearance	Journal Diameter	Clearance	Bearing Bolt Tension Lb. Ft.	Journal Diameter	Clearance	Bearing Bolt Tension Lb. Ft.	Thrust on No.	End-play
1936–46	AA-4	①	.0055–.006	2.624–2.625	.002–.004	40– 45	3.874–3.875	.004–.007	150–170	5	.005–.006
1936–46	AA-6	①	.0055–.006	2.624–2.625	.002–.004	40– 45	3.874–3.875	.004–.007	150–170	7	.005–.006
1936–46	HB-4	1.997–1.998	.0015–.003	3.124–3.125	.005② .003③	105–115	4.499–4.500	.0055② .0035③	310–330	5	.006–.008
1936–46	HB-6	1.997–1.998	.0015–.003	3.124–3.125	.005② .003③	105–115	4.499–4.500	.0055② .0035③	310–330	7	.006–.008
1940–46	HBS-6	1.997–1.998	.0015–.003	3.124–3.125	.005② .003③	105–115	4.499–4.500	.0055② .0035③	310–330	7	.006–.008

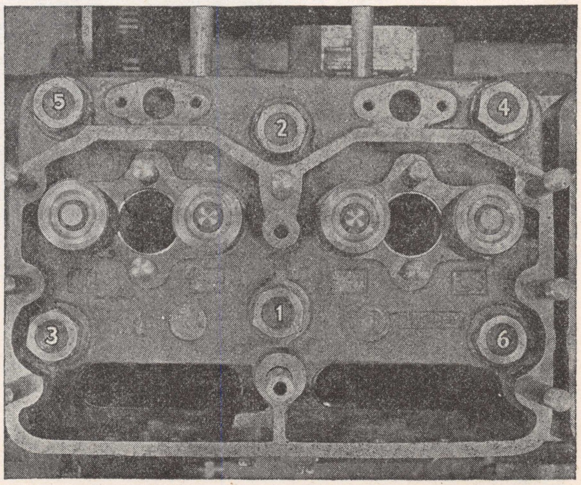
① Front: 1.749–1.750. All others: 1.8745–1.876.
② Copper lead type.
③ Babbitt type.

scribed in their respective paragraphs and in accordance with the recommendations as given in the VALVE SYSTEM table.

NOTE—When the head is removed, be very careful not to place the mating face on any hard surface as this would ruin the copper injector seat. Every precaution should be taken to prevent the mating surfaces of the head and block from being marred, nicked or scratched.

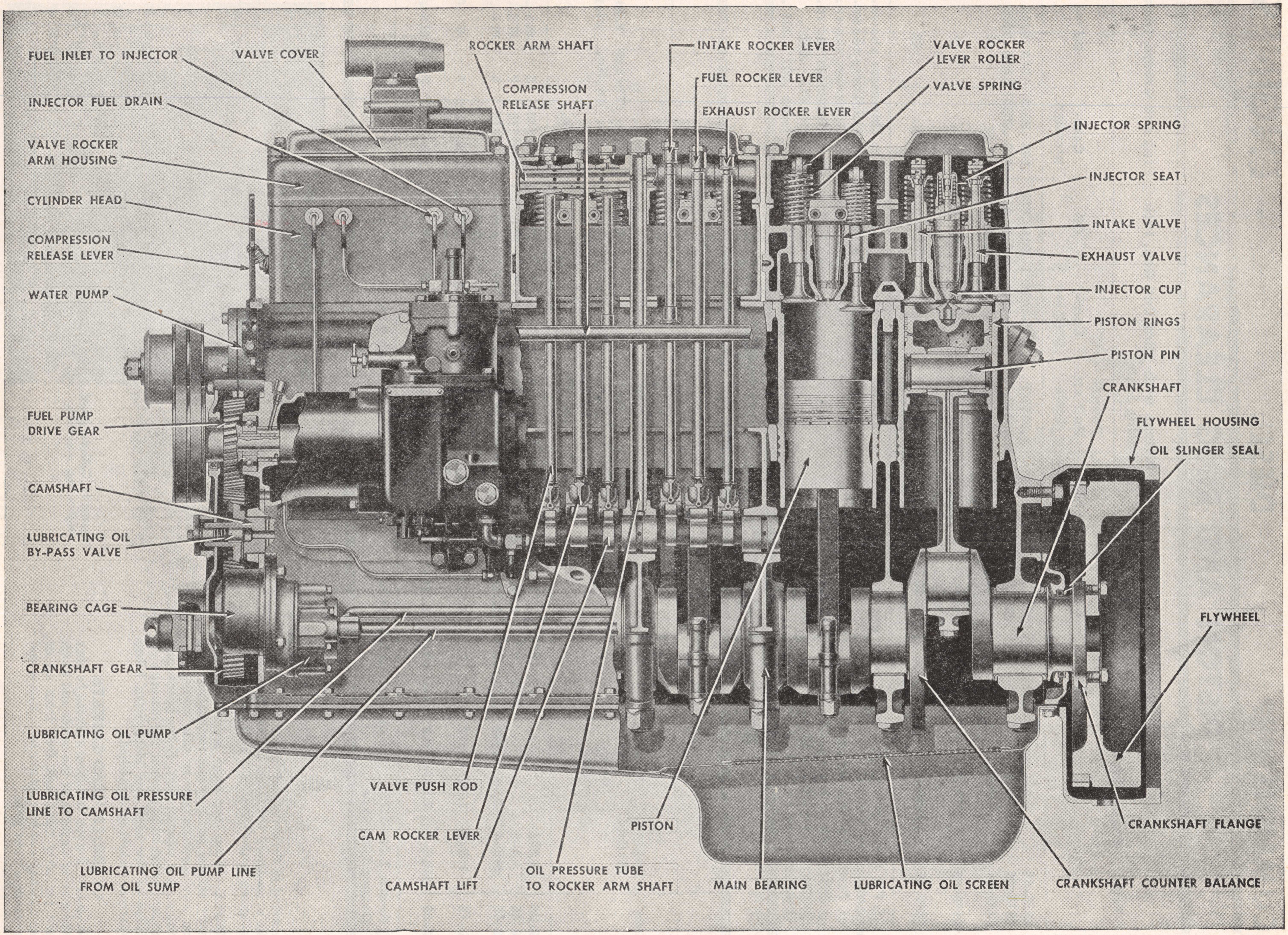
CYLINDER HEAD GASKETS

A and H: Before installing gaskets, be sure the mating surfaces of the heads and block are perfectly clean and free from oil or any particles of foreign matter which would prevent a tight joint.

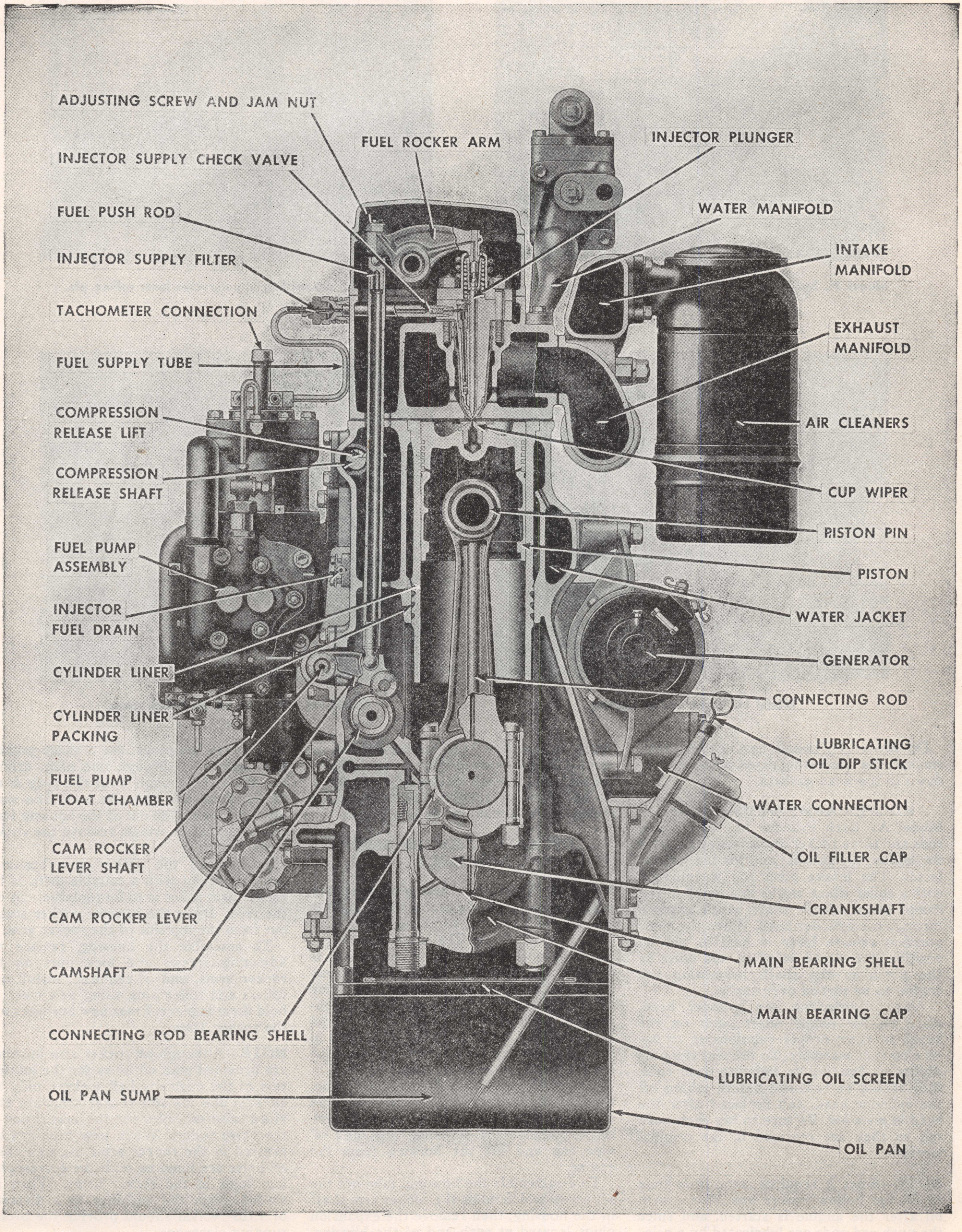


Model H. Cylinder head tightening sequence.

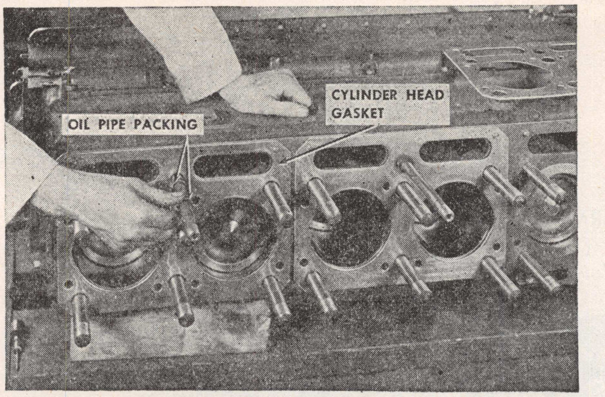
NOTE—For Cummins engines developed since 1942, see page 915.


FUEL INLET TO INJECTOR
VALVE COVER
ROCKER ARM SHAFT
INTAKE ROCKER LEVER
VALVE ROCKER LEVER ROLLER
INJECTOR FUEL DRAIN
COMPRESSION RELEASE SHAFT
FUEL ROCKER LEVER
VALVE SPRING
EXHAUST ROCKER LEVER
VALVE ROCKER ARM HOUSING
INJECTOR SPRING
INJECTOR SEAT
CYLINDER HEAD
INTAKE VALVE
COMPRESSION RELEASE LEVER
EXHAUST VALVE
INJECTOR CUP
WATER PUMP
PISTON RINGS
PISTON PIN
CRANKSHAFT
FUEL PUMP DRIVE GEAR
FLYWHEEL HOUSING
OIL SLINGER SEAL
CAMSHAFT
LUBRICATING OIL BY-PASS VALVE
BEARING CAGE
FLYWHEEL
CRANKSHAFT GEAR
LUBRICATING OIL PUMP
VALVE PUSH ROD
LUBRICATING OIL PRESSURE LINE TO CAMSHAFT
PISTON
CRANKSHAFT FLANGE
CAM ROCKER LEVER
LUBRICATING OIL PUMP LINE FROM OIL SUMP
CAMSHAFT LIFT
OIL PRESSURE TUBE TO ROCKER ARM SHAFT
MAIN BEARING
LUBRICATING OIL SCREEN
CRANKSHAFT COUNTER BALANCE

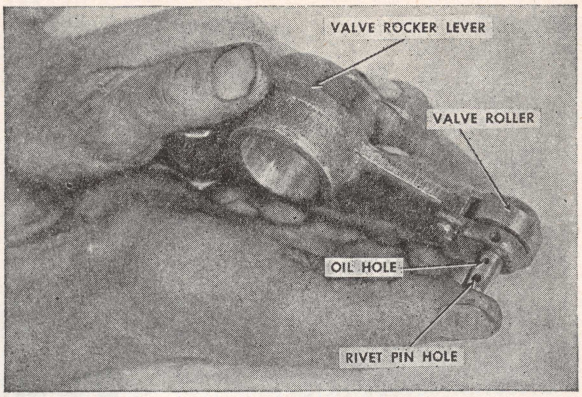
Model H. Side cross sectional view of engine.


ADJUSTING SCREW AND JAM NUT
INJECTOR SUPPLY CHECK VALVE
FUEL PUSH ROD
INJECTOR SUPPLY FILTER
TACHOMETER CONNECTION
FUEL SUPPLY TUBE
COMPRESSION RELEASE LIFT
COMPRESSION RELEASE SHAFT
FUEL PUMP ASSEMBLY
INJECTOR FUEL DRAIN
CYLINDER LINER
CYLINDER LINER PACKING
FUEL PUMP FLOAT CHAMBER
CAM ROCKER LEVER SHAFT
CAM ROCKER LEVER
CAMSHAFT
CONNECTING ROD BEARING SHELL
OIL PAN SUMP
FUEL ROCKER ARM
INJECTOR PLUNGER
WATER MANIFOLD
INTAKE MANIFOLD
EXHAUST MANIFOLD
AIR CLEANERS
CUP WIPER
PISTON PIN
PISTON
WATER JACKET
GENERATOR
CONNECTING ROD
LUBRICATING OIL DIP STICK
WATER CONNECTION
OIL FILLER CAP
CRANKSHAFT
MAIN BEARING SHELL
MAIN BEARING CAP
LUBRICATING OIL SCREEN
OIL PAN

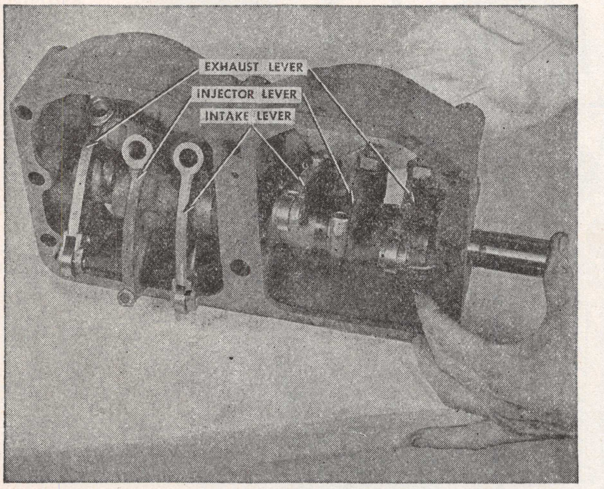
Model H. End cross sectional view of engine.



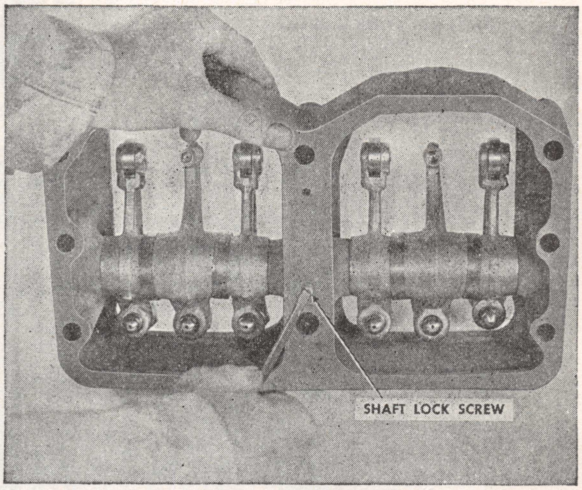
Model H. Installing cylinder head gasket and lubricating oil pipe packing.



Model H. Assembling upper rocker lever rolling pin.



Model H. Upper rocker housing.



Model H. Upper rocker shaft lock screw.

On Model H, install new leather pack rings on the lubricating pipes, pushing them down to the head gaskets.

ROCKER ARMS & PUSH RODS

Model A: Each cylinder has three push rods and three rocker arms, one of each for the intake, the exhaust and for the fuel injector. The intake push rod is equipped with a collar which works in a notch in the compression release shaft which extends through the cylinder head. When the compression release lever is held in the up position, the intake valve is held open by the notch in the shaft, permitting the engine to be turned over easily.

When dismantling the cylinder head, place all the rocker shaft parts on the bench in their proper relationship to assure correct assembly. To prevent the possibility of bending or twisting push rods, they should be removed before taking off the cylinder head, and replaced after the head is installed. Be sure to tag each push rod so they are replaced in the original location.

NOTE—Since it requires some little time to fill the hollow rocker arm shafts with oil after the engine is started, and since the push rod ends are lubricated by a relatively low oil flow rate, initial distress of parts will be prevented if, when assembling, the rocker shafts are lubricated thoroughly. As an added precaution, each end of the rocker arms should also be lubricated.

UPPER ROCKER HOUSING ASSEMBLY

Model H: The general design of the rocker shaft parts is the same as the Model A, that is, each cylinder has three push rods and three rocker arms. The compression release shaft is also similar to that which is used in the Model A, except that it runs through the block but having the same actuating medium. The main difference between the two engines is that on the Model H, the rocker shaft parts are assembled in separate housings, each housing containing the parts for two cylinders.

To remove any one housing assembly, take off the housing cover and loosen the injector and valve adjusting screws three turns. Remove the retaining nuts and oil pipe cap and lift the housing from the engine.

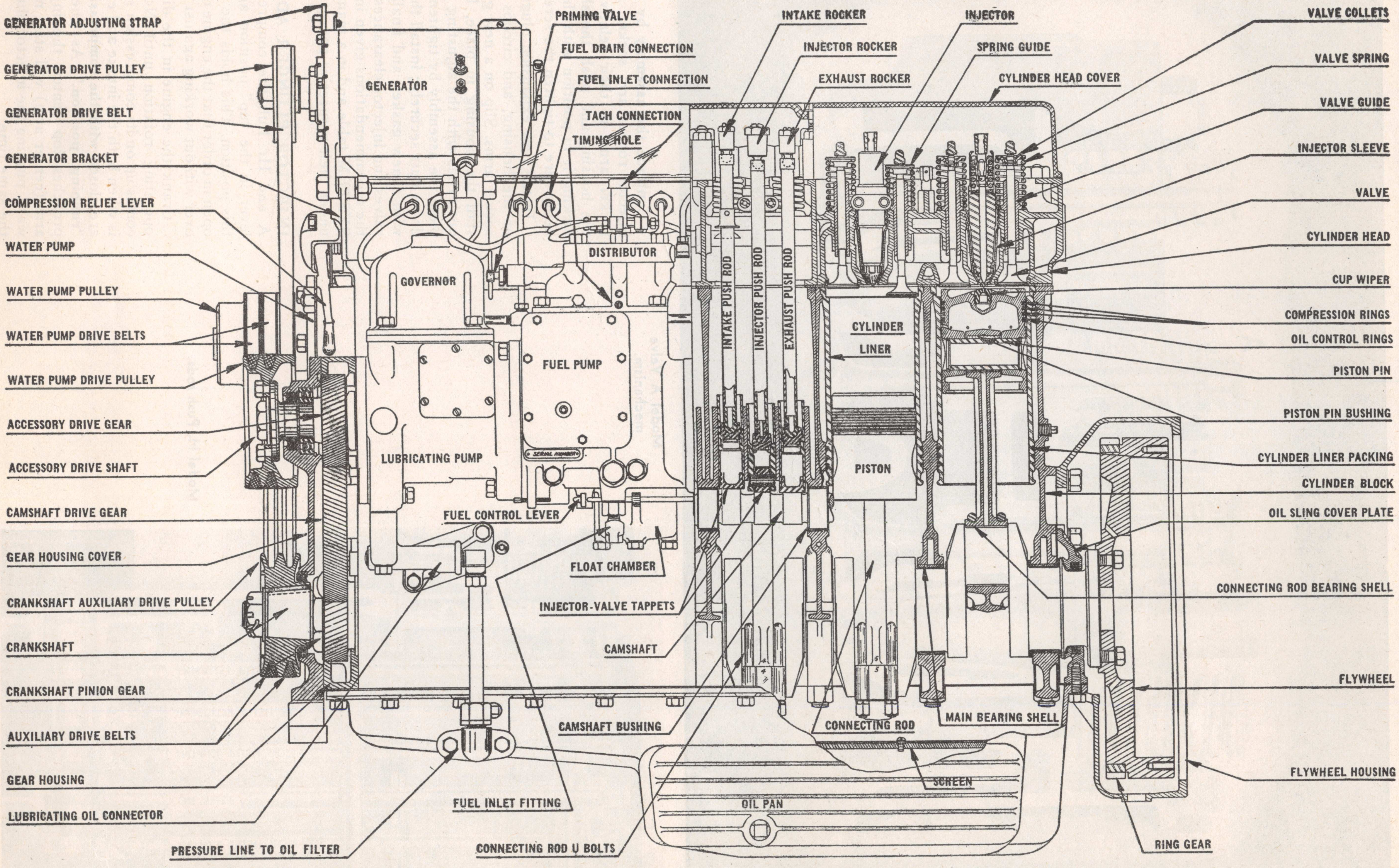
To disassemble the housing, take out the set screw which holds the rocker arm shaft in the housing, then remove the expansion plugs located at each end of the housing. To remove the plugs, use a sharp pointed tool and drive through one plug, driving the shaft far enough until the plug is removed from the opposite end. The shaft may then be driven out of the housing from either end, after which, remove the rocker arms.

To remove the rocker arm bushings, drive them out with a suitable drift. If the rocker arm roller is to be replaced, tap out the rivet. Press the injector rocker socket out from the top side of the rocker arm.

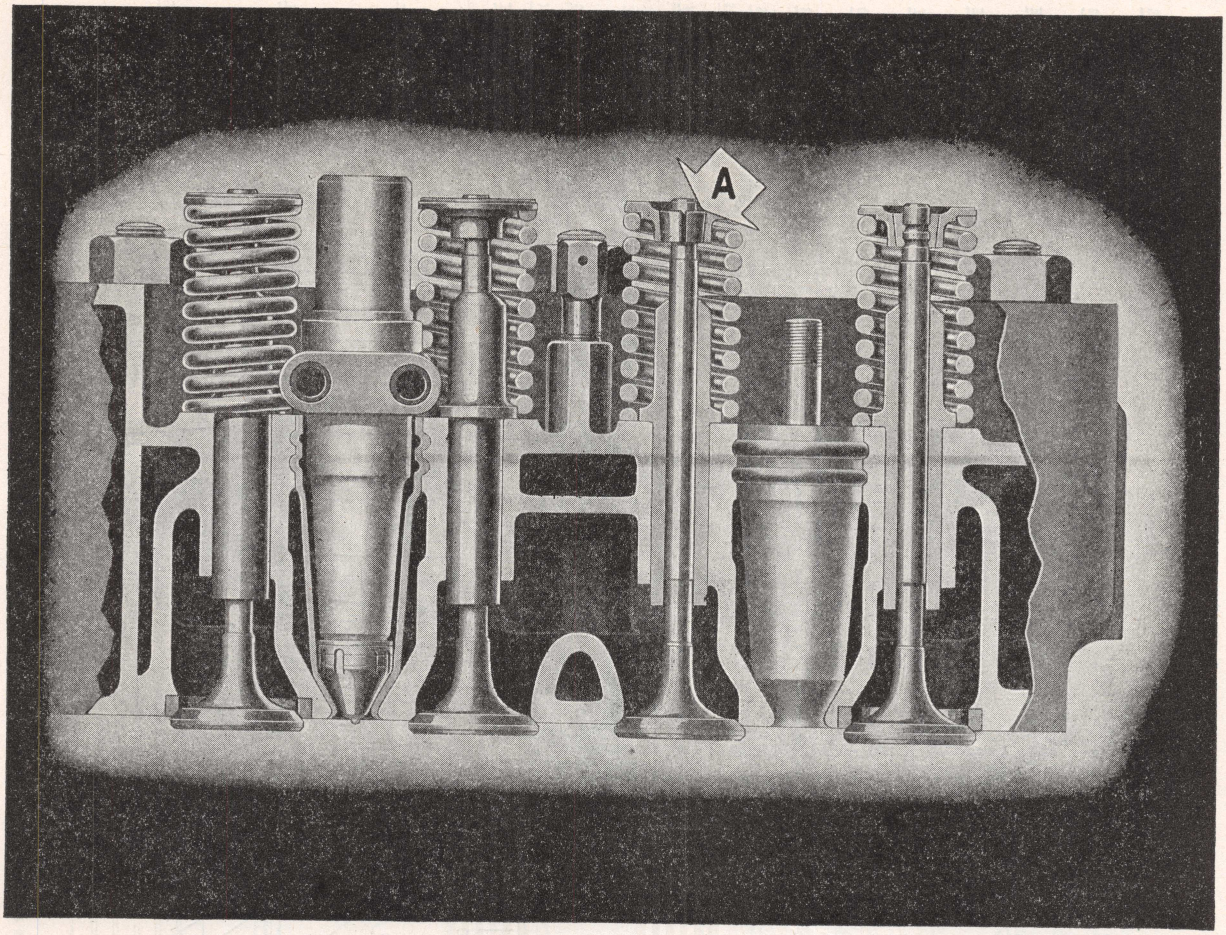
To assemble the housing, replace the adjusting screws and lock nuts on the rocker arms, and, if required, install new rollers and roller pins, using new rivets to hold them in place. Press new bushings into the rocker arms.

NOTE—Although all rocker arm bushings are provided with oil holes for the lubrication of the push rod ball sockets, only the exhaust and injector rocker arms are provided with oil holes for the lubrication of the valve rollers. When new bushings are pressed in the rocker arms, be sure these oil holes are lined up with the corresponding holes in the rocker arms. When installed, ream the bushings to a diameter of 1.125" which should provide the proper running clearance.

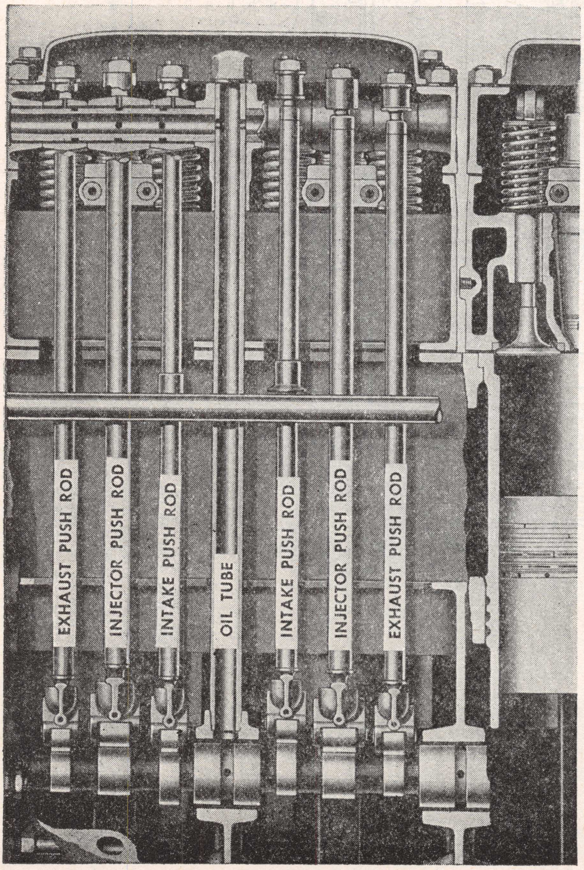
NOTE—For Cummins engines developed since 1942, see page 915.


GENERATOR ADJUSTING STRAP
GENERATOR DRIVE PULLEY
GENERATOR DRIVE BELT
GENERATOR BRACKET
COMPRESSION RELIEF LEVER
WATER PUMP
WATER PUMP PULLEY
WATER PUMP DRIVE BELTS
WATER PUMP DRIVE PULLEY
ACCESSORY DRIVE GEAR
ACCESSORY DRIVE SHAFT
CAMSHAFT DRIVE GEAR
GEAR HOUSING COVER
CRANKSHAFT AUXILIARY DRIVE PULLEY
CRANKSHAFT
CRANKSHAFT PINION GEAR
AUXILIARY DRIVE BELTS
GEAR HOUSING
LUBRICATING OIL CONNECTOR
PRESSURE LINE TO OIL FILTER
GENERATOR
PRIMING VALVE
FUEL DRAIN CONNECTION
FUEL INLET CONNECTION
TACH CONNECTION
TIMING HOLE
DISTRIBUTOR
GOVERNOR
FUEL PUMP
LUBRICATING PUMP
SERIAL NUMBER
FUEL CONTROL LEVER
FLOAT CHAMBER
INJECTOR-VALVE TAPPETS
CAMSHAFT
CAMSHAFT BUSHING
FUEL INLET FITTING
CONNECTING ROD U BOLTS
INTAKE ROCKER
INJECTOR ROCKER
EXHAUST ROCKER
INTAKE PUSH ROD
INJECTOR PUSH ROD
EXHAUST PUSH ROD
INJECTOR
SPRING GUIDE
CYLINDER HEAD COVER
CYLINDER LINER
PISTON
CONNECTING ROD
MAIN BEARING SHELL
SCREEN
OIL PAN
VALVE COLLETS
VALVE SPRING
VALVE GUIDE
INJECTOR SLEEVE
VALVE
CYLINDER HEAD
CUP WIPER
COMPRESSION RINGS
OIL CONTROL RINGS
PISTON PIN
PISTON PIN BUSHING
CYLINDER LINER PACKING
CYLINDER BLOCK
OIL SLING COVER PLATE
CONNECTING ROD BEARING SHELL
FLYWHEEL
FLYWHEEL HOUSING
RING GEAR

Model A. Side cross sectional view of engine.



Model A Valve mechanism.



Model H. Push rods.

Continue the assembly by replacing the injector rocker arm socket. Assemble the rocker arms in their relative position in the housing and push the shaft in place, locking it in position with the lock screw, being sure to tighten the screw securely.

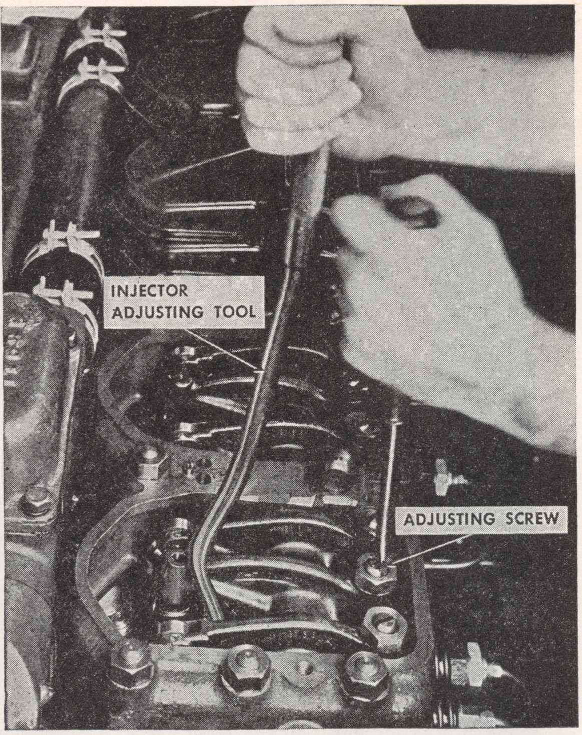
Install new expansion plugs at each end of the housing, and circlips between the rocker arms. Slip on a new gasket and install the housing in place, lining up the push rods with the adjusting screws. Complete the assembly by tightening the hold-down nuts securely; install the oil pipe cap with a new gasket, and finally, adjust the valves and injector clearances according to the recommendations given in the VALVE SYSTEM table and in a manner described under their respective paragraphs.

INJECTOR PLUNGER ADJUSTMENT

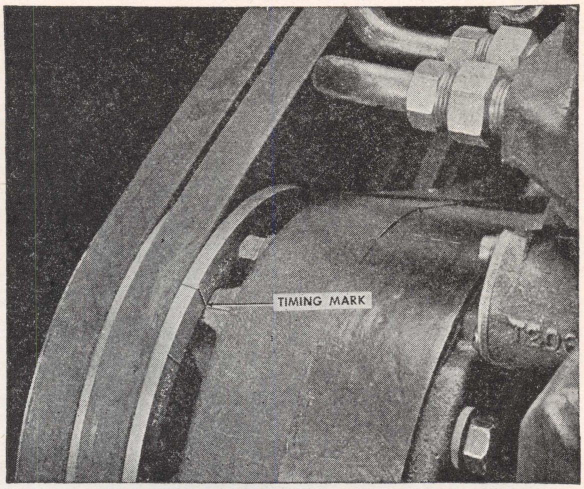
A and H: Pull the compression release lever in the "up" position and hold it in this position. This holds the intake valves open in order that the engine may be turned over without working against compression.

Crank the engine in the direction of its operating rotation until No. 1 cylinder comes up on its compression stroke—which is when both the intake and exhaust valves are closed **with the compression release in "running position."** As the piston approaches top center, the injector rocker arm (center arm) will start moving downward, pushing the injector plunger down at the same time.

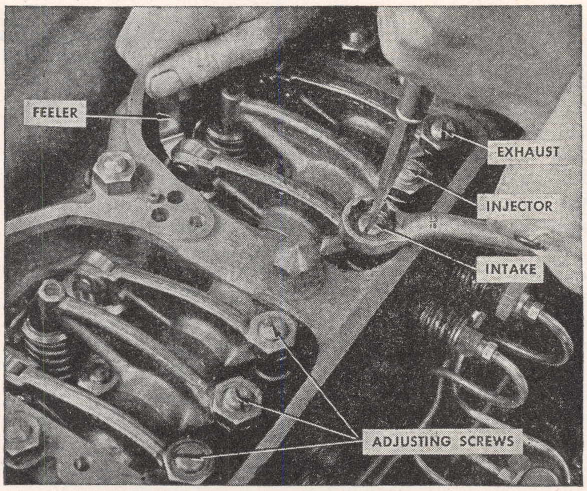
NOTE—For Cummins engines developed since 1942, see page 915.



Models A and H. Adjusting injector plunger.



Models A and H. Timing marks for valve and injector adjustments.



Models A and H. Making valve adjustments.

When the injector rocker arm starts its downward movement, continue to crank the engine approximately ⅛ of a revolution until a notch marked "1 and 6VS" ("1 and 4VS" on 4-cylinder engines) on the water pump drive pulley registers with the top center mark on the gear housing. No. 1 cylinder is now in a position to adjust the injector. Loosen the lock nut on the injector adjusting screw, backing the nut off several turns to avoid the possibility of obtaining a false adjustment.

NOTE—Before making the adjustment, make a careful check to see that the intake and exhaust valves are both closed.

To make the adjustment, use a forked tool or a large open end wrench to push the injector plunger firmly in its seat. Then use a screw driver and turn the adjusting screw down until it just bottoms, then tighten the lock nut.

CAUTION—Correct injector adjustments are very important to obtain efficient operation and long life of certain parts. If the injectors are adjusted too tightly, an overload will be thrown on the camshaft and cam rollers, ultimately breaking down the metal of these parts. Tightening the injector hold-down nuts too tightly will very likely crack the cylinder head and distort valve seats.

When the injector is adjusted properly, crank the engine over until the next "VS" notch cut in the water pump drive pulley indexes with the mark on the gear housing. This brings the cylinder next in the firing order to the correct position for its injector adjustment. Continue this procedure until all clearances are correctly established.

VALVE ADJUSTMENT

A and H: Follow the same procedure for setting the valve clearances as described for the injector adjustment. Turn the engine over until the "VS" mark on the water pump pulley is lined up with the mark on the gear housing. Adjust the valves of this cylinder to the clearances given in the VALVE SYSTEM table.

NOTE—Make sure the compression release lever is in its running position before adjusting the intake valves. Always make valve adjustments when the engine is hot. When a push rod has been disconnected from its rocker arm, use care to start the adjusting screws in the socket of the correct push rod. Start the valve adjustment with the adjusting screws slacked off so that valve clearance will be assured.

Adjust injector plungers and set valves after 1,000 miles or after 50 hours of stationary service when the engine is new. Reset after each 5,000 miles or 50 hours service thereafter.

COMPRESSION RELEASE SHAFT

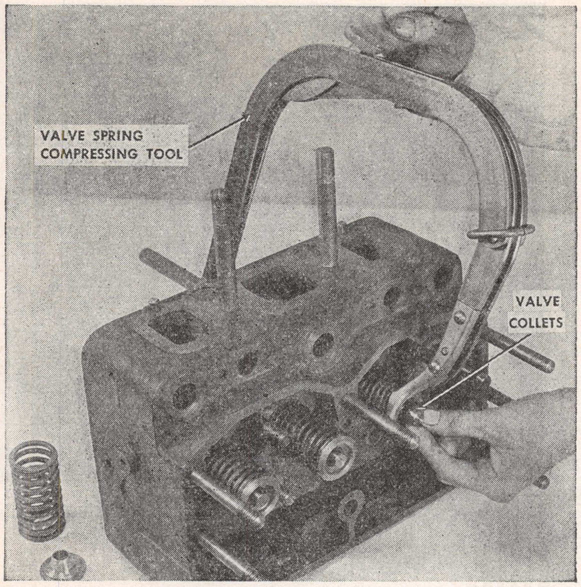
A and H: The intake push rods are equipped with collars which work in a notch in the compression release shaft which extends through the cylinder head on Model A and the cylinder block on Model H. When the compression release lever is held in the "up" position, the intake valves are held open by the notches in the shaft, permitting the engine to be turned over easily.

To remove the shaft, remove the rocker arm assemblies and push rods. Take off the compression release shaft lock screw at the rear end of the cylinder block or head and pull the shaft from the block at the lever end. Do not change the position of the lever on this shaft. Remove the packing gland and old packing.

To install the shaft, slip the packing gland over the shaft, insert the shaft into the cylinder block or head, install new packing and tighten the packing gland in place, after which, lock the shaft in position with the lock screw, being sure the shaft works freely.

Install the push rods and assemble the rocker assemblies to the cylinder heads and adjust the valves and injectors. After the correct injector and valve clearances have been established, install the rocker covers.

NOTE—For Cummins engines developed since 1942, see page 915.



Model H. Assembling valve springs and locks.

NOTE—If for any reason the lever has been removed from the shaft, perform the above operations but before replacing the rocker arm assemblies, continue as follows: With the intake push rod in position in the lower rocker lever socket on Model H (in tappet on Model A), and with the engine on No. 1 top center, turn the compression release shaft until the lifting notch on the shaft is within 1/32" of the collar on the push rod. Assemble the hand lever to the shaft so that when locked in place, it will be in the correct "running position." Then install the rocker arm assemblies and adjust injector and valves.

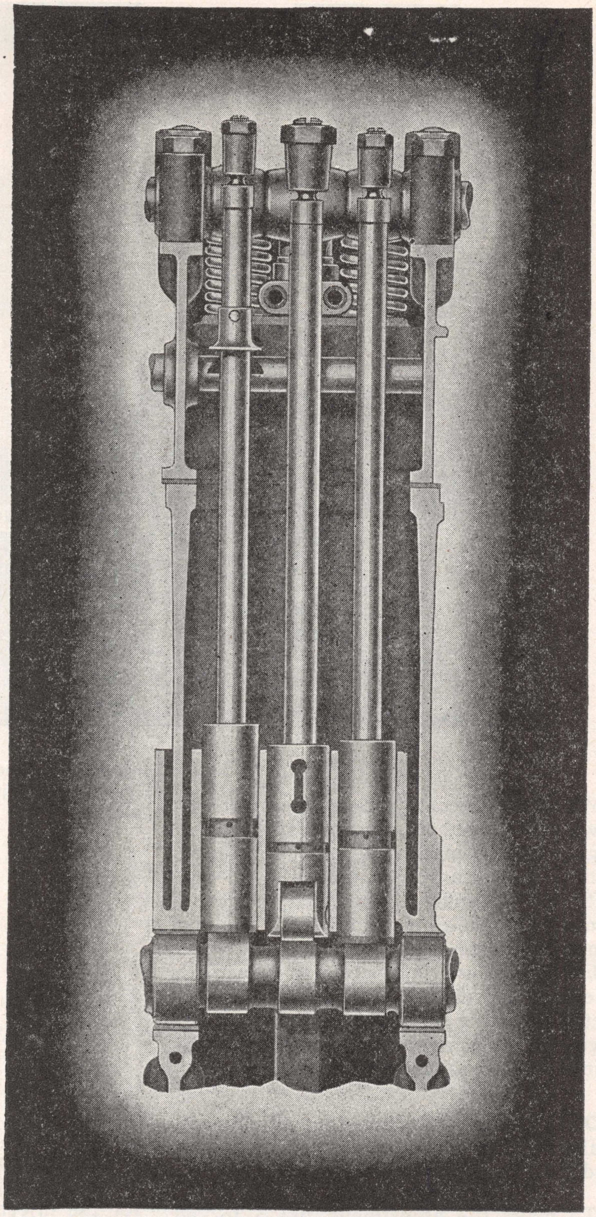
VALVE SEAT INSERTS

A and H: Since these inserts are too hard to reface by the ordinary grinding methods, a high-speed grinding stone or a special lapping tool should be used to perform this operation. When using this equipment, be sure valve guides are clean and the valve guide pilot is a snug fit in order to assure a concentric finish. Finished seats should be checked with a dial indicator and run-out should not exceed .0005".

To remove and install inserts, special puller and driver equipment is available. However, if these tools are not procurable, the following method may be used:

To remove an insert, use a drill which is smaller in diameter than the width of the insert and drill two holes at opposite sides, but not all the way through. Cut through the undrilled portion of the insert with a sharp chisel and remove the two pieces.

To install an insert, pack in "dry ice" for at least fifteen minutes to allow the metal to contract, and heat the valve port area gradually, if necessary, to permit this material to expand. Then press or drive the insert into the cylinder head, using extreme care to see that it is not cocked or misaligned. When installed, finish the seats with the grinding or lapping equipment already mentioned.



Model A. Valve and injector tappets.

VALVE SPRINGS

A and H: Valve springs should be tested every time they are removed. See the VALVE SYSTEM table for the correct free length of the springs and for test specifications.

VALVE STEM GUIDES

A and H: The valve stem guides are pressed into the cylinder head and can be removed by driving or pulling them out through the top of the head. When replacing these guides, they should be driven in with a piece of hard wood to prevent any distortion. When installed, they should be reamed to provide a clearance within the limits given in the VALVE SYSTEM table.

VALVE & INJECTOR TAPPETS

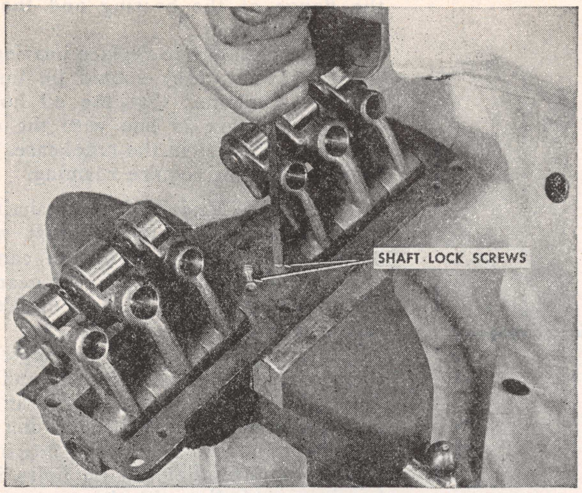
Model A: The tappets are carried in the cylinder block and ride directly on the camshaft to operate the valves and injectors. To remove the tappet assemblies, it is necessary to take out the push rods. After the push rods have been removed, the valve tappets may be fished out with a piece of wire bent to a hook shape on its end.

NOTE—To remove the injector tappets, take off the small oval plates which are located on the side of the cylinder block and held in place by two flat head screws. Remove the small guide pins and fish out the tappets in the same manner as the valve tappets (hooked wire). When replacing the injector tappets, be sure to install the locating pin in its proper position, being sure the tappets work freely.

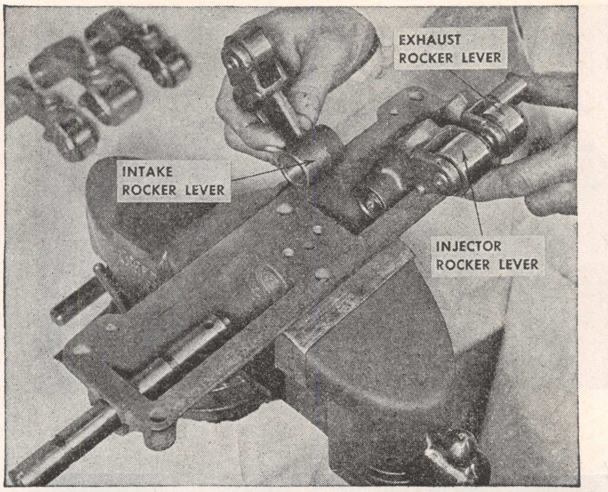
LOWER CAM ROCKERS

Model H: In place of the conventional tappets as used in the Model A engine, these engines are equipped with cam rockers carried in a shaft and enclosed in a housing which is bolted to the side of the crankcase. The inner end of the

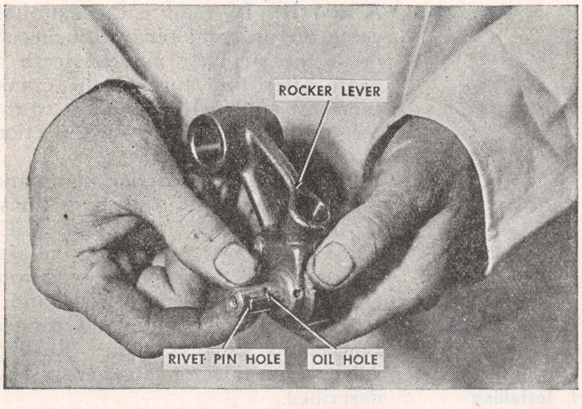
NOTE—For Cummins engines developed since 1942, see page 915.



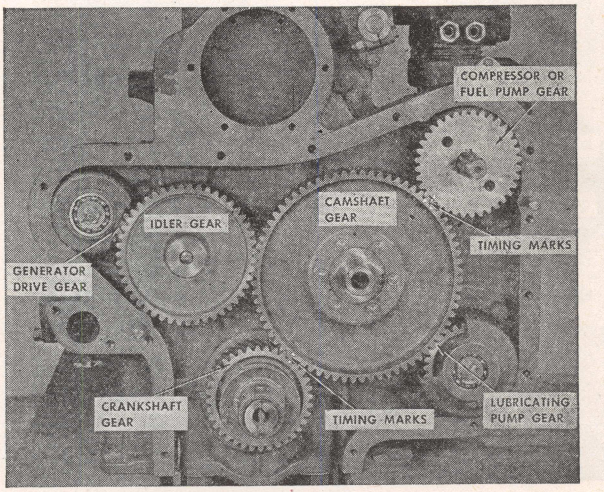
Model H. Lower cam rocker shaft lock screw.



Model H. Assembling lower cam rocker lever housing.



Model H. Assembling lower cam rocker lever roller pin.



Model H. Engine gear train.

cam rocker is equipped with a roller which rides on the camshaft lobes and, through the push rods, actuate the valves and injector plungers.

To remove the cam rockers, take off the upper rocker arm assemblies and the push rods. Remove the Fuel Injection Pump, following the procedure as described in the CUMMINS FUEL INJECTION PUMP chapter. Continue by taking off the air compressor (if equipped). Unbolt the screws which fasten the rocker housing to the cylinder block and remove the housing. The rocker arms may then be removed from the dowel pins.

To disassemble the rocker arms from the shaft, remove the set screws which hold the shafts in the housing. Use a punch to drive out the expansion plug from one end of the housing and drive the shaft far enough to push out the expansion plug at the opposite end of the shaft, after which, drive the shaft from the housing.

If necessary to remove the rollers, tap out the retaining rivet and tap the roller pin from the rocker arm. If required, drive the rocker arm bushings out with a suitable drift.

NOTE—If new bushings are installed, be sure to line up the oil holes in the bushings with the corresponding holes in the rocker arms. Then ream the bushings to a diameter of .750″.

To assemble, insert new roller pins in the rollers, tapping the pin through the roller, and use new rivets to hold in place. Assemble the rocker arms to the shaft, being sure the injector rocker is in the center of each assembly. Replace the shaft lock screws, install new expansion plugs in each end of the shaft housing, seating into the bore of the housing. Using a new gasket, guide the rocker arm and housings over the dowel pins and fasten the assembly to the side of the cylinder block. Complete the assembly by installing the air compressor (if equipped), the fuel injection pump, push rods and upper rocker arm assemblies.

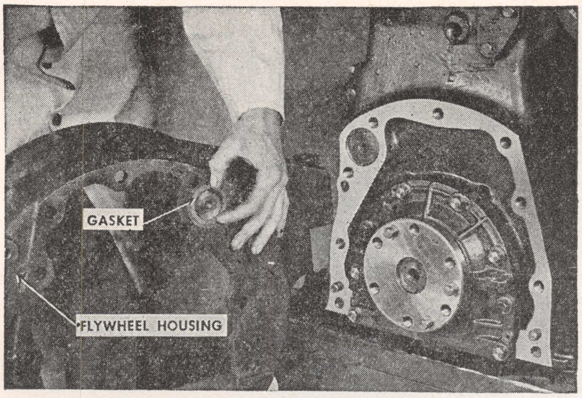
CAUTION—Be sure the push rods are assembled in the correct position.

VALVE TIMING

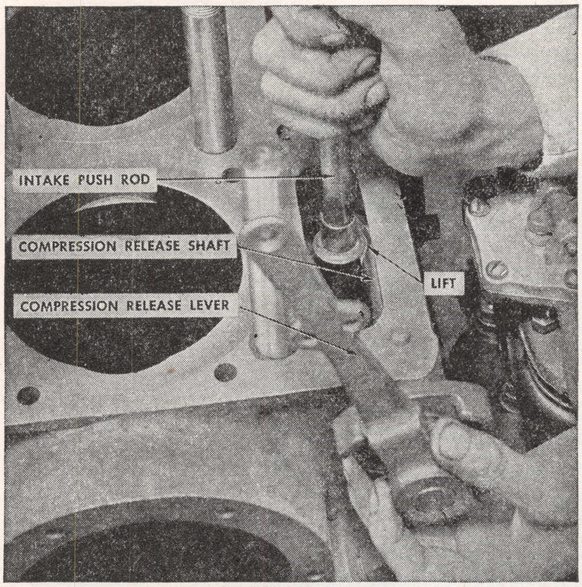
A and H: To check the relationship between the pistons and valves, pull the compression release lever as far back as possible and hold it in this position. This holds the intake valves open in order that the engine may be turned over without working against compression.

With the engine at normal room temperature, crank the engine in the direction of its normal operating rotation until No. 1 cylinder comes up on its compression stroke—which is when both the intake and exhaust valves are closed **with the compression release in the "running position."** As the piston approaches top center, the injector rocker arm (center arm) should start moving downward. When the injector rocker arm starts its downward movement, continue to crank the engine approximately ⅛ of a revolution until the notch marked "1 and 6TC" ("1 and 4TC" on four-cylinder engines) on the water pump drive pulley registers with the top center mark on the timing gear housing. In this position, the similarly marked teeth in the timing gear train should be meshed.

NOTE—Use the "VS" marks when adjusting the valves and the "TC" marks when setting gears.



Models A and H. Gasket for camshaft bore.



Model H. Installing compression release lever. Typical of Model A.

TIMING GEAR COVER

A and H: To remove the gear cover, raise the front of the engine and remove the front engine support. Take off the water pump drive belts, the water pump drive pulley, and all the cap screws which fasten the gear cover to the crankcase.

NOTE—**Remove** the four cap screws in the front of the oil pan and **loosen** all the other cap screws, bolts and nuts in the oil pan in order to insert a small wooden wedge at the front of the pan between the crankcase and pan in order to avoid damaging the oil pan gasket when the gear case cover is removed.

Then remove the two cap screws from the small plate on the face of the gear cover and remove the plate, pressure regulator and spring. The gear cover may now be pried from the dowel pins with the aid of a large screw driver.

Before replacing the gear cover, replace the oil seals if any sign of wear is apparent. Apply a new gasket to the gear cover and assemble the cover over the dowel pins in the crankcase. Install all the mounting cap screws and secure the cover in position. Complete the assembly by replacing the oil pressure regulator, the water pump drive pulley and drive belts, after which, fasten all the oil pan screws, bolts and nuts which were previously loosened, then assemble the front engine support.

CAMSHAFT & BEARINGS

A and H: To remove the camshaft, take off the rocker arm assemblies and push rods. Remove the timing gear cover as explained in the previous paragraph. Remove the lower cam rocker arms on Model H or the tappets on Model A, as already described, then withdraw the camshaft through the front of the engine.

BEARINGS, Model A: All bearings except the front are steel backed, babbitt lined. The front bearing is fitted on the camshaft between a shoulder on the shaft and the camshaft gear. This bearing is made of bronze and is designed to take the thrust. Camshaft end thrust should be held between .004" and .006". If the end play is excessive, press the camshaft gear from the camshaft and install a new bearing. Clearance may be checked by forcing the camshaft to the limit of its end play and inserting a feeler between the flange of the bearing and the back face of the gear.

When necessary to replace bearings because of wear, they should be installed in such a manner that the oil holes in the bearings are in line with the corresponding oil holes in the crankcase. These bearings do not require reaming.

BEARINGS, Model H: Camshaft end thrust is controlled by a thrust washer between the back face of the camshaft gear and the thrust plate in the gear case. If end play is in excess of about .006", install a new thrust washer.

If necessary to replace bearings, drive them out, using a suitable drift and hammer. However, to remove the rear bearing, the flywheel and its housing must first be removed. Install the bearings in such a manner that the oil holes in the bearings are in line with the corresponding oil holes in the crankcase. These bearings do not require reaming.

A and H: To replace the camshaft, reverse the order of removal, being sure to mesh the similarly marked teeth of the gears after first turning the crankshaft, camshaft and fuel pump shaft to the correct position for valve and injection timing.

Install the fuel injection pump and time it in accordance with the instructions given in the CUMMINS FUEL INJECTION SYSTEM chapter. Complete the assembly by replacing the tappets or lower cam rocker assemblies, push rods and upper rocker arm assemblies, and connect the fuel supply and drain lines. Readjust the valves and injector plungers as already described.

NOTE—Be sure to prime the engine before attempting to start.

PISTONS & RODS, REMOVE

A and H: After draining the lubricating oil and removing the oil pan, straighten the lock plates on the connecting rod cap nuts, remove the nuts and take off the caps. Remove the cylinder head, scrape the carbon from the inside of the cylinder, push the connecting rod up from below and remove the piston and rod assembly from the top of the block.

NOTE—Although regular production rods are marked with the cylinder number in which they were originally installed, replacement rods are not; therefore, unmarked rods should be suitably identified with punch marks as they are removed.

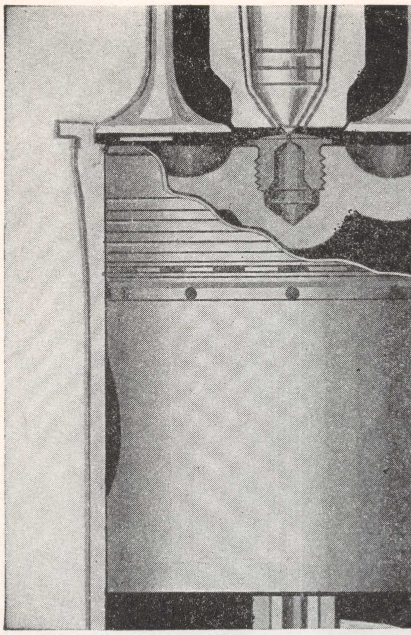
INJECTOR CUP WIPER

A and H: The cup wiper is located in the center of the piston head. Its purpose is to provide better combustion and to prevent carbon from forming on the injector cup spray tip. The cup wiper is screwed into the head of the piston with a special tool and is not subject to replacement or service.

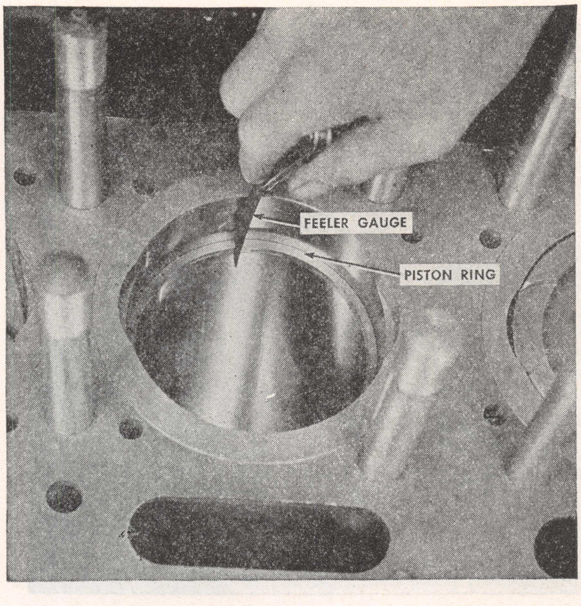
PISTONS, RENEW

A and H: Replacement pistons should not only fit the new or reground cylinder

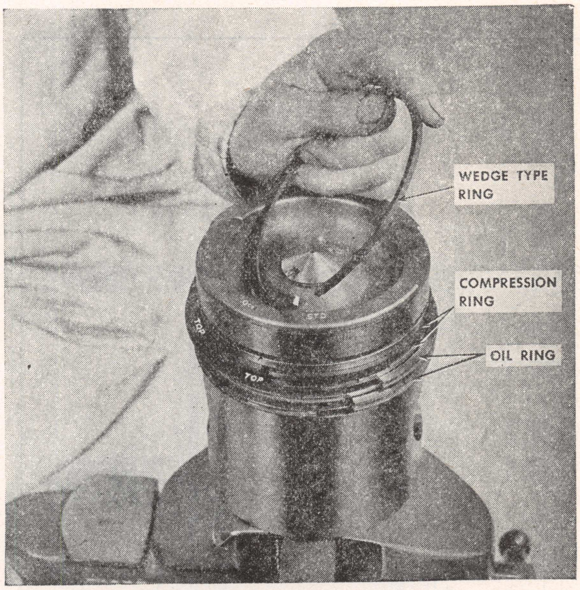
NOTE—For Cummins engines developed since 1942, see page 915.



Models A and H. Injector cup wiper.



Models A and H. Checking ring end gap clearance.



Models A and H. Assembling piston rings.

liner with the proper clearance, but they must also be the same weight as the replaced pistons. The weight is stamped on the head of each piston. The piston oversize number, stamped on the head of the piston, must correspond to the size stamped on the top edge of the cylinder liner.

Piston diameter must be checked at right angle to the piston pin hole on the skirt of the piston for the largest diameter. To determine the exact size the cylinder should be bored, add the desired clearance to the piston size which is stamped on the top of each service piston. After the cylinders are bored, they should be honed smooth. Verify the piston fit by the use of a feeler gauge between the cylinder and thrust side of the piston, with the piston inserted in the bore upside down and in its running position. After the pistons have been fitted properly and assembled to the connecting rods, check the assemblies for alignment on a suitable jig.

NOTE—A variation of 10 degrees between the temperature of the pistons and cylinder bores is sufficient to produce a difference of .0005". Therefore, both the pistons and cylinder bores should be at normal room temperature when fitting pistons. This is particularly important because the clearances given in the PISTON AND RING CLEARANCES table are minimum and pistons must not be fitted with less than specified.

PISTON RINGS, RENEW

A and H: New rings should be fitted with end gaps and groove clearances as given in the PISTON AND RING CLEARANCES table. Ring grooves must be clean and free from carbon and must show no perceptible wear. When rings are fitted properly to the pistons, be sure to stagger the ring gaps so they are spaced equal distances around the circumference of the piston. However, see that no gaps are over the piston pins.

NOTE—Ring end gaps given in the table are for cylinder bores without taper. Fit rings in tapered bores with not less than the maximum dimension given. When fitting rings, pay particular attention to the installation instructions which are usually included in the ring package. This applies to clearances, positions in grooves, etc. Bear in mind that lap joint type rings should not be filed.

CAUTION—To prevent the possibility of bending or breaking the second ring land —thus ruining the piston—any ridge at the top of the cylinder bore should be carefully cut away before removing the piston and rod assemblies. If the available ridge reamer has no provision to control the depth of the cut, it is good practice to bring the piston far enough up into the cylinder to allow the reamer to rest on top of the piston. This will serve to prevent cutting down into the ring travel area. **Never cut down into the ring travel area more than half the depth of the top ring.**

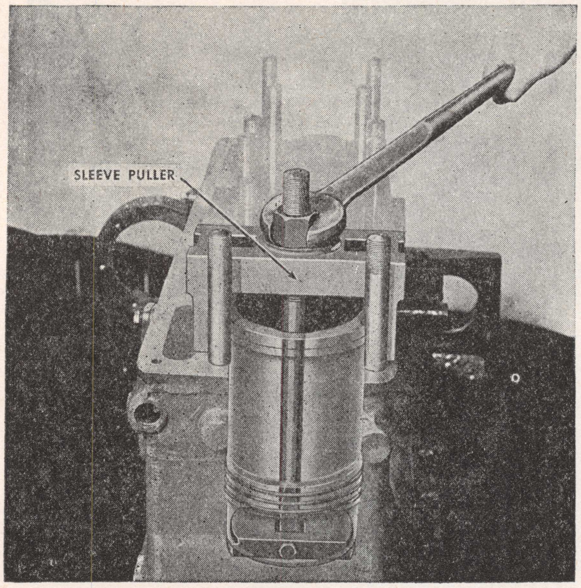
PISTON PINS, RENEW

A and H: The correct fit of piston pins in iron pistons should be one which requires a light push with the palm of the hand to insert the pin. To fit pins in aluminum pistons, place the piston in water which has been heated to about 175 degrees F., allowing it to remain in the water for about two minutes. Then quickly assemble the pin through the rod and piston pin bosses. If the pin will not enter the bosses readily, the piston has most likely cooled, in which case, it should be re-heated.

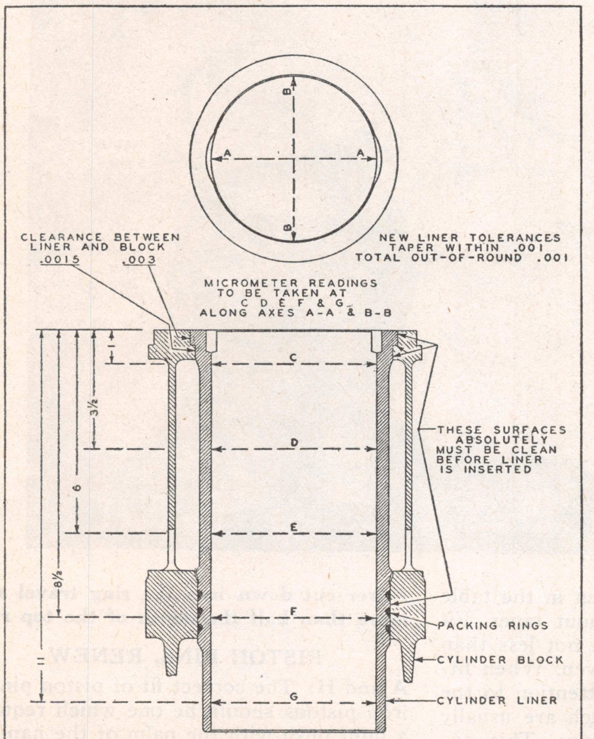
These pins are of the "full-floating" type, being held in place by snap rings in the grooves in the piston bosses.

PISTON PIN BUSHINGS, RENEW

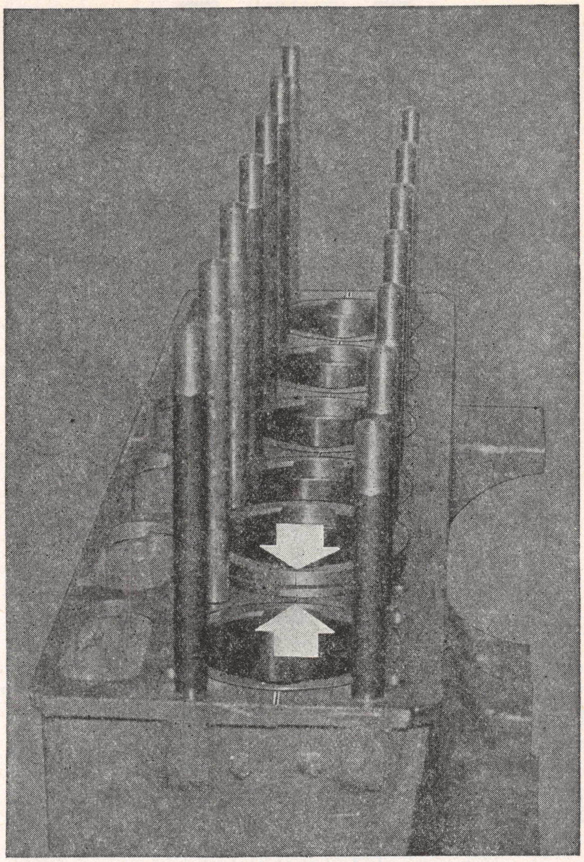
A and H: New bushings should be pressed in place and reamed to provide a light


SLEEVE PULLER

Models A and H. Pulling cylinder sleeves.


A
A
B
B
CLEARANCE BETWEEN LINER AND BLOCK
.0015
.003
NEW LINER TOLERANCES
TAPER WITHIN .001
TOTAL OUT-OF-ROUND .001
MICROMETER READINGS TO BE TAKEN AT C D E F & G ALONG AXES A-A & B-B
1
3½
6
8½
11
C
D
E
F
G
THESE SURFACES ABSOLUTELY MUST BE CLEAN BEFORE LINER IS INSERTED
PACKING RINGS
CYLINDER BLOCK
CYLINDER LINER

Model H. Cylinder sleeve gauge marks. Same procedure on Model A.



Models A and H. Install cylinder sleeves with marks aligned as shown.

push fit of the pin with the parts at normal room temperature. When installed, be sure the oil hole in the bushing lines up with the oil hole in the rod.

The correct fit of these pins in the rod bushing should be from .0015" to .002" on Model H, and from .001" to .0015" on Model A.

CYLINDER SLEEVES

A and H: These engines are equipped with removable wet type cylinder sleeves, held in place by the cylinder head at the top and made water tight at the bottom by three endless rubber packing rings.

To remove the sleeves, take off the cylinder head, oil pan and remove the piston and rod assemblies through the top of the block. Then use a suitable puller to remove the sleeves from the cylinder block.

To install the sleeves, scrape the rust and scale from the inner packing seat and the shoulder at the top of the block. To assure a free fit, first try the fit of the sleeve in the block without the rubber packing rings. Then install the three packing rings in the grooves on the sleeve, coating the surface of the block where the rings seat with soft soap to prevent damage.

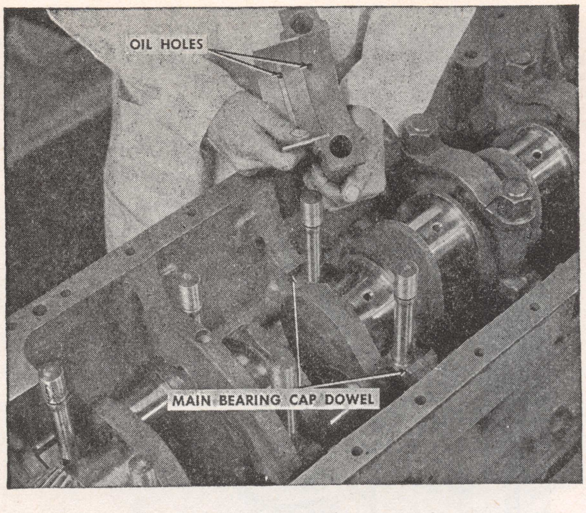
CAUTION—Press the sleeve in place with care to avoid possible shearing of the rings. Do not use oil or grease when installing sleeves as these products are very detrimental to the rubber seal rings.

NOTE—Insert the sleeve in the block with the recesses for the valves properly located. This is done by locating the line on the side of the sleeve with the punch mark on top of the block. Push the sleeve down into the block by hand pressure only; do not use a hammer.

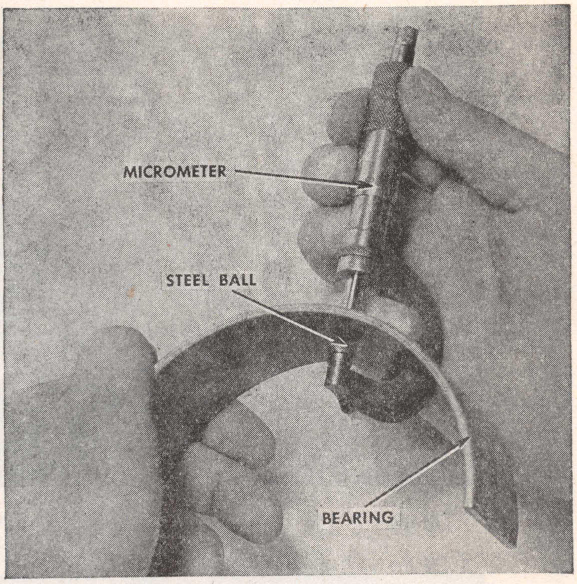
After the sleeve is in position check its inside diameter with a cylinder gauge for out-of-round and taper. If more than .001" out-of-round, or taper from top to bottom is found, pull the sleeve out of the block and check the bore in the cylinder block for excessive dirt or scale. Re-install the sleeve and check at all points with the cylinder gauge as indicated in the illustration.

GENERAL BEARING INSTRUCTIONS

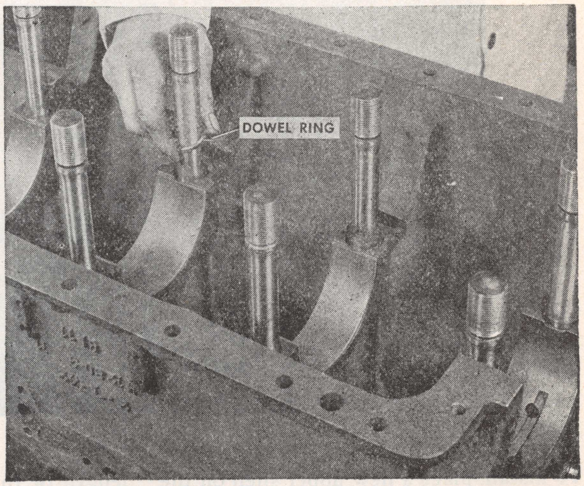
A and H: Main and connecting rod bearings, either standard or undersize, are the precision type and are provided with the recommended clearance for the oil film on the shaft. Under no circumstances should any attempt be made to scrape or ream these bearings.



Models A and H. Registry of oil hole in main bearing and cap.



Models A and H. Checking bearings.



Models A and H. Main bearing dowel ring.

The method of measuring a bearing shell —as shown in the illustration—is to use a micrometer in conjunction with the steel ball, the latter of which will rest on the inside of the bearing shell. Bearing wear can be found by checking the dimensions of a new bearing shell against that of the old one. As bearing shells are in halves, it will be necessary to take the worn dimension of the bearing shell in the bottom half of the shell.

A properly fitted bearing, after a reasonable period of service, will show a dull gray appearance, indicating running on an oil film. Bright spots indicate metal-to-metal contact, and black spots, excessive clearance.

CONNECTING ROD BEARINGS, RENEW

A and H: These bearings are of the precision insert type and when worn, they may be replaced by simply taking off the bearing caps and slip the old shells out and the new ones in. Bearings should be replaced in sets and under no circumstances should rods or caps be filed, altered or mutilated in any way in an attempt to obtain proper bearing fit.

NOTE—Before replacing bearings, make sure that the crankpins are not nicked or scored, and that all parts are thoroughly clean. This is particularly important because the presence of one small particle of metal, carbon or other foreign matter, lodged between the back of the bearing and the rod, or between the face of the bearing and the crankpin, will very likely cause a hot spot due to the elimination of the oil clearance at that point, eventually resulting in a bearing failure or a scored crankpin.

CAUTION—These bearings are designed for use without shims and under no circumstances should shims be used in an attempt to obtain a bearing fit, because the proper "crush" fit of the bearings in the connecting rod bores will not be obtained.

To check the fit of new bearings, use a piece of brass shim stock ¼" wide, the length of which should be ¼" less than the length of the bearing, while the thickness should be approximately the same as the minimum allowable clearance.

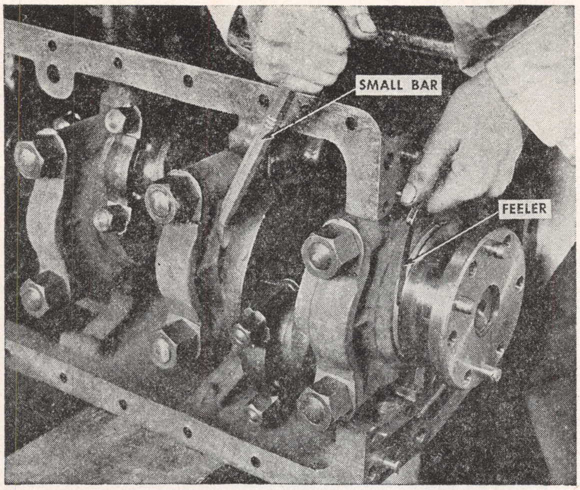
CAUTION—To avoid damaging the bearing material, smooth down the edges of the shim stock on an oil stone so that no sharp edges remain. Install the shim between the bearing and the crankpin, in the center of the bearing, then tighten the cap bolts to the recommended torque tension. When fitted properly, it should not be possible to move the rod endwise by hand, but a light tap with a hammer should cause the rod to move endwise. Then remove the checking shim and re-install the cap, tightening the cap bolts with a torque wrench, after which the rod should move endwise by hand. If the rod is too loose with the checking shim in place, the crankpin should be turned down and undersize bearings fitted.

NOTE—Connecting rod caps must not be interchanged or turned end for end. Matched marks stamped on connecting rod and cap must face camshaft side of engine. Small lip projecting from bearing shell fits in the groove in the rod for the purpose of doweling it in place.

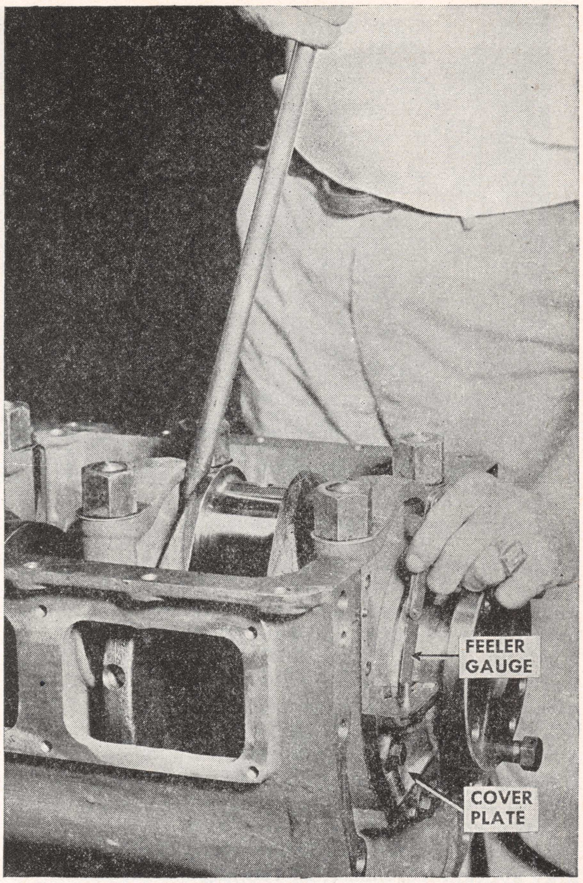
MAIN BEARINGS, RENEW

1932-42 All: NOTE—Before replacing bearings, make sure that the crankshaft journals are not nicked or scored. Use care also, to see that all parts are thoroughly clean. This is particularly important because one small particle of metal, carbon, dirt or other foreign matter, lodged between the back of the bearing and the cap or saddle, or between the bearing face and the crankshaft journal, will very likely cause a hot spot due to the elimination of the oil clearance at that point, eventually resulting in a bearing failure or a scored journal.

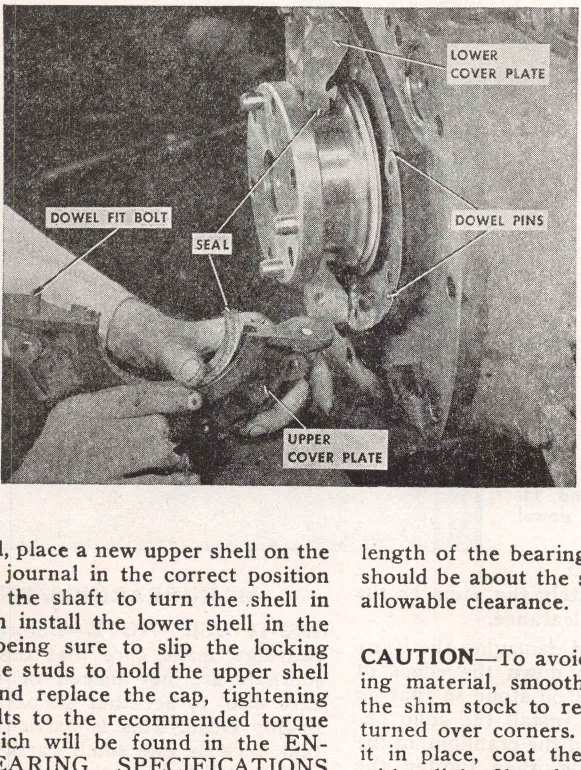
When bearings become worn, they can be replaced without removing the crankshaft in the following manner: Remove the bearing cap and take out the worn lower shell. A suitable tool can be made to remove the upper shell by using a cotter pin with the rounded end flattened to form a T shape. Insert the long end of the pin in the oil passage hole in the crankshaft journal and, by rotating the crankshaft in the reverse direction, the T-shaped head will contact the bearing and force it out.



Models A and H. Checking crankshaft end thrust.



Models A and H. Checking clearance between cover plate and crankshaft.



Models A and H. Inserting crankshaft oil seal.

To install, place a new upper shell on the crankshaft journal in the correct position and rotate the shaft to turn the shell in place. Then install the lower shell in the cap, first being sure to slip the locking rings on the studs to hold the upper shell in place, and replace the cap, tightening the cap bolts to the recommended torque tension which will be found in the ENGINE BEARING SPECIFICATIONS table.

NOTE—Bearings should be replaced in sets and under no circumstances should any attempt be made to shim, file, alter or otherwise mutilate the bearing caps to obtain proper bearing fit.

NOTE—Main bearing caps are assembled so that marks are on the camshaft side of engine.

Should a bearing burn out, the metal should be carefully removed from all oil passages in the crankshaft and in the cylinder block. Improper cleaning of these passages will result in another bearing failure.

To check the fit of new bearings, use a piece of brass shim stock ¼" wide, the length of which should be ¼" less than the length of the bearing, while the thickness should be about the same as the minimum allowable clearance.

CAUTION—To avoid damaging the bearing material, smooth down the edges of the shim stock to remove sharp edges or turned over corners. And before inserting it in place, coat the shim on both sides with a light film of engine oil.

Then lay the shim lengthwise in the center of the bearing and install the bearing cap to the crankshaft, tightening the cap bolts to the recommended torque tension. Test the fit of the bearing by rocking the flywheel through an arc of 2"—not more than 1" in either direction. The bearing may be considered fitted properly if the shaft is movable with a fairly heavy drag.

NOTE—Remove the checking shim and replace the cap, but do not tighten the cap bolts, as this bearing must be loose in order to check the fit of the other bearings. It is good practice to fit bearings by starting at the center, then the rear bearing, front bearing, and finally, the intermediates.

CRANKSHAFT END THRUST

A and H: Crankshaft end thrust is controlled by flanges on the rear main bearing. Through normal wear, the end play will seldom become excessive but whenever new bearings are fitted, the clearance should be carefully checked and, if required, the bearing flanges may be dressed down to obtain the desired end play.

CRANKSHAFT REAR OIL SEAL

A and H: To assemble the seal and cover plates, place a gasket over the dowel pins on the rear of the cylinder block. Install new asbestos seals into the recesses of both the upper and lower cover plates.

NOTE—The packing must be trimmed on three sides at each end to a 1/32" x 45 degree bevel, the inside edge being left square. Packing ends should not extend more than 1/32" above the joining surfaces of the cover plates.

Assemble the upper cover plate over the dowel pins on the cylinder block and fasten the cover plate securely with cap screws and lock washers. Force the crankshaft back to the limit of its end play and check the clearance between the crankshaft oil slinger and the opposing face of the cover plate. The clearance should be from .004" to .006".

NOTE—If the clearance is not within the above limits, cover plates may be moved to or from the block to obtain the desired clearance by the use of gaskets of .005" and .010" thicknesses.

Then loosen the cover plate just enough to allow the plate to clear the dowels and assemble new connection gaskets, after which, the lower cover plate is assembled to the upper plate, bolting them securely together.

After installing the cap screws and washers to the lower plate, tap both plates in position over the dowel pins and tighten the cap screws alternately to bring the plates up evenly all around. Finally, install the oil pan, flywheel and flywheel housing.

FLYWHEEL AND HOUSING

A and H: Whenever replacing the flywheel, it should be checked for wobble or excessive run-out. If a dial indicator is available, mount it on the flywheel housing and allow its stem to contact the flywheel as the engine is being turned slowly. Make a note of the high and low sides of the flywheel through one complete revolution and if run-out exceeds .010", it should be removed and the crankshaft flange recess inspected for burrs, dirt or other foreign matter.

To assemble the flywheel and housing, shellac a new gasket to the flywheel housing and place the housing in position over the dowel pins in the cylinder block.

NOTE—If a new housing is being installed, remove the dowel pins from the cylinder block and mount the housing to the block with cap screws. Then use a dial indicator to check the concentricity of the housing in relation to the crankshaft. It may be necessary to shift the housing slightly one way or another to obtain this result. If this is done, ream the dowel pin holes so that when oversize pins are installed, a true fit over the dowel pins will be secured.

Assemble the flywheel over the dowel pins on the crankshaft, using a new gasget, then bolt the flywheel securely in place. Finally, check the flywheel for wobble and run-out as directed above.

STANDARD AIR COMPRESSOR

Model A: To remove the standard air compressor on these engines, simply remove the compressor drive belts, take out the mounting bolts and lift the assembly from the engine.

Model H: NOTE—Before removing the standard compressor on these engines, time the engine before removal of the fuel pump as described under the FUEL PUMP, REMOVE paragraph in the Cummins Fuel Injection Pump chapter.

To remove the compressor, uncouple the chain at the fuel pump drive coupling and take off the fuel pump. Relieve all pressure from the air lines and disconnect the pipe to the air tanks. Disconnect the external oil pipe at the bottom of the compressor, and remove the cooling water lines on the front of the unit. Turn the water pump on the low point of its eccentric and take off the fan belts, after which, use a suitable puller to remove the water pump drive pulley from the compressor shaft.

NOTE—On engines where it is impossible to use a puller, two 7/16" x 20 SAE cap screws, two inches long, threaded the full length, can be used in the two puller holes in the pulley. When using these screws, it is very important that a piece of flat iron, ⅛" x 1" be inserted between the pulley and the gear housing to prevent damage to the oil seal. Turn each of these cap screws alternately ½ turn at a time in order to pull the pulley evenly from the shaft.

With the pulley removed, take out the cap screws from the mounting flange and remove the compressor and its drive gear from the engine.

NOTE—Since the fuel pump is driven from the air compressor shaft, the compressor drive gear must be correctly timed when replaced. This is accomplished in the following manner:

Crank the engine until No. 1 cylinder is at top center of its compression stroke. When in this position, two center-punch marks will appear on the face of the camshaft gear. Mesh the compressor gear with the camshaft gear by indexing the one punch-marked tooth on the compressor gear between the two punch-marked teeth on the camshaft gear.

NOTE—This can be checked through the front of the gear housing by putting a chalk mark on the top of the two teeth on the camshaft gear and a chalk mark on the marked compressor gear tooth.

When the gears are properly meshed, fasten the compressor unit to the engine, and install and time the Fuel Injection Pump as explained in the Cummins Fuel Injection Pump chapter under FUEL PUMP TIMING. After timing the Fuel Injection Pump, connect the coupling and attach water, oil and air lines to the compressor unit.

NOTE—On some engines, the compressor is mounted over the governor, generator, and on the end of the crankshaft. All these installations are accessible for removal and servicing without the necessity of performing the timing operations mentioned above.

ENGINE OILING

LUBRICATING OIL PUMP

Model H: To disassemble the pump after removing it from the engine, disconnect the pump body from the pump bracket and lift the body from the bracket. Press the idler gear stud from the pump body, and with a puller, remove the drive gear, using the two tapped holes in the gear provided for that purpose. Tap the edge of the bracket with a soft hammer and take it off. After unscrewing the nut from the end of the drive shaft, press the pump drive gear and shaft from the ball bearing. Remove the snap ring from the bearing cage and tap the bearing from the cage.

To assemble the pump, install the Woodruff key in the drive end of the shaft and press the drive gear on the shaft until it is snug against the shoulder. Press the ball bearing into the cage and lock it in place with the snap ring. Slip the end of the drive shaft in the cage and replace the retaining washer, nut and cotter pin. Press a new bushing in the pump bracket and ream it to size with a ⅞" reamer. Using a new gasket, insert the pump bracket over the bearing cage. Install the Woodruff key in the shaft and press the pump gear on until the shaft gear has a clearance of .0015" between the gear and bracket. Press the idler gear shaft into the pump body so that the shaft is slightly below the face of the gear body. Attach the pump body to the pump bracket, using a new gasket to avoid leakage. Turn the drive gear to see that the pump gears are free.

Using a new gasket, install the pump assembly to the rear face of the timing gear case, meshing the drive gear carefully to the camshaft gear, after which, fasten the assembly securely. Prime the oil pump by applying clean oil through one of the oil line connections in the pump. Replace the external oil lines, tightening all connections securely.

Model A: The lubricating oil pump used on these engines is of the positive gear type and consists of two helical cut gears running in a cast iron case. The pump is built into the front end of the governor drive gear housing and is driven by the fuel pump shaft.

The pump may be inspected by removing the Fuel Injection Pump from the engine. Then take off the four allen-head screws in the face plate on the front of the governor drive housing, and the capscrews on the back of this flange in order to remove the plate.

When new, the pump idler gear shaft has from .001" to .002" clearance; pump housing clearance from .002" to .003", and the pump body gasket thickness is .003".

NOTE—If the pump is disassembled, be sure to fill it with clean oil when assembling so it will not run dry for the first few seconds of operation.

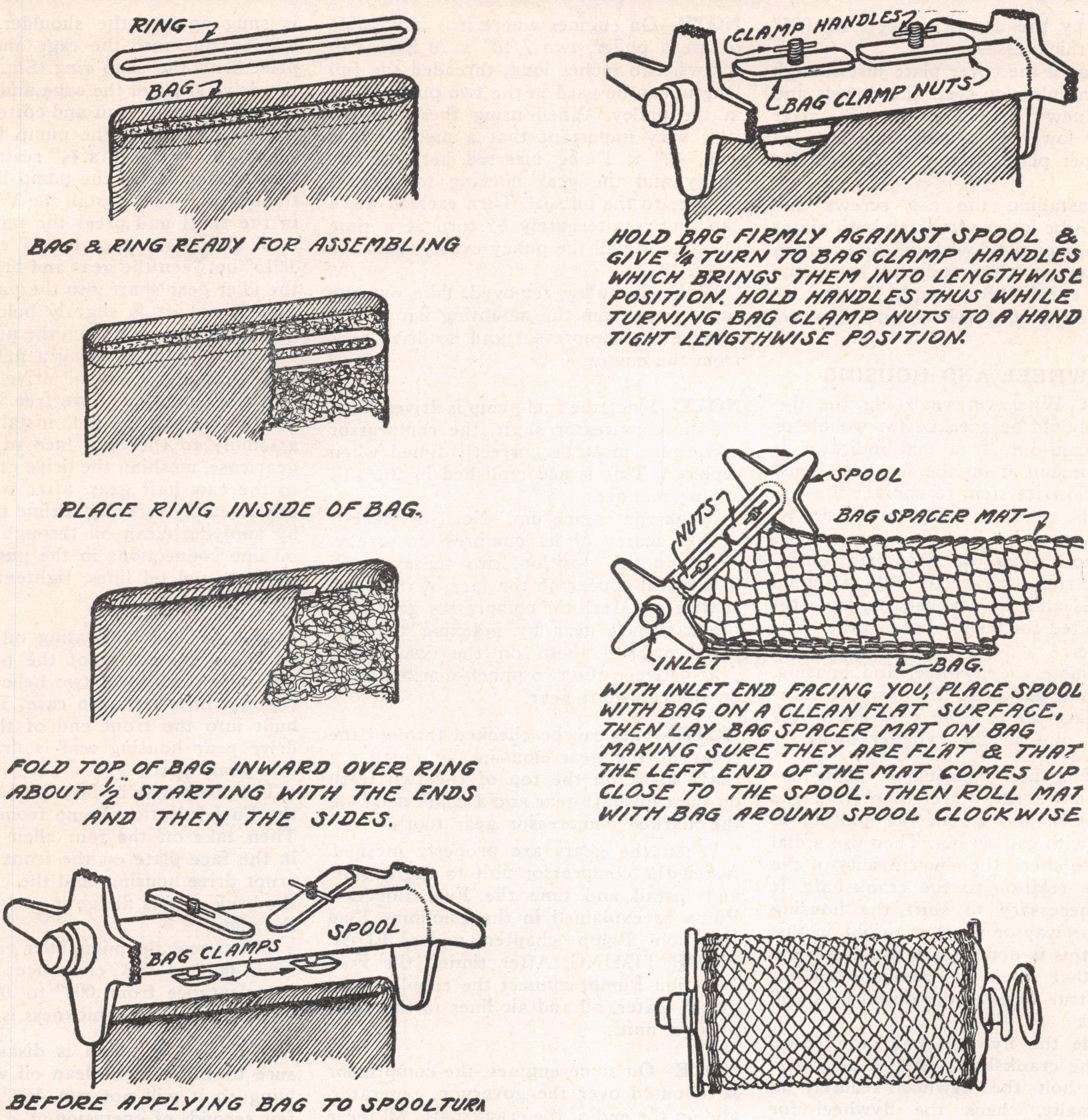
OIL PRESSURE REGULATOR

Model H: The oil pressure regulator is located at the front end of the hollow camshaft. Oil from the pump is delivered at from 30 to 45 pounds pressure to the third bearing of the camshaft, a fitting on the side of the crankcase being provided for this purpose. The third bearing is grooved and drilled so oil can fill the camshaft for its entire length.

The oil pressure regulator consists of a spring-loaded piston-type valve. When the valve is open, oil is spilled over the timing gears. The pressure regulating spring is backed up by another piston which bears against the inspection plate which is bolted to the timing cover plate at this point.

To change the oil pressure, it is only necessary to remove this plate and replace the spring with a stiffer or weaker one, depending on whether more or less oil pressure is desired.

Model A: The oil pressure regulating valve



BAG & RING READY FOR ASSEMBLING

PLACE RING INSIDE OF BAG.

FOLD TOP OF BAG INWARD OVER RING ABOUT ½" STARTING WITH THE ENDS AND THEN THE SIDES.

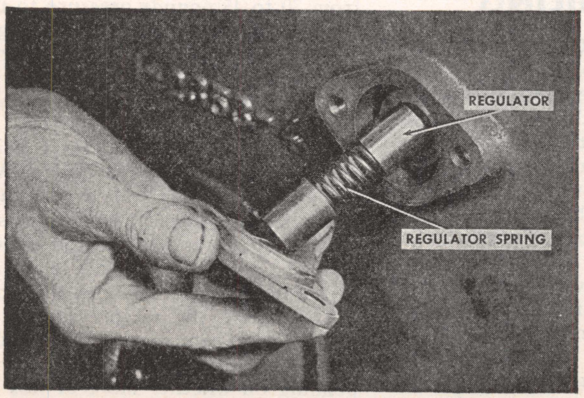
BEFORE APPLYING BAG TO SPOOL TURN BAG-CLAMPS LENGTHWISE SO THAT THEY WILL ENTER BAG OPENING.

HOLD BAG FIRMLY AGAINST SPOOL & GIVE ¼ TURN TO BAG CLAMP HANDLES WHICH BRINGS THEM INTO LENGTHWISE POSITION. HOLD HANDLES THUS WHILE TURNING BAG CLAMP NUTS TO A HAND TIGHT LENGTHWISE POSITION.

WITH INLET END FACING YOU, PLACE SPOOL WITH BAG ON A CLEAN FLAT SURFACE, THEN LAY BAG SPACER MAT ON BAG MAKING SURE THEY ARE FLAT & THAT THE LEFT END OF THE MAT COMES UP CLOSE TO THE SPOOL. THEN ROLL MAT WITH BAG AROUND SPOOL CLOCKWISE

ASSEMBLED FILTERING ELEMENT READY TO INSERT INTO SHELL.

Models A and H. Method of changing lubricating oil filter bag.



Model H. Installing lubricating oil pressure regulator.

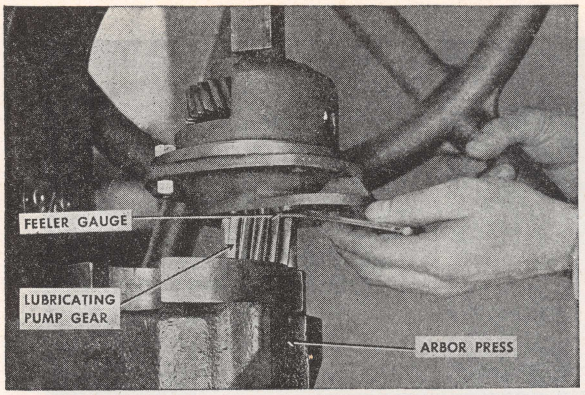
is located directly under the governor weight housing. It may be adjusted with a screw driver after the governor weight housing is removed. If the proper quality of oil is used, it should seldom be necessary to make any adjustments on this regulator.

LUBRICATING OIL FILTER

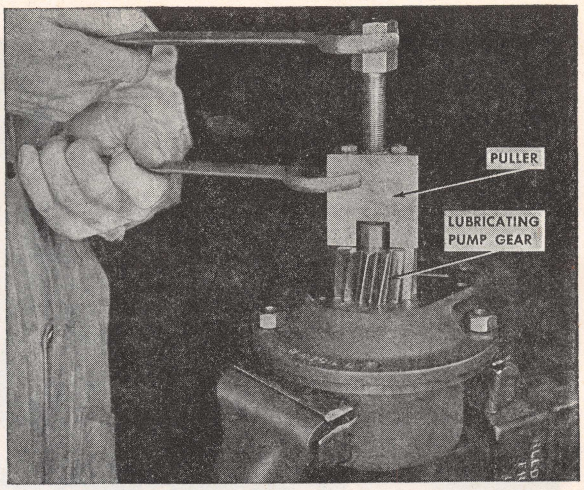
A and H: The lubricating oil filter is located in the crankcase sump on Model H engines, and on the manifold side of the Model A engines. The filter bag should be changed every 1,500 miles in automotive service or 75 hours of industrial operation.

When changing filter bags, the engine oil should be drained from the sump, and the entire crankcase and sump should be washed or cleaned out with flushing oil. When performing this operation, proceed as follows:

1. Remove the filter bag in the filter and throw it away.



Model H. Assembling lubricating oil pump gear.



Model H. Pulling lubricating oil pump gear.

2. Put on a new filter bag and replace the assembly in the filter. For the flushing oil, use five gallons (3½ gallons on Model A) of fuel oil mixed with ½ gallon of fresh lubricating oil.
3. Cover the radiator, start the engine and let it idle at 800 to 900 r.p.m., for at least 15 minutes.
4. Stop the engine, remove the plug and filter bag assembly and allow the engine to drain no less than 30 minutes.
5. Remove the filter bag that was put on when the flushing operations were started and keep it for future flushing work only.
6. Put on a clean filter bag and put the assembly back in the housing. Be sure to let the filter bag compartment drain completely of the flushing oil.

NOTE—It is important to remove the old filter bag before flushing the engine because it is filled with solids and impurities removed from the lubricating oil while the engine has been in operation. If this bag is not removed, the flushing oil will dissolve these solids and carry them into every working part of the engine. It is also important to use a clean bag just for flushing because this is the only possible way to catch the sludge, carbon, etc., which the flushing oil washes loose.

The radiator is covered so that the engine and flushing oil will be hot during the flushing operations. Sludge is heavy and gummy and the flushing oil must be hot to cut it thoroughly.

IMPORTANT—Every time a new filter bag is installed, it is necessary to put an additional gallon (½ gallon on Model A) of lubricating oil into the crankcase, since that much oil is contained in the filtering system.

To change the filter bag, proceed as follows: First, remove cover of the filter by removing nuts which hold it in place. After the cover is removed, pull out the entire filter element. Unroll the bag and remove it from the spool. To remove the bag from the spool, unscrew the flat nuts on the two clamp screws about ⅛". Depress the clamp screws and turn them one-fourth turn, i.e., the pins in the clamp screws will stand across the spool. This being done, the bag with its clamp bar can readily be pulled off. Then remove the clamp bar, insert the new bag in the clamp bar so that the lips of the bag will just be rolled over the clamp bar. Place the clamp bar with bag on the spool again, depress the clamp screws and turn same back one-fourth turn, so that the pins point parallel with the axis of the spool. Tighten up the flat clamp nuts again, being sure that the clamp screws do not turn or twist when doing so, as this would have a tendency to cut the bag. The bag being clamped in position, place the spacing mat on the bag and roll up on the spool with the spacing mat rolling inside next to the spool.

With the filter element properly rolled up, place back in the filter housing again, being sure that the pilot enters the pilot hole in the filter housing; then be sure that the conical spring on the end of the filter, which holds the entire filter firmly in place, is properly attached to the filter element, put on the cover again, making sure that the copper gasket in the recess is clean and in good shape—also the cover itself. Then tighten up the nuts evenly, which is very essential, as otherwise a leak might occur at this cover. Also, make sure that the lock washers under the nuts are not left off, as this might result in a loose cover during operation, and loss of lubricating oil.

If the oil or liquid you are filtering does not clean up as you think it should or filter fast enough check the following:

The bag is either too thin or too thick or the filter too small or the by-pass valve leaks, or there is a leak under the oval bag ring, or there is a hole in the bag, or the bag needs changing, or the bag spool does not seat properly in the cover.

WARNING—Do not attempt to clean old filter bags. Replace with new ones.

AUXILIARY LUBRICATING OIL FILTERS

A and H: Several makes of auxiliary oil filters are used, especially on engines working under extreme dust conditions. The element in auxiliary filters should be changed when the oil in the crankcase turns black or gets dirty. The point of usefulness of the absorption type filter is reached when the oil turns black.

When an element is changed, the filter sump should be drained and all water and sludge wiped out with clean cloths (not waste). For best results replace only with cartridges sold by the manufacturer of the unit.

CRANKCASE VENTILATOR

A and H: The interval at which the ventilator and air cleaner should be cleaned can only be determined by the type of service to which the vehicle is subjected. Vehicles operating in dusty or sandy areas require more frequent service than vehicles operating under more favorable conditions.

IMPORTANT—For vehicles operating in dust storm areas, the cleaner should be serviced immediately after such storms occur.

For normal service however, the breather should be inspected at least every 2,000 miles, and if a sludge formation is evident, remove the breather and clean it thoroughly in fuel oil. Allow the breather to soak for at least 30 minutes then blow it out with compressed air, while at the same time, tapping it lightly to dislodge any solid particles of sludge.

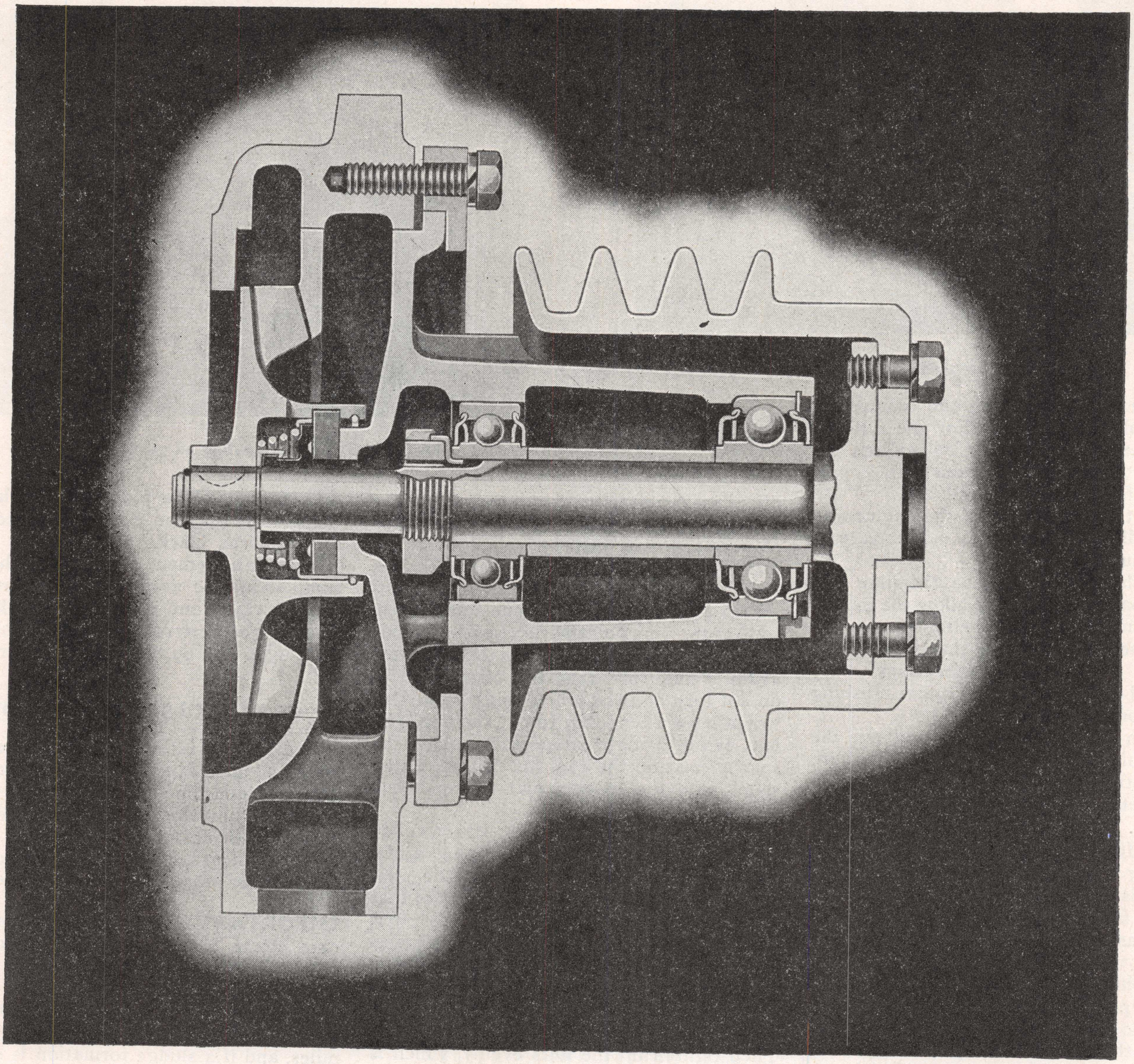
If the breather is fitted with an air cleaner, it should be removed and washed every 1,000 miles. After the element is washed, blow it dry with compressed air and, if the cleaner is of the oil-wetted type, dip the element in fresh engine oil before assembling. If it is of the oil bath type, wipe out the oil reservoir thoroughly with a clean cloth and fill it to the proper level with fresh engine oil.

RECOMMENDED LUBRICATING OIL SPECIFICATONS

A and H: The following grades of lubricating oils should be used in the crankcase:

Extra hot weather and well worn engine	SAE No. 40
Hot Weather (80 to 100 degrees)	SAE No. 30

NOTE—For Cummins engines developed since 1942, see page 915.



Model A. Cross sectional view of water pump.

Average Weather (20 to 80 degrees ....SAE No. 20

Cold Weather (20 degrees and below) ....SAE No. 10

The SAE numbers given should be adhered to closely. It would not be satisfactory, for instance, to substitute an SAE No. 30 light grade, or SAE No. 20 light grade, for the corresponding straight SAE No. 30 or SAE No. 20.

Very good service is obtained from the paraffin base oils, although any high grade oil will give satisfaction. The cheaper grades of oil tend to char and cause rings to stick and cylinder walls to wear rapidly.

More engines have been ruined and worn out by use of inferior oil than from any other cause. The oil in the engine should be changed every 1,000 to 1,500 miles in automotive service, or 75 hours operation in industrial use.

COOLING SYSTEM

WATER PUMP, REMOVE

A and H: To remove the pump, remove the cap screws in the water pump clamp ring and rotate the pump housing on its eccentric to loosen the drive belts, then remove the belts and lift the pump from the engine.

NOTE—Do not attempt to remove the pump from the engine without first removing the drive belts. If not removed, the belts will cause the pump to bind and breakage may result. When installing the pump assembly, use a new gasket, and do not install the belts until the assembly is bolted loosely in place by the clamp ring. Then turn the pump to the lowest point of its eccentric, and the belts may then be "rolled" on by turning the engine.

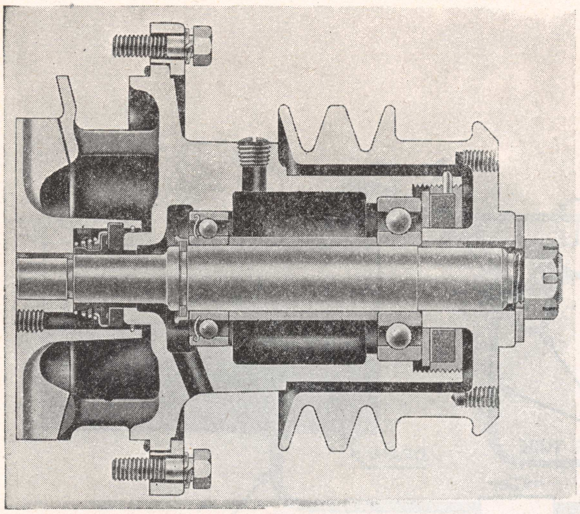
To tighten the belts, the pump body should be turned in a counter-clockwise direction. To do this, use a screw driver inserted in the hole in the pump body. Belts have the proper tension if the outside belt can be pushed down with normal thumb pressure approximately ¾" below the top surface of the inside belt.

WATER PUMP, OVERHAUL

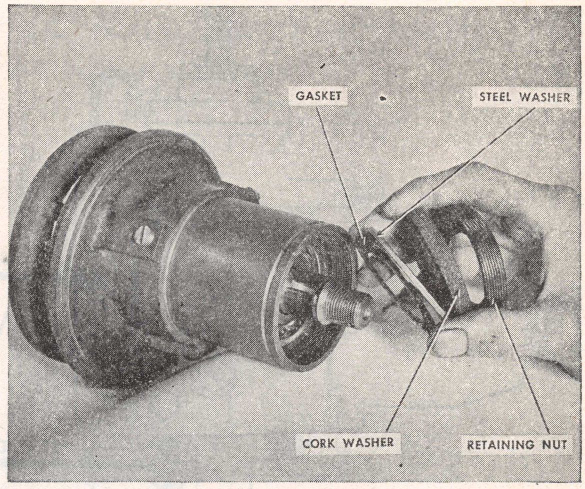
Model A: To prevent leaks, the pump is equipped with a seal having lapped faces and held in place by spring tension. The pump shaft is supported on two sealed ball bearings which require no lubrication. If the pump leaks due to a scored or broken seal, the seal will have to be replaced, and when doing so, the seal assembly must be handled carefully to prevent any damage.

After the seal is replaced and the pump re-assembled, run the engine at idling speed for a short time to see whether or

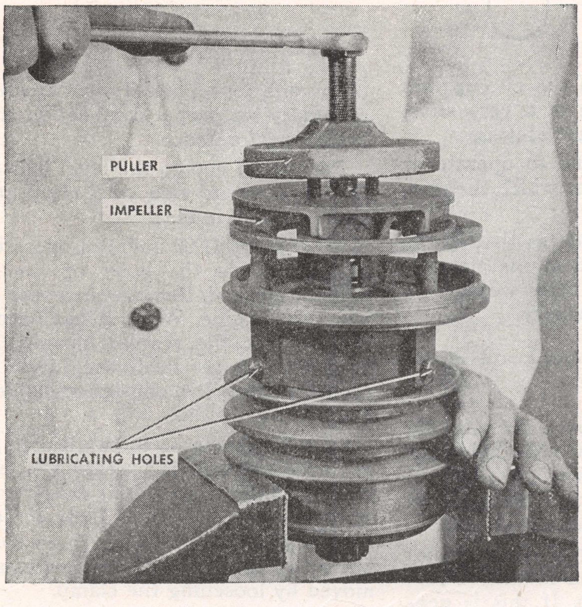
NOTE—For Cummins engines developed since 1942, see page 915.



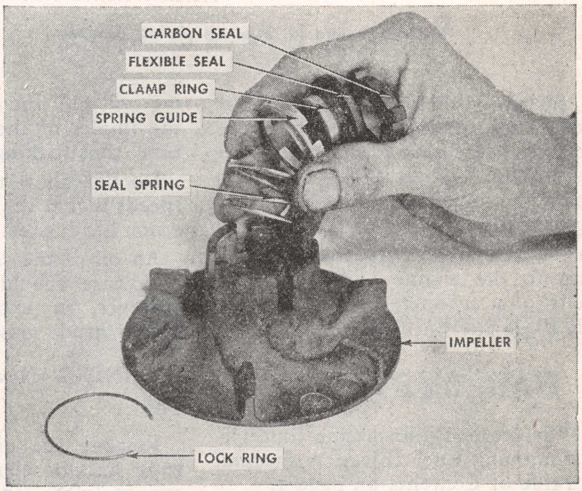
Model H. Cross sectional view of water pump.


GASKET
STEEL WASHER
CORK WASHER
RETAINING NUT

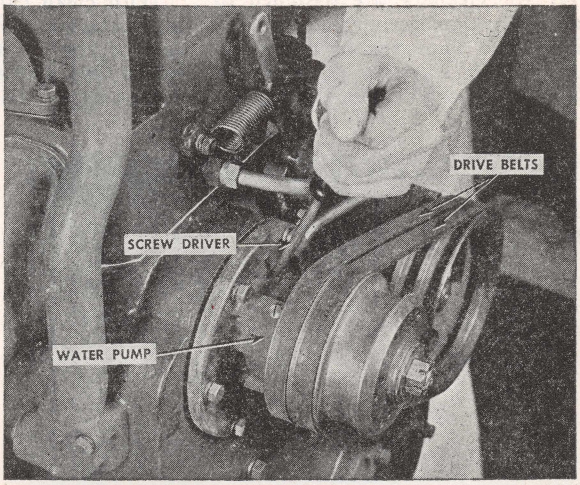
Model H. Assembling water pump bearing retainer.


PULLER
IMPELLER
LUBRICATING HOLES

Model H. Pulling water pump impeller.


CARBON SEAL
FLEXIBLE SEAL
CLAMP RING
SPRING GUIDE
SEAL SPRING
IMPELLER
LOCK RING

Model H. Assembling water pump shaft carbon seal.


DRIVE BELTS
SCREW DRIVER
WATER PUMP

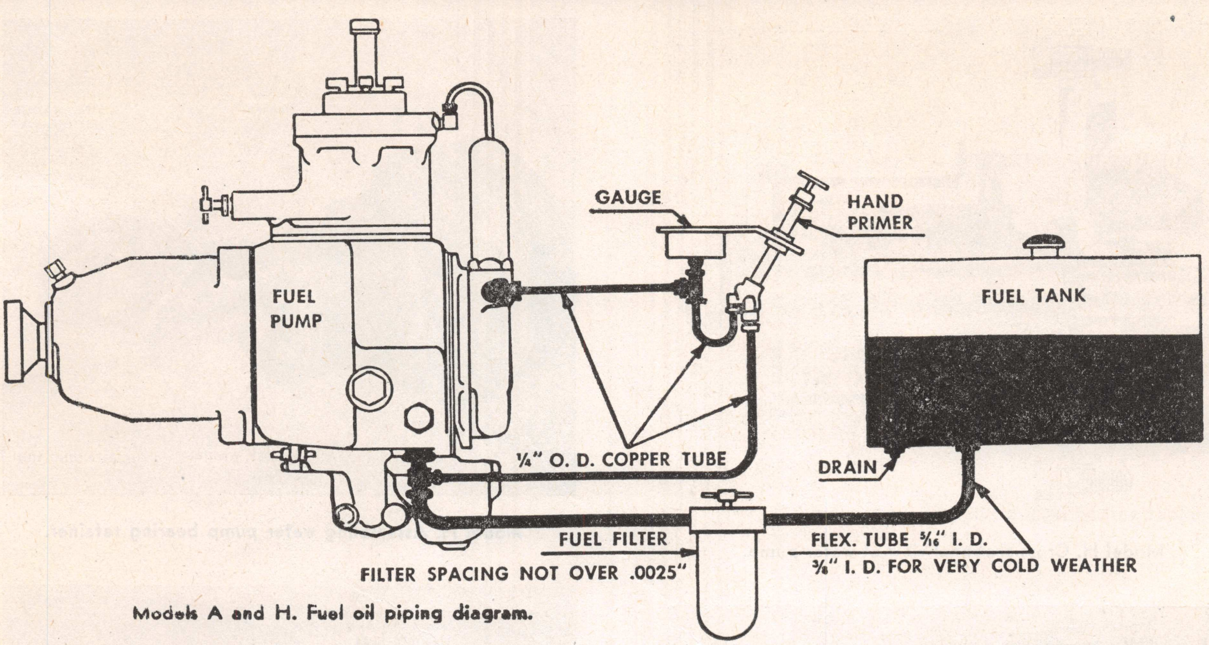
Model H. Tightening water pump drive belts. Same procedure on Model A.

not the seal is seated properly. In most cases, there will be a small water leak which will continue until the seal seats itself. However, if after five or ten minutes the water leak does not stop, very likely the seal has not been assembled correctly, in which case, it should be disassembled and installed as shown in the illustration.

Model H: In general, this pump is the same as the Model A pump but the service is somewhat different. To disassemble the pump, use a suitable puller to remove the impeller from the shaft. Remove the lock ring and pull out the seal assembly. Use a puller to remove the drive pulley, release the snap ring from the pump housing and screw out the retainer. Finally, press the shaft and bearing assembly from the impeller side of the housing.

To assemble the pump, install the bearings to the shaft with the lock ring and retainer. With the gasket and washers inserted, screw the retaining nut down flush with the face of the housing, lining up the lock ring hole and inserting the lock ring in place. Assemble the Woodruff key to the shaft and press the drive pulley on the shaft, locking in place with a nut and cotter pin.

NOTE—Before assembling the carbon seal to the impeller, inspect the faces of both the seal and impeller on which the seal rides, for any nicks or scratches. If any scratches or marks are present, reface the impeller to obtain a smooth flat surface



Models A and H. Fuel oil piping diagram.

for the carbon seal to ride against for proper operation. Check the seal over the shaft to make sure that it fits freely before assembling. Complete the operation by pressing the impeller in place until it is down against the shoulder of the shaft.

When the assembly is completed, install the pump to the engine and adjust the drive belts in a manner described under WATER PUMP, REMOVE.

FUEL SYSTEM

NOTE—For detailed information concerning the Cummins Fuel Injection System, see the Table of Contents on page 1.

AIR CLEANER

A and H: Air cleaners are designed to handle a certain maximum volume of air. As engine speed increases or decreases, the volume of air traveling through the cleaner varies proportionately. Overspeeding will pull the oil from the oil cup into the intake of the engine in a very short time, thus making the filter useless.

Do not allow the engine to operate at speeds higher than that for which the governor is adjusted.

An oil of the same grade as that in the crankcase should be used in the cleaner; however, in extremely cold weather a lighter grade may be necessary.

WARNING—Never use crankcase drainings.

Remove the oil cup by loosening the wing nuts or clamp screw that holds the cup in place on the lower part of the cleaner. Empty the oil from the cup and wash thoroughly with cleaning solvent.

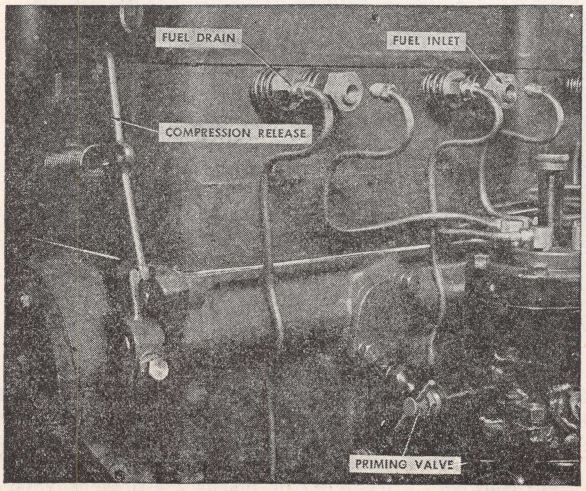
With clean cloth or brush (not waste) and cleaning solvent, wash the inside surface of the air inlet tube. If this is neglected, dirt will gradually build up on inside of tube. This will prevent the passage of a sufficient quantity of air which is necessary for proper combustion and good engine performance.

Fill the oil cup to the level indicated by the bead on its side with clean fresh oil and assemble to cleaner.

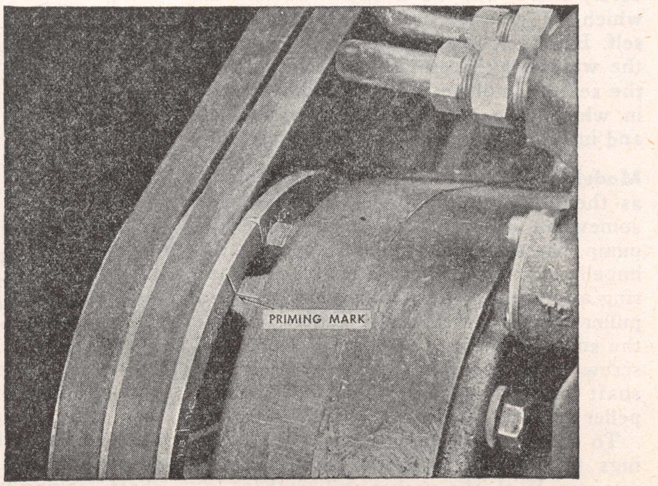
After every 1,000 hours of operation, the screens inside the body of the cleaner must be cleaned. Remove the entire cleaner from the engine. When it has been disassembled for the regular cleaning job as described above, flush the inside of the cleaner body with a non-inflammable cleaning solvent.

Certain models of these cleaners, which are used on engines operating in extreme dust conditions, are fitted with removable screens inside the filter. These screens are held in place with a clamp ring around the bottom of the air inlet tube and can be removed by loosening the clamp.

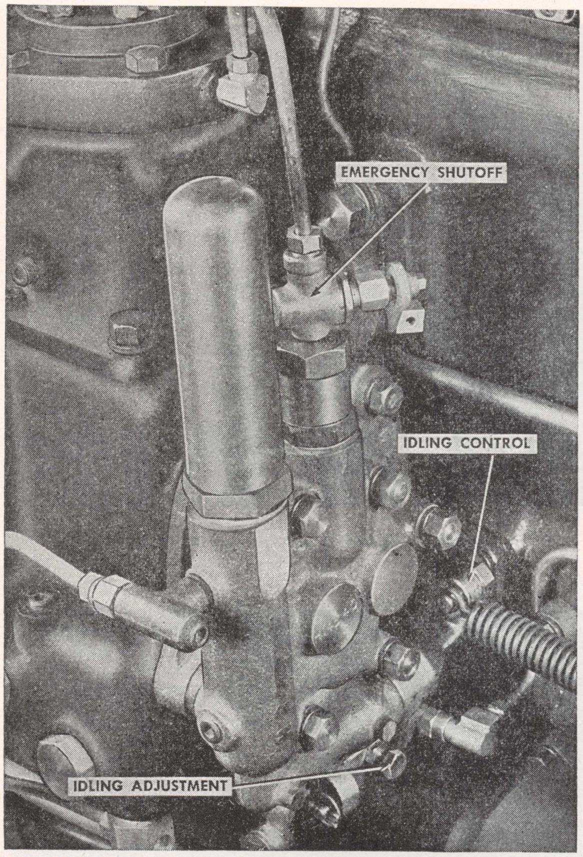
After thoroughly flushing, blow the screens out well with compressed air



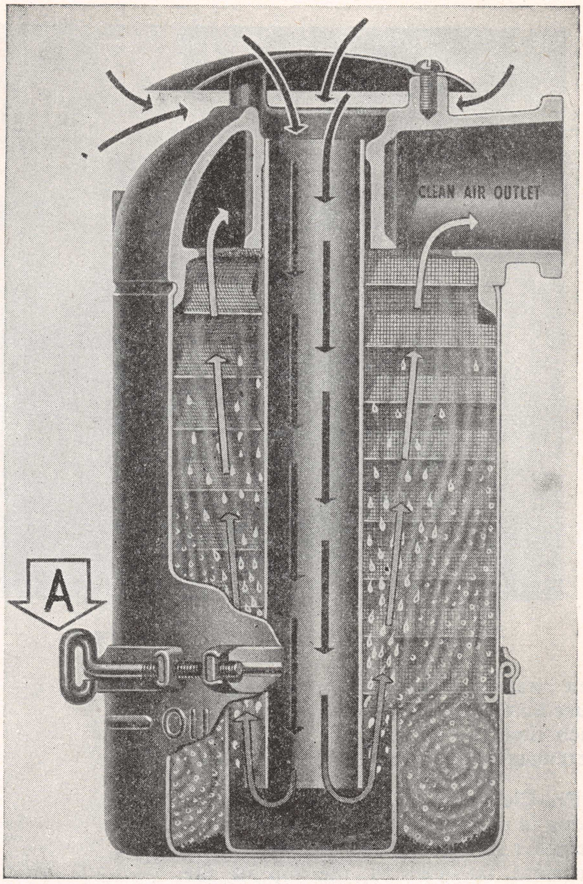
Model H. Position for priming engine. Typical of Model A.



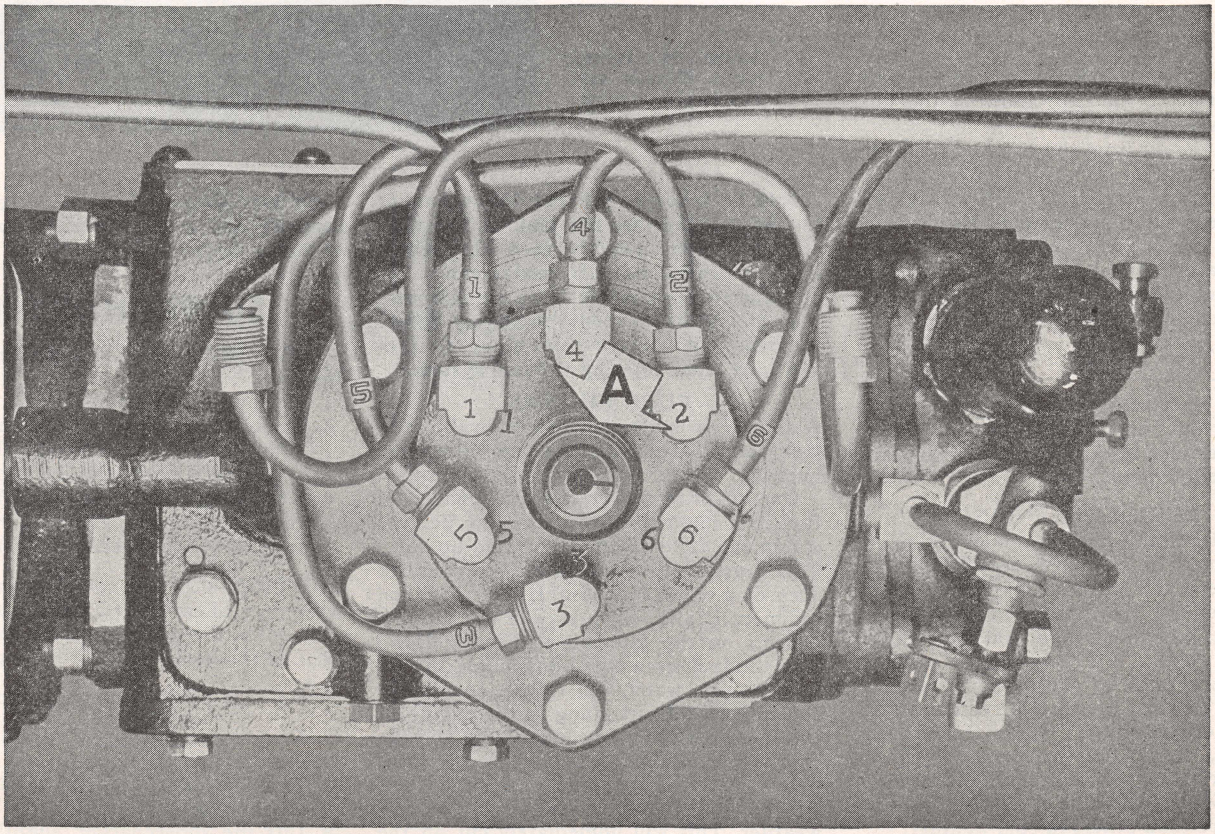
Models A and H. Priming mark.


EMERGENCY SHUTOFF
IDLING CONTROL
IDLING ADJUSTMENT

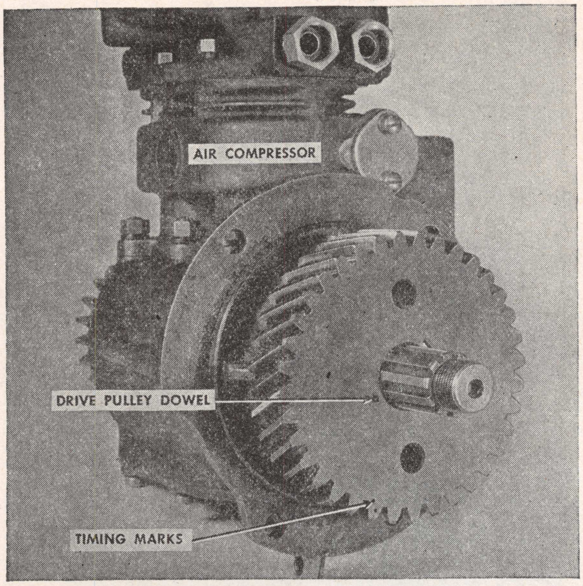
Models A and H. Emergency shut-off and idling control.


CLEAN AIR OUTLET
A
OIL

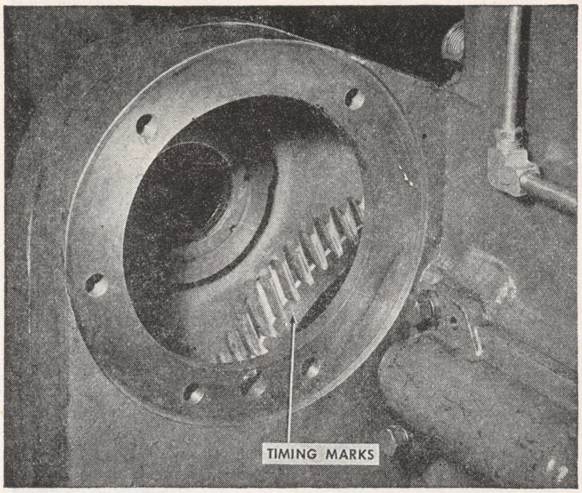
Models A and H. Cross section of air cleaner


4
1
2
4
A
1
2
5
6
5
6
3
3

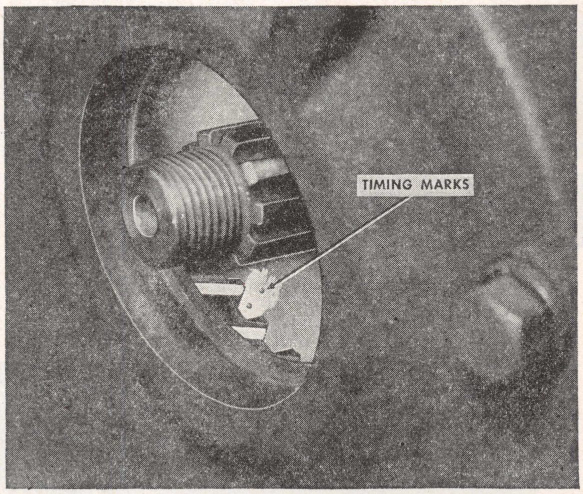
Model A. Showing numbered fuel lines. A indicates tachometer connection.



Model H. Timing marks on air compressor gear.



Model H. Timing marks on camshaft gear.



Model H. Timing marks through seal hole in gear housing.

When cleaner is replaced on the engine, be sure all connections are air tight.

Each time the air cleaners are serviced the crankcase breather should be cleaned.

Air Pre-Cleaners: On models of engines working in extreme dirty conditions, an air pre-cleaner is used. The pre-cleaner is an attachment fastened to the top of the regular air cleaner for collecting excessive dust going into the intake of the air cleaner. A small jar is screwed on the pre-cleaner for collecting dust and must be cleaned according to operating conditions.

Oil Bath Type Breather: Remove the wing nut on top of the cap, allowing the unit to be disassembled.

Drain the oil from the cup and wash the cup thoroughly.

Wash the screen in the cup with cleaning solvent and blow out with air.

Refill the cup with clean oil, the same weight as used in the engine, to the oil level bead around the cup.

Reassemble, and install it on the engine.

Screen Type Breather: The screen type breather is serviced in the same manner as the oil bath type. The screen type breather does not carry oil in the cup. Dip the screen in clean lubricating oil and assemble to engine.

FUEL LINE PIPING

A and H: All injector drain lines and manifold should be checked occasionally for stoppage. Care must be taken to prevent the use of any sharp bends in the fuel piping so as to have a minimum vibration in the line.

The use of 5/16" inside diameter fuel lines for normal weather is recommended. When operating in freezing and cold weather, it is best to use ⅜" inside diameter tubing, so the fuel can flow more freely. Some fuels have a tendency to congeal more than others in cold weather.

When filling the fuel tank, precaution should be taken to prevent dirt, water, or lint from going into the tank. A 100-mesh screen strainer should be used when filling from oil drums and open containers.

If any fuel line connections are removed, they should be washed thoroughly before removing and before reinstalling to prevent dirt from entering the fuel system.

FUEL FILTERS

A and H: It is necessary to drain the sediment and water from the fuel filter frequently.

Due to different grades and quality of fuel it is impossible to make any definite statement as to when this should be done. This must be determined by the operator according to the fuel used. If this water and sediment is allowed to stay in the filter, it collects on the filtering element and will stop the fuel from passing through. In cold weather the water will freeze, completely shutting off all fuel going to the engine. If the fuel lines have any low points and the engine is allowed to sit idle for a short period of time, any water in the fuel lines will find the low spots and freeze in cold weather. This will immediately cut off the fuel flow to the fuel pump.

Be sure that all fuel lines are installed properly and are of the right size. (Refer to piping diagrams for size.)

SUPERCHARGER

SUPERCHARGER, OVERHAUL

Remove:

1. Remove air cleaner.
2. Disconnect vapor line from rocker housing to supercharger intake tube.
3. Disconnect lubricating oil tubes.
4. Remove the eight nuts and lockwashers around the flange of the intake tube and remove the tube. (Fig. A.)

CAUTION—Cover supercharger opening with piece of cardboard. Do not use rags.

5. Loosen the manifold clamp nuts.
6. Lift intake manifold from engine.

NOTE—Do not lose rubber packing ring.

7. Remove lubricating oil drain lines and spring on drain cock.
8. Remove four bolts holding supercharger to block.
9. Lift the supercharger slightly upward and backward and remove from engine.

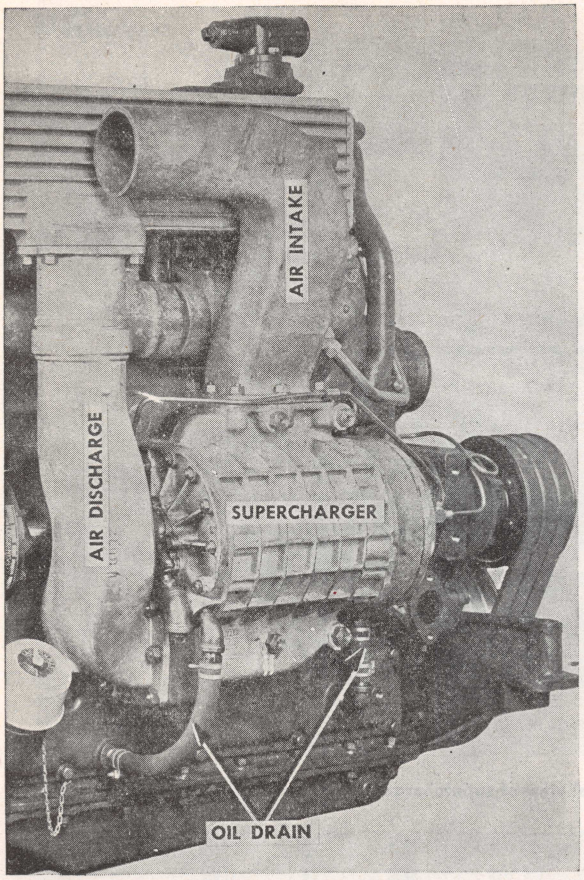


Fig. A. Models A and H. Supercharger.

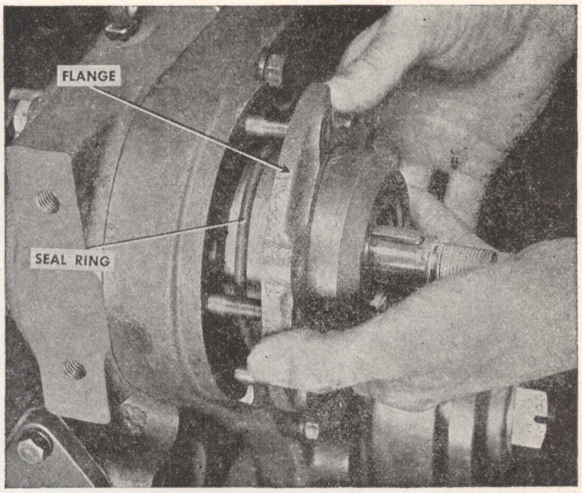


Fig. C. Model H. Supercharger drive seal unit.

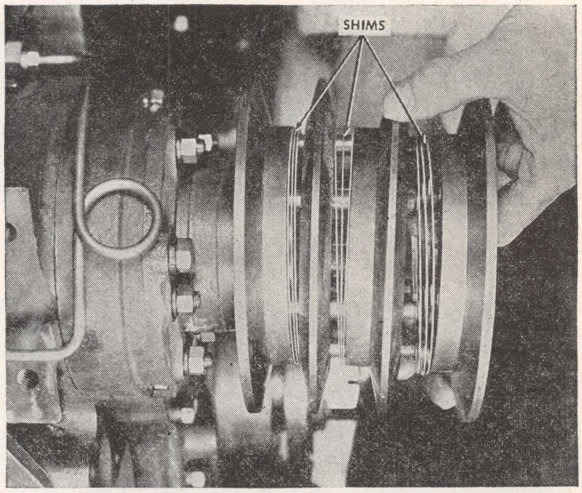


Fig. D. Models A and H. Supercharger drive pulley and shims.

Drive Unit, Remove:

1. Remove eight nuts and lockwashers from the face of the drive pulley.
2. Remove sheaves and shims, keeping them in proper sequence.
3. Remove cotter pins, nuts and washer from front of shaft.
4. Pull the driving sheave with puller. (Fig. B.)
5. Remove six nuts and lockwashers and one cap screw and lockwasher from packing ring.
6. Remove packing ring and rubber seal.
7. Remove four cap screws from rear bracket.
8. With a soft hammer, tap on the front end of the shaft and remove entire unit from gear case.

Gear Case Cover, Remove:

1. On supercharged engines it will be necessary to remove the supercharger drive unit described above, remove crankshaft pulley and pull flange from crankshaft. This flange is fitted to a taper.
2. Proceed with instructions for removing the cover as described for engines without supercharger.

SERVICE AND INSTALLATION OF SUPERCHARGER DRIVE UNIT

Disassembly:

1. Lift key from front of shaft.
2. Press on end of shaft to remove bracket and shaft from cage.
3. Remove cotter pin, nut and lockwasher from coupling end of shaft.
4. Pull coupling with suitable puller.
5. Remove coupling key from shaft.
6. Press shaft from bracket.
7. Remove snap ring and take bearing from bracket.
8. Press bearing from front of cage.

Assembly:

1. Inspect bearings for wear and replace if necessary.
2. Press bearings on shaft in correct position.
3. Assemble keys to shaft.
4. Inspect oil seals. If defective, replace.
5. Install inside snap ring in bracket.
6. Press shaft into bracket until bearing rests against snap ring.
7. Install outer snap ring in bracket.
8. Press coupling in place on shaft.
9. Assemble coupling washer and nut on shaft and lock with cotter pin.
10. Place cage gasket on bracket and press cage over large bearing until it seats on bracket.

NOTE—Make sure cap screw holes in cage, gasket and bracket are aligned.

11. Assemble unit to engine with new gasket.
12. Install the four cap screws which hold the unit to the gear case.
13. On Model H, place rubber seal over cage against gear case cover. (Fig. C.)
14. Assemble packing ring over studs, and tighten down with six lockwashers and nuts. Install one lockwasher and cap screw.
15. Place driving sheave on shaft with keyway in proper alignment with key. Pull on with suitable puller and lock with washer, nut and cotter pin.

CAUTION—The six bolts which hold the pulley together must be placed in position in the driving sheave before it is assembled to the shaft.

16. Assemble shims and sheaves. (Fig. D.)

NOTE—Drive belts must be assembled with sheaves and shims.

17. Place the lockwashers on the six bolts and start the nuts.
18. Tighten each nut one complete turn and then rotate engine one-half turn. Repeat these operations until pulley members are tight. Rotating the engine eliminates the possibility of the belts becoming pinched.

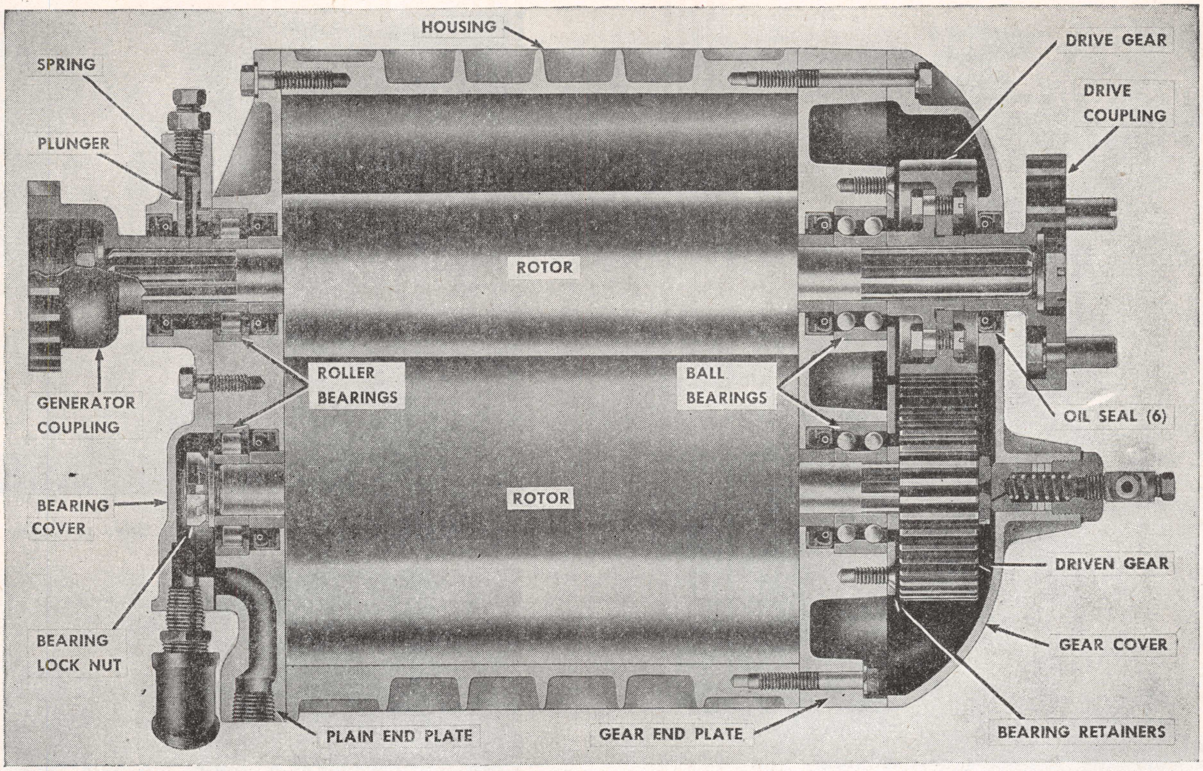

HOUSING
SPRING
PLUNGER
DRIVE GEAR
DRIVE COUPLING
ROTOR
GENERATOR COUPLING
ROLLER BEARINGS
BALL BEARINGS
OIL SEAL (6)
BEARING COVER
ROTOR
DRIVEN GEAR
BEARING LOCK NUT
GEAR COVER
PLAIN END PLATE
GEAR END PLATE
BEARING RETAINERS

Fig. E. Models A and H. Cross sectional view of supercharger.

GENERATOR DRIVE
COUPLING WRENCH
PULLER

Fig. F. Models A and H. Pulling generator drive sprocket.

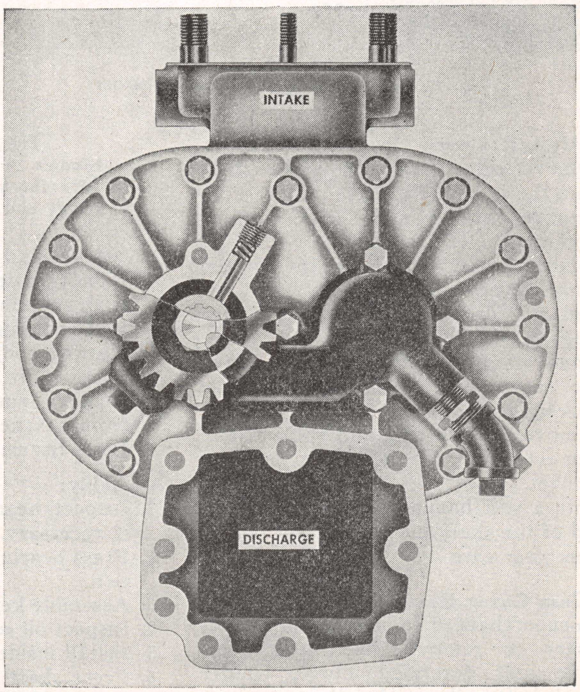

INTAKE
DISCHARGE

Fig. G. Models A and H. Supercharger oil metering pin.

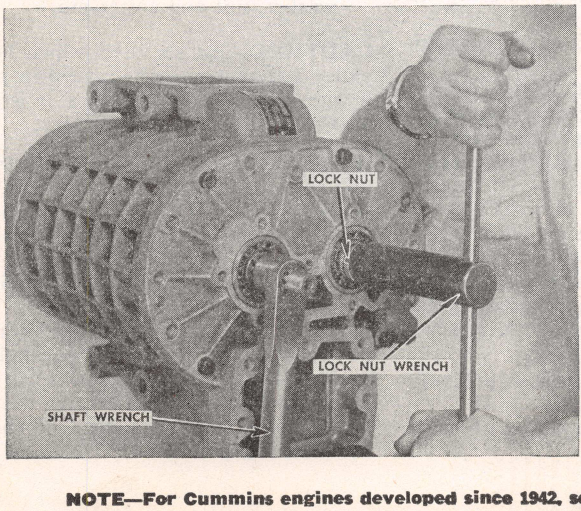

LOCK NUT
LOCK NUT WRENCH
SHAFT WRENCH

Fig. H. Models A and H. Removing supercharger bearing lock nuts.

Supercharger drive belts are tightened in the following manner:

1. Remove the nuts, lockplates, sheaves, shims and belts from the drive pulley.
2. Omit one shim from each section of the pulley and reassemble pulley as per instructions 16, 17, and 18 under ASSEMBLY OF SUPERCHARGER DRIVE UNIT.
3. Repeat the above procedure for further tightening if necessary.

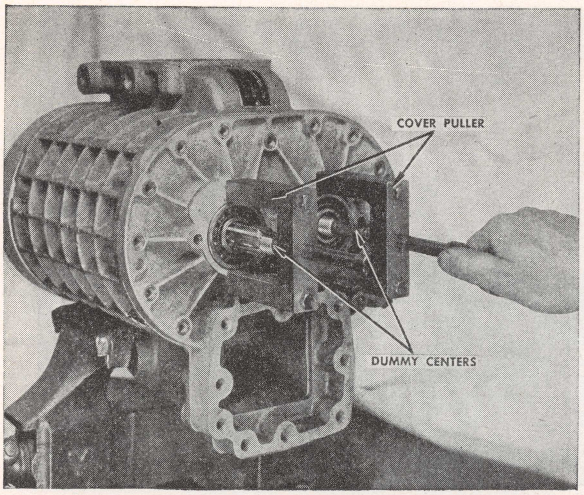


Fig. J. Models A and H. Pulling supercharger plain end plates.

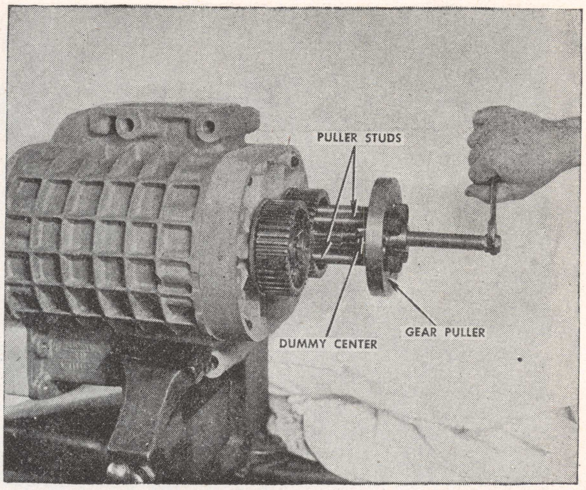


Fig. K. Models A and H. Pulling supercharger drive gear.

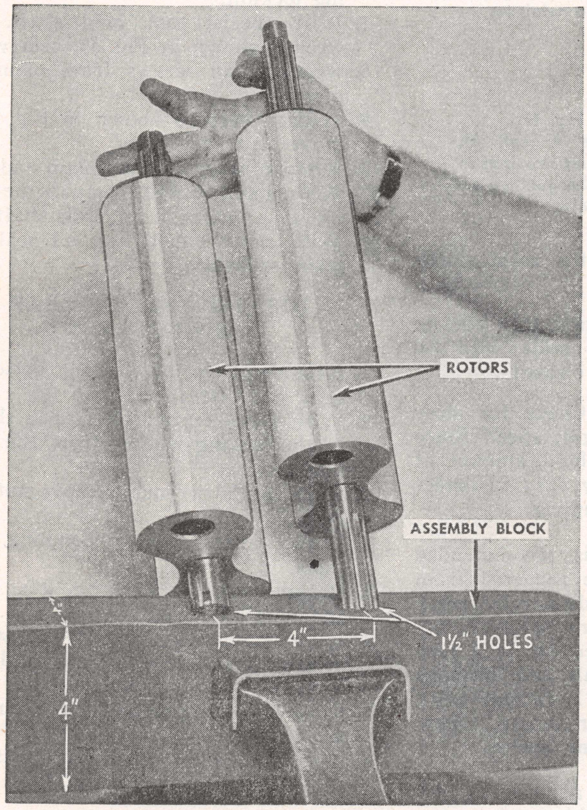


Fig. L. Models A and H. Supercharger rotors.

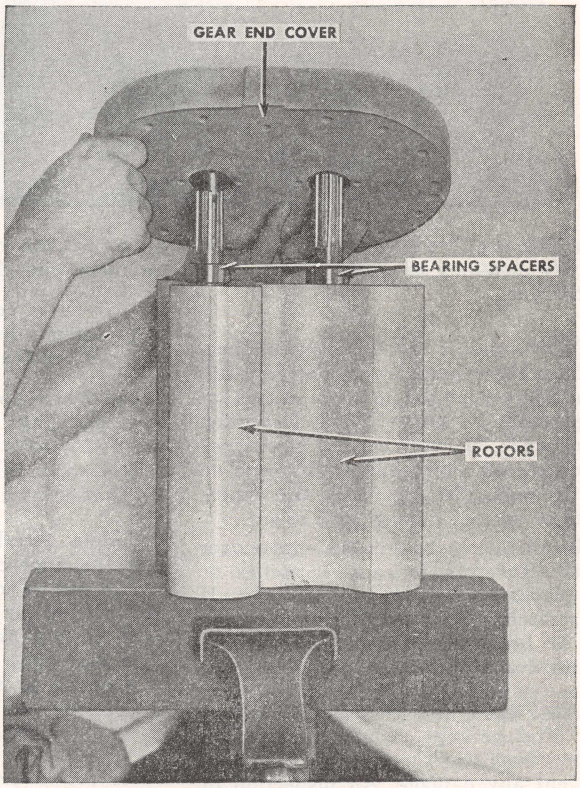


Fig. M. Models A & H. Installing supercharger gear end plate.

WARNING—Always make sure that each section of the drive pulley contains the same number of shims.

If one section should have less shims than the other two, then that particular groove would have a greater pitch diameter and consequently the belt running in that groove would be tighter than the other two. This means that the tightest belt would do all the driving until it was worn down to the same tension as the others. The rapid wear encountered under those conditions would make the belt practically useless.

NOTE—Do not destroy shims that are removed. Save them for further use.

SUPERCHARGER INSTRUCTIONS

The following instructions are prepared so that the operator may give the necessary inspection and care in replacing bearings and oil seals in the supercharger.

Other operations require special equipment and we recommend that for any major service the supercharger be returned to the nearest Cummins dealer.

All instructions and clearances given are for superchargers with aluminum rotors and housing.

PERIODIC INSPECTION

A periodic inspection of the supercharger should be made every 15,000 miles or 750 working hours without removal from engine.

Clean Supercharger: It is very important that the exterior of the supercharger be thoroughly cleaned before attempting any inspection. Wash thoroughly with kerosene or mineral spirits.

CAUTION—Do not use any solution that will damage aluminum or any other finished surfaces.

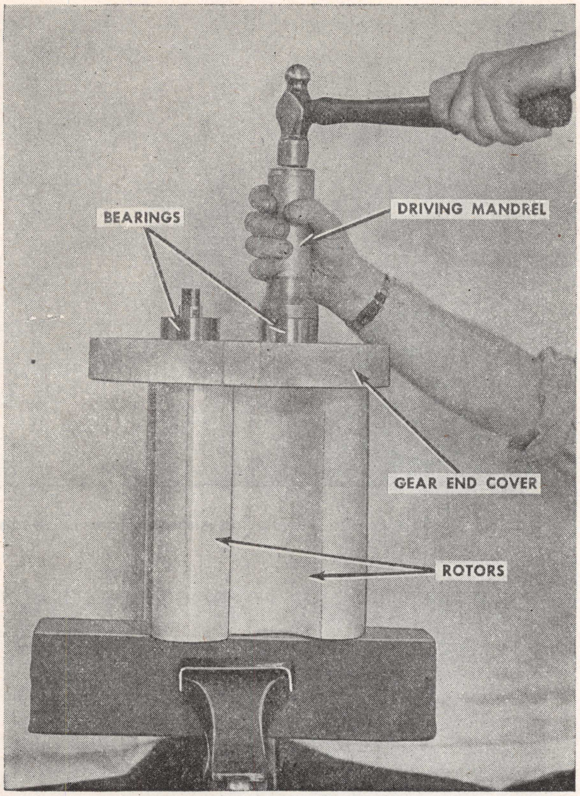


Fig. N.
Models A and H. Installing bearings in supercharger gear end plate.

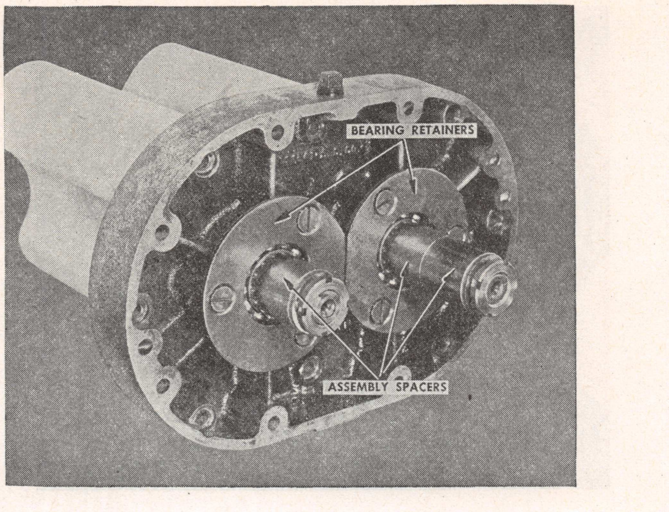


Fig. O.
Models A and H. Supercharger bearing retainers.

Inspect Rotors: Remove intake and discharge connections to expose interior of supercharger.

CAUTION—Before removing any connections from the supercharger, it is very important that precaution be taken to see that engine cannot be started while inspection is being made. Be very careful when connections are off supercharger that you do not drop rags, dirt, etc., into the supercharger or serious damage will result.

With suitable means turn the engine over and inspect rotors for any scratches or rough places created by grit and dirt. If deep scratches or marks are found on rotors or housing, return to the nearest Cummins dealer for repair.

Clean Air Filters: It is very important that the air filter be kept clean to receive full efficiency from the supercharger and also to prevent any damage. An inspection of the supercharger intake should be made to determine whether or not the oil from the air filter is being pulled over into the supercharger. This can be caused from overfilling of the air cleaner oil cup and overspeeding of the engine.

Leaking Oil Seals: To check for leaking oil seals, operate at idling speed for a few minutes.

WARNING—Before starting engine, be sure to remove rags, waste or any loose parts that are within range of supercharger suction.

Stop engine and examine inside of end-plates. Leaking seals will allow a film of oil to radiate out from the rotor shafts on these end-plates.

NOTE—It is very important that you do not confuse leaking oil seals with oil being pulled over from air cleaners.

Loose Drive Couplings: Check for loose drive couplings at low engine speed. Since the gears have only a slight amount of back lash, it will be very easy to detect any looseness in the coupling.

Complete Overhaul: It is recommended that the supercharger be removed from engine and be completely dismantled every 60,000 miles or 3,000 working hours regardless of previous inspection. It is very important that all oil seals and bearings be replaced at this time. If further work is necessary on the supercharger, return it to the nearest Cummins dealer.

Tools for Overhaul: In addition to the hand tools that are available to the average mechanic, certain special tools must be used in replacing bearings and oil seals in the supercharger. It is recommended that tools similar to those illustrated in the following text be used.

DISASSEMBLY OF PLAIN END-PLATE

1. Remove supercharger from engine.
2. Remove generator drive sprocket with special puller shown in Fig. F.
3. Remove lubricating oil line.
4. Remove lubricating oil inlet fitting, spring and metering pin or plunger as shown in Fig. E.
5. Remove cap screws from bearing retainer and take off retainer.
6. With small screwdriver, raise the ear of the locking washer from the bearing locknut.
7. With special tool, hold shaft. With wrench shown in Fig. H, remove nut.
8. Remove cap screws from plain end-plate.
9. With pullers as shown in Fig. J, remove plain end-plate.
10. Remove bearings from plain end-plate.
11. With small punch, remove the bearing inner races from each shaft.
12. With small punch, tap oil seal from plain end-plate.

DISASSEMBLY OF GEAR END-PLATES

1. Remove drain plug from bottom of gear end-plate and drain oil.
2. With small screwdriver, raise the ear of the locking washer from the coupling locknut.
3. With special wrench, remove nut from shaft.
4. With puller, remove coupling from shaft.
5. Remove cap screws from gear cover and take off cover.
6. Remove bearing locknut and washer in same manner as nut removed from opposite end of shaft.
7. Remove cotter pins and nuts from gear bolts.
8. Assemble puller studs to bolts and pull gears as shown in Fig. K.

CAUTION—Remove idler gear first.

WARNING—Never remove gears from hub. Always remove puller studs from bolts and assemble nuts and cotter pins in place.

9. With a block of wood tap ends of rotor shafts to remove rotors from housing.
10. Remove Allen head screws and cap screws from gear end housing.
11. With a clean block of wood, remove gear end-cover by tapping from within housing.
12. Remove flat head screws from bearing retainers and remove retainers.

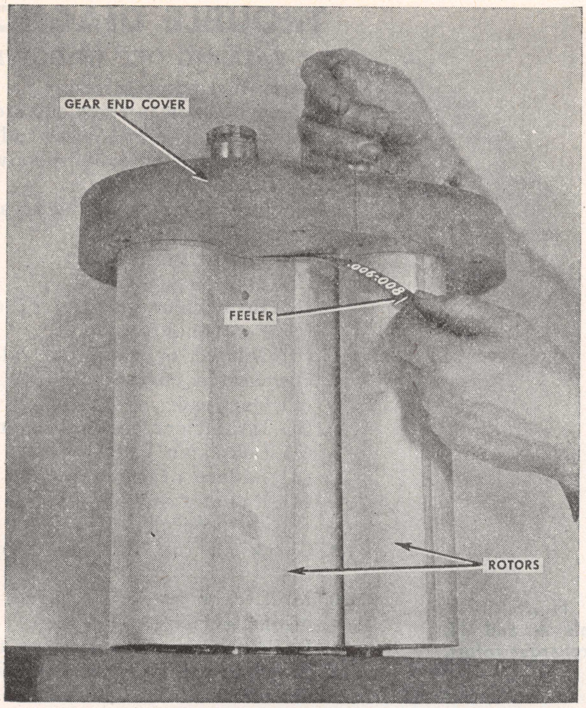


Fig. P. Models A and H. Checking supercharger gear and plate clearance.

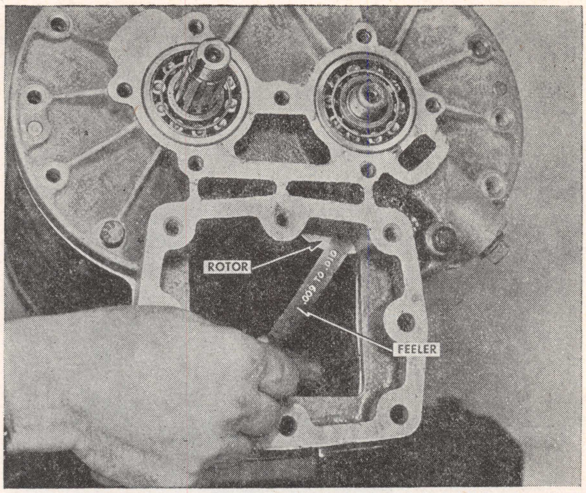


Fig. Q. Models A and H. Checking supercharger plain end plate clearance.

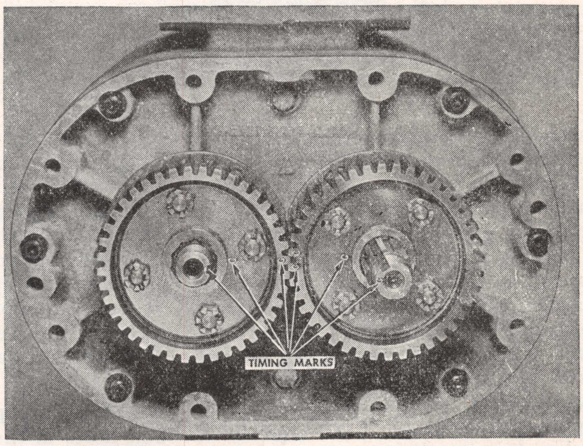


Fig. R. Models A and H. Supercharger gear timing marks.

13. Tap bearings from gear end-cover.
14. With small punch, remove oil seals from gear end-cover.

SERVICE AND ASSEMBLY OF SUPERCHARGER

1. Wash all parts thoroughly with kerosene or mineral spirits.

WARNING—Do not use any washing solution that is harmful to aluminum.

2. Inspect inside of housing for burrs and scratches.
3. Inspect rotors, end-plates and shafts for cracks, abrasions and cuts.

NOTE—If housing, end-plates and rotor assemblies are worn or scratched excessively, return the supercharger to your nearest Cummins dealer for repair.

4. Assemble rotors to a block of wood as shown in Fig. L.
5. Assemble new oil seals to gear cover with sealing lip pointing away from rotor.

CAUTION—Always use new oil seals when repairing supercharger.

6. Assemble gear cover to shaft as shown in Fig. M.
7. Assemble new bearings to shaft and cover as shown in Fig. N, with bearing name out.

CAUTION—Always use new bearings when repairing supercharger.

8. Assemble bearing retainers to housing with lock-washers and flat head screws as shown in Fig. O.
9. To check clearance between rotors and gear cover, place temporary assembling spacers to shafts and tighten in place as shown in Fig. O.
10. With feeler gauge check clearance between rotor and gear cover.

CAUTION—This clearance must be from .006″ to .008″. If excessive clearance is present, use thinner spacers between ball bearing and rotors. If clearance is too little, use thin shim washers to obtain proper clearance. Do not proceed further in assembly until .006″ to .008″ clearance is obtained. (Fig. P.)

11. Assemble rotors and gear cover to housing and secure in place with Allen head cap screws and lock-washers.
12. Assemble oil seals to plain end-plate with sealing lip pointing away from rotor.
13. Assemble plain end-plate to housing over dowel pins and secure in place with lockwashers and cap screws.
14. Assemble bearings to shaft with bearing name out.
15. Check rotor end clearance as shown in Fig. Q. This clearance must be from .009″ to .010″.

CAUTION—If this clearance cannot be attained, return supercharger to your nearest Cummins dealer for repair.

16. Assemble gears to shafts with timing marks in correct position as shown in Fig. R. In earlier superchargers, the letter "x" was used for timing marks.

CAUTION—Press on drive gear first. When pressing on gears always rest on opposite end of shaft.

17. Assemble clamp washer and lock washer. Tighten in place with shaft nut. Bend over ear of lockwasher into locknut groove.

CAUTION—Make certain that shaft does not extend more than 1/16″ beyond locknut, otherwise the oil plunger operation will be impaired.

NOTE—If new rotor assemblies or gears are necessary, return supercharger to nearest Cummins dealer.

18. Assemble new oil seal to gear cover, flush with outside face of cover. Sealing lip should be pointing toward rotors.
19. Assemble spring and oil plunger to cover in correct position, making sure small hole in bottom of plunger is clean.

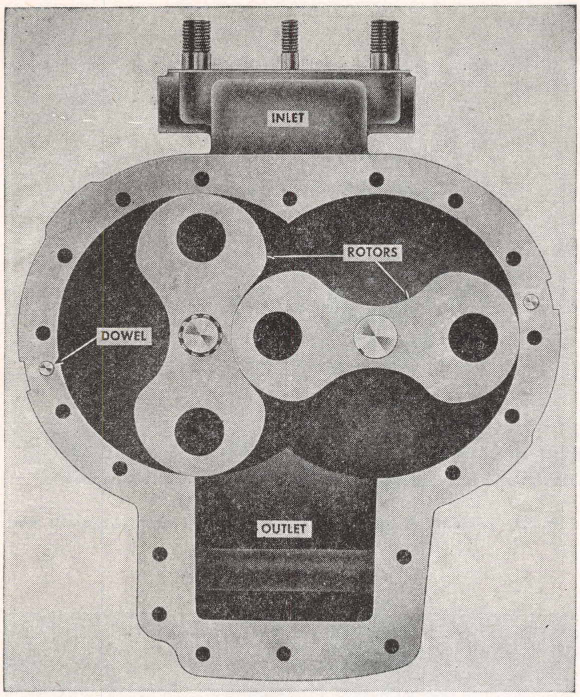


Fig. S.
Models A and H.
Supercharger rotors.

20. Assemble cover to supercharger using non-hardening gasket cement on cover gasket. Secure in place with lockwashers and cap screws.
21. On plain end assemble new oil seal to bearing cover.
22. Assemble bearing cover to supercharger using new gasket and non-hardening gasket cement. Secure in place with lockwashers and cap screws.
23. Assemble oil regulating pin to bearing cover. Assemble spring and oil supply fitting in place and assemble oil line to supercharger.
24. Press generator drive coupling to shaft.

CAUTION—When pressing on coupling always rest on opposite end of shaft.

25. Lock in place with clamp washer and lockwasher and then tighten nut.
26. Check plain end-plate clearance, as shown in Fig. Q. Manually rotate rotors to check for possible incorrect assembly.

INSTALLATION OF SUPERCHARGER

1. **At all times before final connection of outlet and inlet ends of manifolds to supercharger, the ports should be kept covered. Masking tape may be used. Do not stuff rags into inlet or outlet ports at any time as they might be left there on assembly to engine.**
2. It is important that the ports be kept closed as foreign matter or loose parts may enter, in which case damage will be caused when the supercharger is started.
3. Care must be given to the tightening of the mounting bolts of the supercharger. Extreme tightening will cause distortion in the housing which will cause rotors to scrape. When installing the supercharger on the engine the coupling flanges should mate properly, as excess misalignment might cause damage to the supercharger.
4. Lift supercharger to engine and engage coupling.
5. Start the upper left and lower right bolts to support the supercharger.
6. Start and tighten the upper right and lower left support bolts.

NOTE—The upper right and lower left bolt holes in the supercharger are reamed holes, and fit the support bolts snugly. A slight coating of oil on the bolts will ease their installation.

7. Tighten the other two support bolts.
8. Replace coupling chain.
9. Install generator. Make sure generator and supercharger couplings are properly aligned.
10. Install intake manifold in place, making sure expansion joint is properly assembled.
11. Tighten manifold clamps.
12. With gasket, assemble supercharger intake tube to supercharger, and tighten down with washers and nuts.
13. Reconnect drain tubes and drain cock spring.
14. Reconnect oil supply tubes.
15. Reconnect vapor tube to rocker housing.
16. Install air cleaner.

ELECTRIC SYSTEM

NOTE—For service information on Generators, Generator Regulators, Starting Motors and Starter Switches, see the Table of Contents on page 1.

TROUBLE DIAGNOSIS

FALLING OFF IN POWER

1. Dirty fuel pump screen.
2. Spray holes in injector cup stopped up.
3. Incorrect valve or injector adjustment.
4. Leaky intake or exhaust valves.
5. Low fuel oil pressure.
6. Air filter stopping up due to accumulation of dust and dirt.
7. Insufficient lubrication:
   (a) Low oil pressure.
   (b) Insufficient quantity of oil.
   (c) Poor quality of oil.
   (d) Diluted or worn out oil.
8. Overheated engine:
   (a) Overload.
   (b) Insufficient cooling water.
   (c) Loose fan belts.
   (d) Failure of water pump.
   (e) Radiator stopped up and not cooling properly.
9. Check all fuel lines for stoppage of fuel.
10. Muffler or silencer stopped up or of insufficient size.
11. Back pressure exhaust pipe too small.
12. Stuck piston rings or excessive cylinder wear.
13. Fuel pump distributor discs scored.
14. Improper grade of fuel.
15. Injector cup gasket leaking.

IF ENGINE STOPS

1. Roll engine over by hand to see if it is free.
2. Check fuel level in tank.
3. Obstructions or ice in fuel line cutting off flow of fuel.
4. Check oil level in crankcase.

FAILURE TO START

1. Check fuel level in tank.
2. No fuel pressure. (Fuel line broken or leaks at fittings.)
3. Emergency fuel shut off cock on fuel pump closed.
4. Fuel pump screen may be stopped.
5. Fuel lines full of air. Prime all lines.
6. Battery low, giving insufficient cranking speed.
7. In freezing weather, condensation may be frozen in fuel lines obstructing flow of fuel. Thaw fuel lines.

RUNNING OUT OF FUEL

When the engine runs out of fuel and the fuel supply has been replenished, proceed as follows:

1. Disconnect the fuel line on the pressure side of priming pump.
2. Work priming pump to remove all air from the lines to this point.
3. Connect fuel line and build up 60 pounds pressure on fuel gauge with priming pump.
4. Crank the engine with starter and continue to work the priming pump until the pressure pump starts to build up pressure.
5. To tell when the pressure pump is working, stop the priming pump and watch the fuel pressure gauge to see that it does not drop off in pressure immediately.

NOTE—For Cummins engines developed since 1942, see page 915.

6. When the engine starts after the fuel lines have been empty, it will knock and miss considerably for a short period of time until all the air in the lines has been expelled and solid fuel is going into the injectors.

ENGINE MISSING

1. Leaky check valve in injector or fuel inlet connection.
2. Dirty injector spray holes.
3. Spray tip off of injector cup.
4. Injector plunger sticking.
5. Valves sticking.
6. Valve clearance too close. Reset valves.
7. Valves leaking and need re-grinding and re-facing.
8. Air in fuel lines.
9. Water in fuel. Check filter and fuel supply tank.
10. Distributor disc scored.
11. Injector cup leaking.

ENGINE SMOKING

1. Dirty injector cup spray holes.
2. Valves leaking or clearances too close.
3. Valve clearances too wide. Re-check.
4. Injector adjustment set improperly.
5. Check all fuel lines to see that they lead to their proper connections.
6. Engine overloaded. Fuel setting has been altered. If more fuel is injected than the amount of air in the cylinder will support in combustion, the engine is being overloaded and surplus fuel will not burn.
7. Engine running too cool. Running temperatures should be 140° to 160° F.
8. Suction lines on fuel pump admitting air. Check fuel lines for leaks.
9. Scored distributor disc. If scored, bad leak will likely occur at top ⅛" pipe inspection hole in side of distributor housing when the plug is removed.
10. Injector plunger sticking. Refer to paragraph on injector plunger sticking.
11. Check valves leaking in fuel inlet connection or injector check valve.
12. Injector cup spray tip cracked.
13. Air cleaner stopped up.

ENGINE KNOCKS

1. Overloaded.
2. Dirty injector cup spray holes.
3. Air in fuel lines. Tighten all fuel lines and check for leaks.
4. Injector push rod bent because of improper injector adjustment and striking cylinder block.
5. Loose bearing.
6. Loose piston pins.
7. Piston slap, due to worn pistons and cylinder walls.
8. Loose flywheel.
9. Injector cup spray tip cracked.
10. Priming valve open.

ENGINE OVERHEATING

1. Insufficient amount of cooling water.
2. Stoppage of cooling system.
3. Insufficient amount or poor quality of lubricating oil.
4. Loose water pump belts.
5. Valve clearances improper. Re-check.
6. Overloading. Fuel pump seal has been broken.
7. Sludge or lime formation in water jacket.

LOCATING WEAK CYLINDER

Loosen the fuel supply line at the fuel inlet connection. This will cause the cylinder to miss.

Set the throttle to turn the engine about 700 to 800 RPM. Loosen each line separately and listen to the exhaust to see if any change occurs. Before proceeding to next cylinder, tighten fuel line again. Check all cylinders in this manner.

The following will cause a weak cylinder:

1. Check valve leaking in fuel inlet connection or injector.
2. Leaking or sticking valves.
3. Sticking injector plunger.
4. Injector spray hole stopped up.
5. Fuel inlet connection gasket leaking at injector body. Replace gasket.
6. Low compression caused by stuck rings. Check by turning engine over by hand.
7. Improper injector plunger adjustment.
8. Injector cup gasket leaking.
9. Scored distributor disc.

DILUTION OF LUBRICATING OIL

1. Stuck piston rings.
2. Overload. Fuel pump seal has been broken and more fuel is injected than will burn in the available air.
3. Injector cup gasket leaking. Cup leak can be detected by build up of fuel around the body, while it is in the cylinder head and the engine is running.
4. Fuel inlet or drain connections leaking.
5. Injector drain lines and manifold not draining properly to fuel pump.
6. Worn injector plungers permitting excess by-pass of fuel.
7. Vacuum in crankcase caused by air-tight or dirty breather cap. Use breather caps furnished by Cummins Engine Company.
8. Injector cup spray tip cracked.

LOW LUBRICATING OIL PRESSURE

1. Lubricating oil diluted.
2. Insufficient lubricating oil.
3. Loose suction line or defective gasket.
4. Gauge line stopped up. Remove and clean out.
5. Excessive wear in lubricating pump.
6. Loose engine bearings.
7. Insufficient amount or improper quality of lubricating oil.
8. Excessive oil leaks around valve rollers and rocker levers.

EXCESSIVE USE OF LUBRICATING OIL

1. Oil leaks. Check engine for external leaks.
2. Improper quality of lubricating oil.
3. Stuck piston rings.
4. Oil drain holes in piston stopped up.
5. Excessive wear on cylinder walls.
6. Scored piston or sleeve.
7. Injector shield left off and not keeping oil from going into injector drain.
8. Overload.
9. Injector rocker lever socket worn.
10. Injector plunger link worn.

AVOID DILUTION AND SLUDGE FORMATION

Dilution and sludge are enemies to any internal combustion engine. The Diesel engine is no exception.

1. Avoid idling for long periods.
2. Change oil according to your observations and working conditions. Each engine and its operation has its own lubricating problem and must be treated as such.
3. Use only a good quality of lubricating oil.
4. Flush engine with a good quality fuel oil. This must be done while the engine is hot to obtain satisfactory results. Dirt and sludge are hard to break loose when cold.
5. Use a good, clean fuel oil.
6. Keep injector cup spray holes open and spraying an even pattern.
7. Use proper size drill for cleaning the injector cup spray holes.
8. Use proper injector cup gaskets.
9. Keep injector adjusted according to instructions.
10. Use proper gaskets for the injector fuel inlet and drain connections. Check to see that they are tight.
11. Operating with stuck rings accumulates sludge rapidly.
12. Change lubricating oil filter.
13. Do not operate at overload.
14. Fuel pump setting too high.
15. Engine water temperature too low. Operating temperatures 140° to 160° F.

DROP IN FUEL PRESSURE

1. Improper quality of fuel oil.
2. Air leak in suction line. Examine closely for loose connections.
3. Fuel filter stopped up. Clean and drain regularly.
4. Congealed fuel in fuel lines.
5. Water in fuel freezing in cold weather.
6. Excessive wear in fuel gear pump.

STICKING INJECTOR PLUNGER

It is caused by one of the following:

1. Dirty or gummy fuel.
2. Fuel oil not having the proper viscosity or one that possesses no lubricating qualities.

Should it be necessary to use such a fuel oil until proper grade is obtained, add one quart of lubricating oil to every five gallons of fuel oil.

3. Uneven tension on the injector hold down nuts causing distortion in the injector body. Loosen the nuts and retighten evenly, as previously instructed. If this is causing the trouble, the plunger will return to its correct position immediately.

If the above methods do not correct the trouble, return the injector to the NEAREST CUMMINS DEALER FOR SERVICING.

4. Never interchange injector plungers and bodies. Injector plungers are not

sold separately as the fit required is so close that it is impractical to make them interchangeable.

A FEW DON'TS

1. Don't ream or lap injector plunger or body. Return to nearest Cummins' Dealer for service.
2. Don't run the engine with loose bearings.
3. Don't clean injector cups except when necessary. Use only drills furnished by Cummins Engine Company.
4. Don't use cheap or inferior lubricating oil.
5. Don't run the engine too cool. Keep the water temperature between 140° to 160° F.
6. Don't run the engine idle for long periods. Shut off unless it is working.
7. Don't operate at overload.
8. Don't operate on kerosene.
9. Don't tamper with the governor setting.
10. Don't tamper with the fuel pump seal. If this seal is broken it will void warranty.
11. Don't race the engine.

STARTING THE ENGINE

A and H: Fill the cooling system with clean soft water or cooling solution.

Fill the oil pan with oil as recommended, to high mark on bayonet gauge.

When the engine is started for the first time or has been standing for a long period, pump the fuel pressure to 60 or 70 pounds on the fuel pressure gauge with the fuel priming pump. This is done in order to prevent excessive cranking of the engine and running the chance of scoring the distributor discs.

Pull the idling control into running position and lock it.

Set throttle for half-speed.

When starting a new installation or engine in cold weather, release the clutch as this lightens the load on the starting motor.

A compression release is provided on the engine to relieve the pressure in the cylinder when turning the engine over to make valve and injector adjustments. This release can be used in case of a low battery or when the engine oil is stiff on a cold morning.

Release compression and start the engine spinning with the starting motor. When the engine has acquired the highest possible momentum, close the compression release and continue to hold the starter switch down until the engine fires.

CAUTION—If the engine does not start after approximately 30 seconds do not continue to crank. It is an indication that the fuel is not being delivered to the injectors. Before cranking any more, check all fuel lines and valves to see that your fuel is not shut off.

After starting the engine, check the following:

Lubricating Oil Pressure.
Fuel Oil Pressure.
Generator Charging Rate.

If engine should race intermittently without change of position of fuel throttle, it is an indication of air in the fuel lines. If engine continues to act in this manner, there is definite indication of an air leak in the suction line to the fuel pump. Correct this and pump the air out of the fuel lines as mentioned in PRIMING THE ENGINE.

After starting the engine in cold weather, it should be run until the lubricating oil is warm and is circulating freely as this insures longer life and lessens the danger of scored sleeves or pistons.

WARNING—Do not pull compression release lever when engine is running faster than idling speed or damage will result to the valves. Do not use shut off cock to stop engine except in case of engine runoff, or scored distributor discs will result.

PRIMING THE ENGINE

When the engine is started for the first time or after it has been overhauled, the fuel system will be dry and it will be necessary to prime all supply lines with clean fuel.

Check all lines leading to the engine to prevent any leaks.

Check the priming pump lines to make sure they are installed properly.

Disconnect all injector fuel supply tubes.

Open priming valve approximately two turns. This valve is solely for the purpose of priming, as it by-passes the fuel around the metering pump.

With the hand crank or other suitable means turn the engine over until the intake valve on No. 1 cylinder starts to open. Continue to turn the engine over until the mark "3 and 4 P.R." on the water pump drive pulley comes to the timing mark on the gear cover.

Work the priming pump until solid fuel appears at the loosened injector fuel inlet connection.

Tighten the fuel line on the cylinder just primed and give the primer one or two (no more) strokes. This pushes the solid fuel to the injector cup to prevent excessive cranking when you are ready to start the engine.

Turn the engine over until the next "P.R." mark on the water pump drive pulley indexes with the mark on the gear cover. This brings the cylinder listed next on the firing order to the correct position for priming. Prime this cylinder as previously instructed. It is necessary to prime each cylinder separately. Only one cylinder indexes at a time in the distributor to give a clear passage for the fuel.

After the injector supply lines are primed and tightened, close the priming valve.

CAUTION—Close priming valve by hand only. If valve turns hard, loosen packing nut or point of valve is likely to be broken.

WARNING—Do not attempt to run the engine with the priming valve open or serious damage will result.

With the priming valve open, a passage is formed directly from the fuel pressure pump to the injector. Since the fuel is coming directly from the pressure pump to the injector, the governor has absolutely no control over the fuel system. The pressure pump gives the injector an excessive charge of fuel each time the passages in the distributor index to supply fuel to each cylinder. This, in turn, makes the engine run at an excessive speed.

The only means of shutting the fuel off when the priming valve is open is by the emergency shut off.

NOTE—For Cummins engines developed since 1942, see page 915.

DODGE DIESEL ENGINES

Year	Engine Model ①	Number Cylinders and Valve Arrangement	Bore and Stroke	Displacement Cubic Inches	Compression Ratio	Taxable H. P.	Brake H. P. at R. P. M.	Maximum Torque at R. P. M. Pounds Feet	Oil Capacity Quarts
1939	T84	6-I	3¾x5	331.35	14.75	33.75	95@2600	226@1000	14
1940	T106	6-I	3¾x5	331.35	14.75	33.75	95@2600	226@1000	14
1941–46	T126	6-I	3¾x5	331.35	14.75	33.75	100@2600	240@1200	14

① Engine model is identified as being the prefix to the engine serial number. For example, T126–1001: T126 being the engine model.

TUNE UP CHART

Year	Engine Model	Firing Order	Injection Timing, Degrees	Nozzle Discharge Pressure, Lb. Sq. In.	High Idle Speed R. P. M. ①	Low Idle Speed R. P. M.	Valve Timing	
							Intake Opens, Degrees	Exhaust Closes, Degrees
1939–40	T84, T106	153624	②	2200④	2600	500	31BTDC	17ATDC
1941–46	T126	153624	③	2200④	2600	500	31BTDC	17ATDC

① Maximum governed speed—no load.

② For pump numbers 324 and below, 4½ degree BTDC: for pump numbers 325 and above, 14 degrees BTDC.

③ For pump numbers BBB-286-RR-032 or lower, 4½ degrees BTDC: for pump numbers BBB-286-RR-043 and higher, 14 degrees BTDC.

④ For new nozzles or nozzles with new springs. Nozzles which have been in use and having the same springs, 2,000 pounds, plus or minus 50.

VALVE SYSTEM

Year	Engine Model	Stem Clearance		Tappet Guide Clearance	Tappet Clearance				Valve Spring Pressure Test		Valve Seat Angle Degrees
					Running Hot		Timing				
		Intake	Exhaust		Intake	Exhaust	Intake	Exhaust	Free Length, Inches	Pounds at Inches, Length	
1939–46	All	.002–.004	.003–.005	.002–.004	.014	.014	.017	.017	I-2 5/16 O-2½	99@①	45

① Combined pressure of both springs when valve is open.

PISTON AND RING CLEARANCES

Year	Engine Model	Piston Skirt, Inches		Fitting Pistons with Shim and Spring Scale		Ring End Gap, Inch ①		Ring and Groove, Inch	
		Top	Bottom	Shim Thickness	Pounds Pull on Scale	Compression	Oil	Compression	Oil
1939–46	All	.003	.003	.003	12 to 15	.007–.017	.000	②	.002

① Ring end gaps are for cylinder bores without taper. Fit rings in tapered bores with not less than the maximum figure given.

② Top ring, .005″: second and third, .0035″.

ENGINE BEARING SPECIFICATIONS

Year	Engine Model	Camshaft		Connecting Rod			Mains				
		Journal Diameter	Clearance	Journal Diameter	Clearance	Bearing Bolt Tension Lb. Ft.	Journal Diameter	Clearance	Bearing Bolt Tension Lb. Ft.	Thrust on No.	End-play
1939–46	All	③	.002–.004	2.3115–2.3125	.001–.003	53–57	2.999–3.000	.002–.004	75–80	7	.004–.008

③ No. 1, 2¼″. No. 2, 2⁵⁄₃₂″. No. 3, 2⅛″. No. 4, 1⅝″.

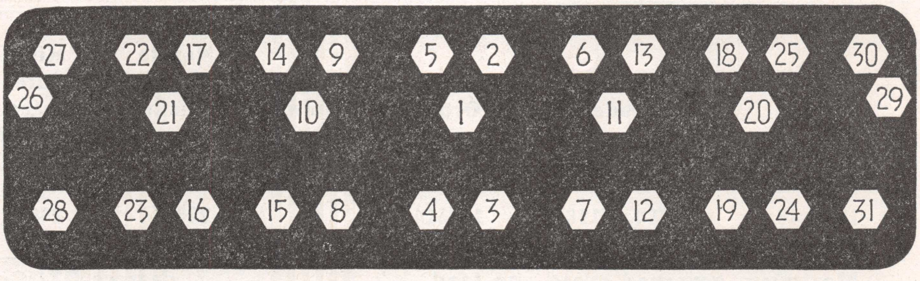
ENGINE

NOTE—For detailed information on Diesel Fuel Injection Systems, see the Table of Contents on page 1.

NOTE—See Trouble Diagnosis data at the end of this chapter.

CYLINDER HEAD

1939-46: When installing a cylinder head always use a new gasket. Make sure the gasket, cylinder head and cylinder block are entirely free from carbon and dirt. Tighten cylinder head nuts in the sequence shown in illustration, drawing them down evenly with a tension indicating wrench until each nut has been tightened to a definite tension of 80 to 85 lbs.

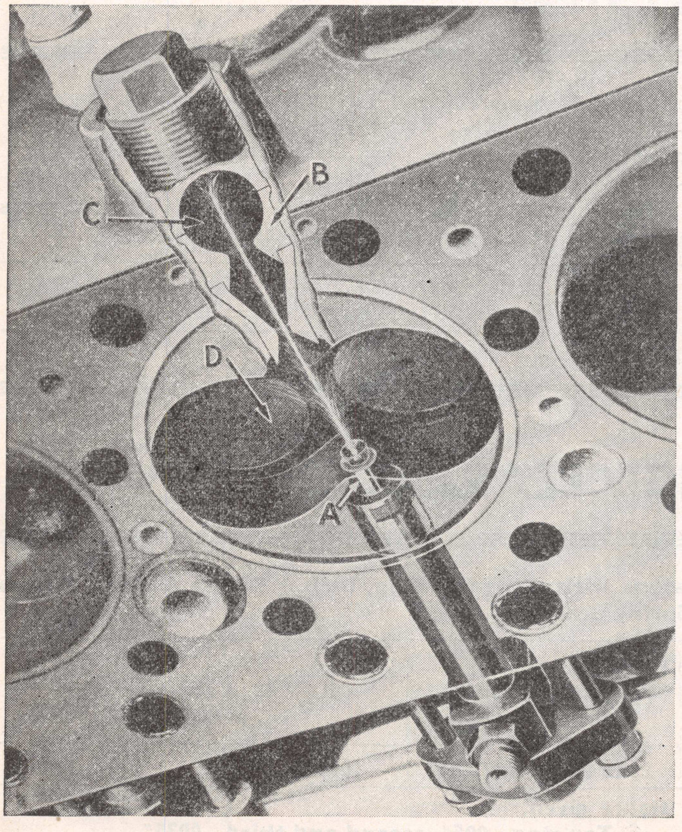


Cylinder head tightening sequence. 1939-46.

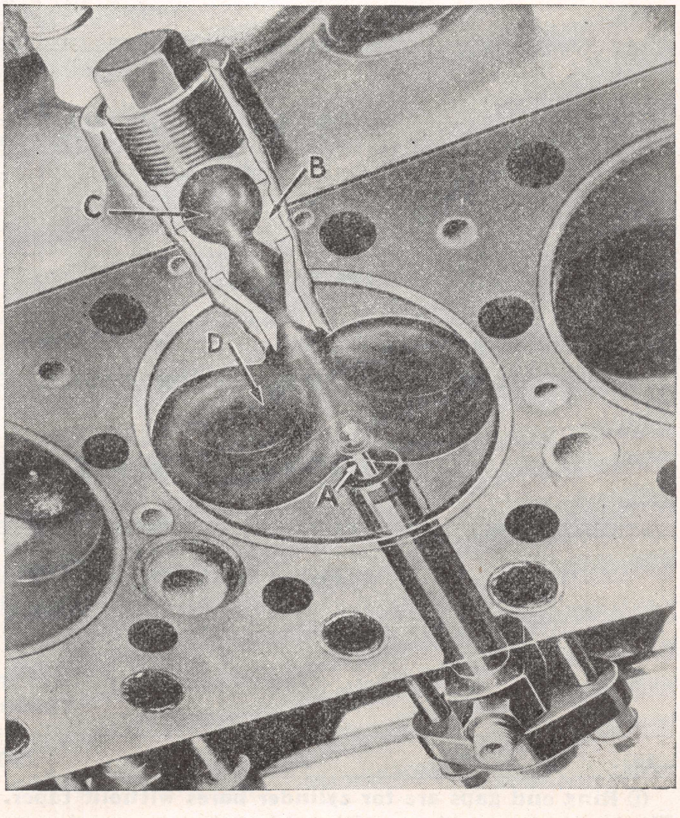
NOTE—Two tension figures are usually given as above. The lower one is for clean and oily threads and the higher limit for clean and dry threads. In every case the threads should be free from rust or dirt, otherwise a false reading would be obtained due to the increased friction. Always re-check the valve timing and valve tappet clearance after the head has been finally tightened on a hot engine.

CYLINDER HEAD ENERGY CELLS

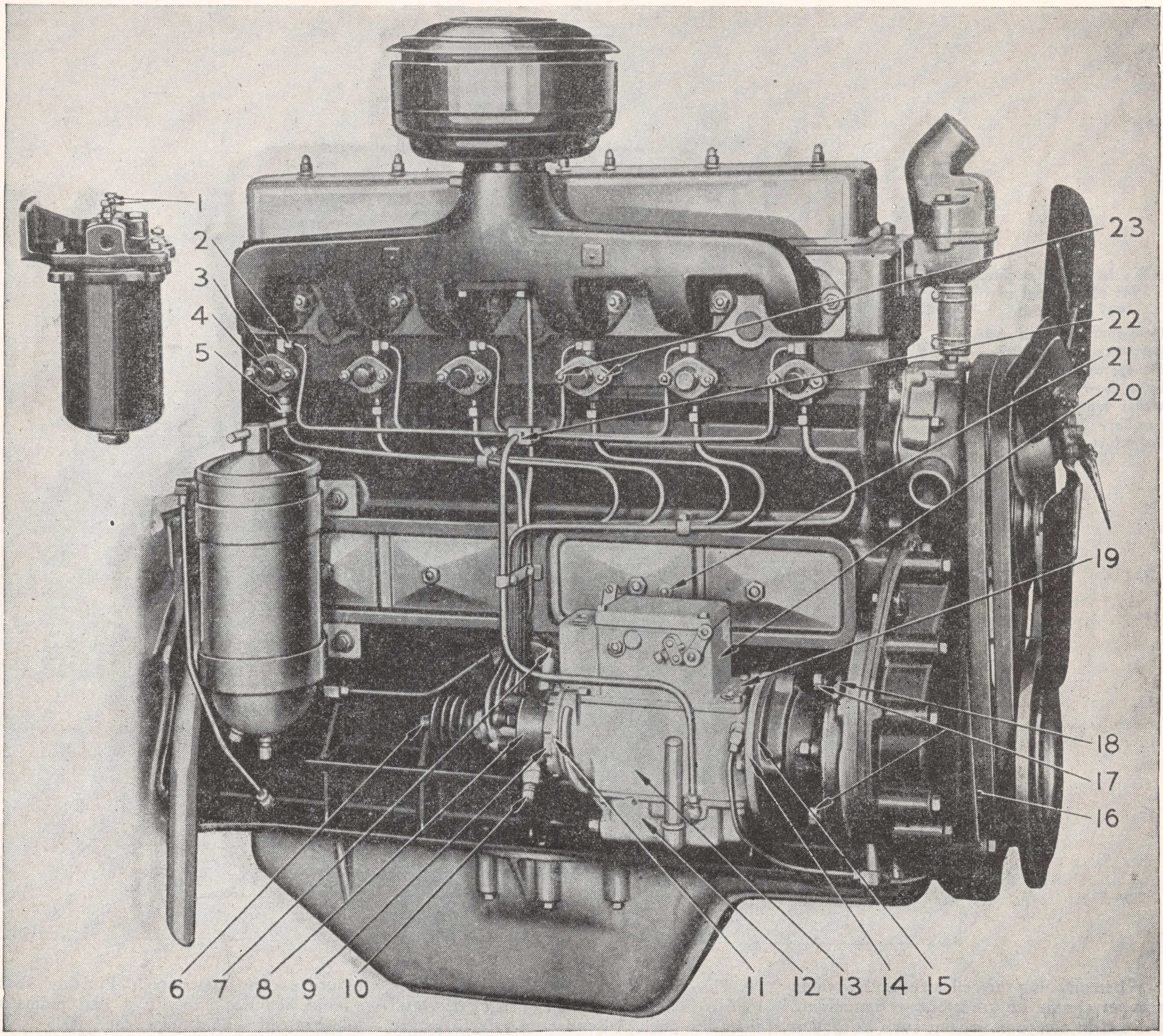
1939-46: The energy cells are located in the cylinder head directly opposite the fuel in-



FUEL INJECTION. 1939-46.



FUEL BURNING. 1939-46.



Right side view of engine. 1941-46. Typical of 1939-40 models.

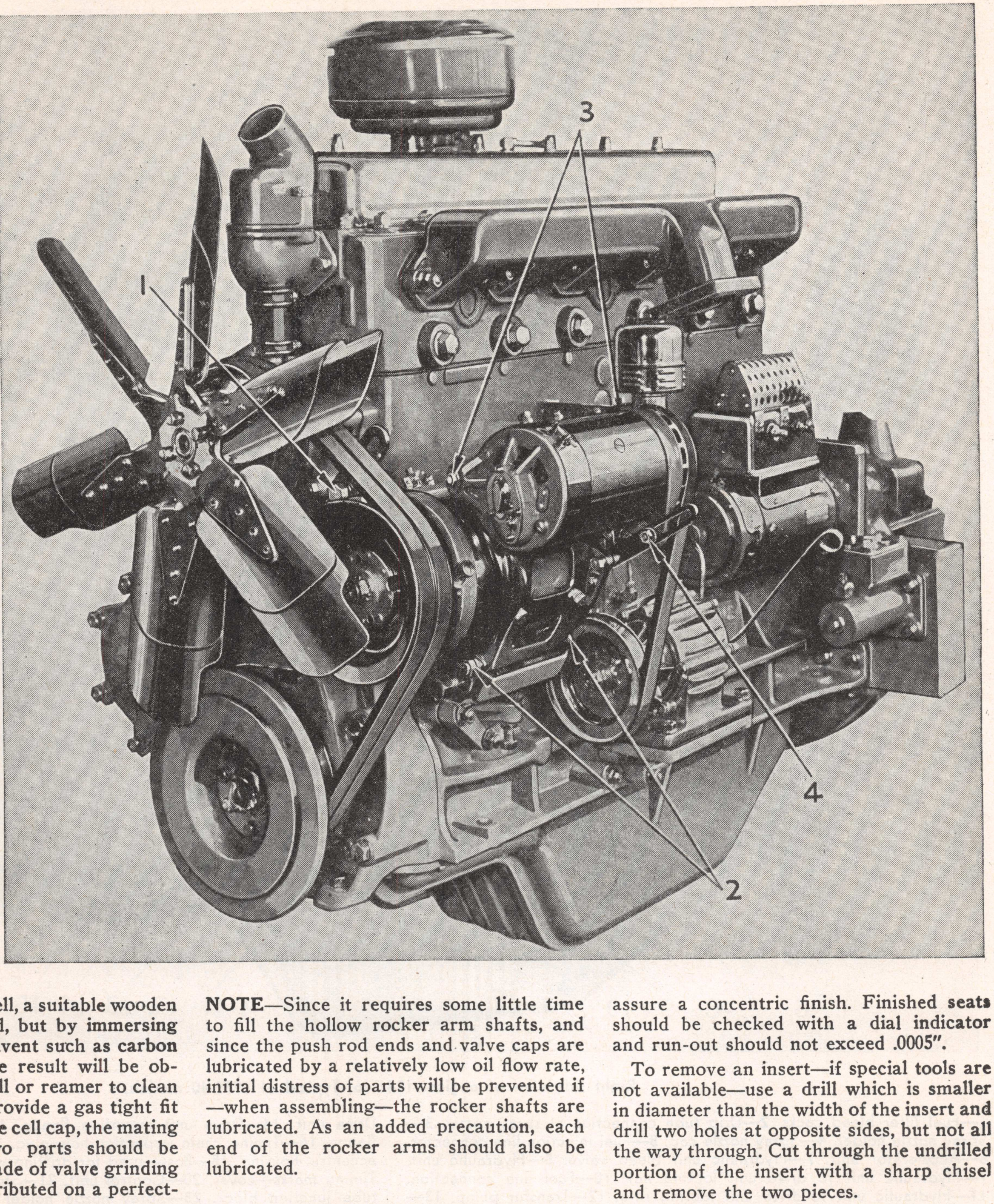
1—Fuel filter bleed cocks. 2—Drip tube connection at spray nozzle. 3—Spray nozzle holder. 4—Spray nozzle cap. 5—Fuel injection line connector. 6—Accelerator unit. 7—Hydraulic unit bleed valve. 8—Hydraulic unit. 9—Hydraulic unit to drive unit locking nut. 10—Fuel line connection. 11—Hydraulic unit to drive unit locking ring. 12—Transfer pump. 13—Drive unit. 14—Drive unit mounting flange. 15—Drive unit companion flange. 16—Timing chain inspection hole plug. 17—Fuel pump drive shaft eccentric housing. 18—Boss—used for drifting when adjusting chain. 19—Timing marks—cover. 20—Control unit. 21—Stop control lever. 22—Drip tube junction block. 23—Spray nozzle holder nuts.

jection nozzles. The primary purpose of the cells is to increase turbulence and control combustion. When the cell is charged with fuel from the injection nozzle, the initial combustion takes place in the main combustion chamber. The fuel in the inner chamber of the cell is partially burned, developing high pressures, which causes the remainder of the fuel to return to the main chamber. This action creates intense turbulence, insuring complete burning of the entire fuel charge. At the same time, the rate of burning is controlled so that high pressures on the piston are avoided.

The energy cell is made in three pieces and held in place by a large retaining plug. All joints of the cell are **ground** to a perfect finish. If the cell is removed for cleaning, or any other purpose, all parts of the cell and the cavity in the cylinder head must be thoroughly cleaned of carbon, and the cell reseated in the cylinder head by grinding with a very fine compound.

To remove the energy cell, remove the retaining plug, then remove the injection nozzle. With a pointed piece of 7/32" brass rod inserted through the spray nozzle opening, drift the cell out of the cylinder head. When an engine has been in service for a considerable length of time, the energy cells may not drift out easily. In such cases, penetrating oil applied to the outer end of the cell, after the retaining plug has been removed, will help to free the cell in the block. Excessive drifting on the inner end of the cell will ruin the operation of the cell and also make removal still more difficult by expanding the end.

NOTE—When the energy cell is replaced, the retaining plug should be properly **but not over tightened.** A leak at the retaining plug would be due to improper seating of the cell joint or the cell in cylinder head, and could not be eliminated by excessive tightening of the retaining plug.



Left side view of engine. 1941-46. Typical of 1939-40 models.

1—Generator belt adjusting strap bolt. 2—Generator bracket hinge bolts. 3—Auxiliary generator hinge bolts. 4—Auxiliary generator adjusting strap bolt.

When cleaning the cell, a suitable wooden scraper should be used, but by immersing the cell in a carbon solvent such as carbon tetrachloride, the same result will be obtained. Never use a drill or reamer to clean the small orifice. To provide a gas tight fit between the cell and the cell cap, the mating surfaces of these two parts should be lapped, using a fine grade of valve grinding compound, evenly distributed on a perfectly flat lapping plate.

ROCKER ARMS

1939-46: When disassembling rocker arm assemblies, place all parts on the bench in their proper relationship to assure correct assembly. To prevent the possibility of bending or twisting push rods, they should be removed before taking off the cylinder head, and replaced after the head is installed.

Before assembling rocker arms, always check the end surfaces of the valve stem and the push rod seats to make sure that they are not pitted or rough. If worn or pitted, it will be difficult to maintain proper running clearance.

NOTE—Since it requires some little time to fill the hollow rocker arm shafts, and since the push rod ends and valve caps are lubricated by a relatively low oil flow rate, initial distress of parts will be prevented if —when assembling—the rocker shafts are lubricated. As an added precaution, each end of the rocker arms should also be lubricated.

VALVE SPRINGS

1939-46: Valve springs should be tested every time they are removed. See the VALVE SYSTEM table for the correct free length of the springs and for test specifications.

EXHAUST VALVE SEAT INSERTS

1939-46: Since these inserts are too hard to reface by the ordinary grinding methods, a high-speed grinding stone or a special lapping tool should be used to perform this operation. When using this equipment, be sure valve guides are clean and that the valve guide pilot is a snug fit in order to assure a concentric finish. Finished seats should be checked with a dial indicator and run-out should not exceed .0005".

To remove an insert—if special tools are not available—use a drill which is smaller in diameter than the width of the insert and drill two holes at opposite sides, but not all the way through. Cut through the undrilled portion of the insert with a sharp chisel and remove the two pieces.

To install an insert, pack in "dry ice" for at least fifteen minutes to allow the metal to contract, and heat the exhaust valve port area gradually, if necessary, to permit this material to expand. Then press the insert into the cylinder head, using extreme care to see that it is not cocked or misaligned. When installed, finish the seats with the grinding or lapping equipment already mentioned.

NOTE—Should an insert become loose, a .010" oversize insert is available. Suitable counterboring equipment should be used to cut the insert bore to accommodate the oversize insert.

VALVE STEM GUIDES

1939-46: It is good practice to remove and install one guide at a time. When installing an intake guide, measure the depth of an intake guide not yet removed in order to determine the correct depth of the guide being installed. The same procedure should be followed when replacing exhaust guides. When installed, the guides should be reamed to provide a clearance within the limits given in the VALVE SYSTEM table.

VALVE TAPPETS AND GUIDES

1939-46: The valve tappets must be a free fit in their guides yet without excessive side play. Valve tappet wear on these engines is very low but if the valve tappets have to be removed for the purposes of replacement, it can be done in the following manner. Remove the valve tappet cover plates. Remove the valve push rods. If the cylinder head has already been removed, the push rods will naturally be out of the way. If not, loosen up the valve tappet adjustment sufficiently to slip the valve push rods out from under the valve rocker arms. Push rods must be withdrawn from the top of the engine after the valve rocker arm cover has been removed.

Then turn the engine over until all the valve tappets in one of the two banks are loose. Remove the two cap screws which hold the valve tappet guide bank in place. Then the valve guide assembly can be withdrawn through the cover plate opening. If the valve tappets are too loose a fit in this valve guide assembly, it is probably most economical to install an entire new assembly with new properly fitted tappets.

NOTE—This same procedure must be followed whenever the camshaft has to be removed, since the valve tappets interfere with the removal of the camshaft if they are not lifted out of the way before the camshaft is withdrawn.

VALVE TIMING

1939-46: Intake opens 31 degrees before TDC and exhaust closes 17 degrees after TDC. Check the timing with the engine at normal room temperature and the tappet clearance at .017". Then crank the engine until No. 1 piston is coming up on its exhaust stroke and stop when the 31 degree mark before TDC on the vibration damper is in line with the indicator. In this position, No. 1 intake valve should be tight against the valve stem. Continue cranking the engine until the 17 degree after TDC mark on the damper is in line with the pointer; at this point, the No. 1 exhaust tappet should just begin to leave the end of the valve stem.

NOTE—If the engine is cranked, or any attempt is made to operate the engine with the camshaft far out of time, the lobes on the piston head will strike the open valves, resulting in serious damage. See TIMING CHAIN for correct valve timing and chain adjustment.

TIMING CHAIN

1939-46: If necessary to reset the camshaft for correct valve timing, remove the chain case cover and loosen the chain to the limit of adjustment. Then set No. 6 piston at the top of its compression stroke. With the crankshaft sprocket in that position, a zero mark will be found on the sprocket tooth which is on the center line between the crankshaft and camshaft. With the timing chain off the camshaft sprocket, rotate the camshaft until the zero mark on that sprocket lines up with the zero mark on the crankshaft sprocket. With both marks definitely on a line between the centers of their respective shafts, install and adjust the timing chain.

TIMING CHAIN, ADJUST

1939-46: Adjust timing chain by rotating the eccentric housing of the fuel injection pump drive shaft. Loosen the five nuts that hold the housing to the chain case. Rotate top of housing flange away from the engine to tighten chain and toward the engine to loosen chain.

Adjust chain so it can be deflected by hand ⅛" at the center of the span between the fuel pump drive sprocket and the crankshaft sprocket. Use inspection hole in front of chain case cover to check adjustment made with cover on. Check and reset fuel pump timing after adjusting chain.

CAMSHAFT, REMOVE

1939-46: To remove the camshaft, the following procedure should be followed.

1. Remove the crankshaft vibration damper.
2. Remove the oil pan.
3. Remove the oil pump and screen.
4. Remove the oil pump drive shaft by removing the upper support screw.
5. Remove the valve tappet cover plate.
6. Remove the valve tappets as explained under Valve Tappet Guides.
7. Place a jack under the front end of the engine and remove the timing chain case cover.
8. Loosen up the timing chain by turning the eccentric housing of the fuel injection pump shaft toward the crankcase.
9. Unbolt the camshaft sprocket and then remove timing chain and sprocket.
10. Remove the camshaft sprocket hub thrust plate screws and withdraw the cam shaft.

NOTE—Be very careful not to nick the camshaft bearings with the sharp edges of the cams as the shaft is being withdrawn.

CAMSHAFT & BEARINGS

1939-46: The camshaft end thrust is controlled by a steel thrust plate bolted to the cylinder block behind the camshaft sprocket hub. The end play should be held to within .003" and .005". This end play can be checked by pulling the hub out as far as possible and then inserting a feeler gauge between the base of the hub and the thrust plate on the front end of the engine.

All camshaft bearings, except the rear, are removable and seldom if ever have to be replaced. If the bearing clearance is excessive, new bearings may be pressed in place after the worn camshaft bearings have been pulled out. Replacement bearings are finished to such close limits when manufactured so that they do not require reaming, scraping or burnishing when installed.

PISTONS & RODS, REMOVE

1939-46: Pistons and rods are removable through the top of the cylinder bores. Although regular production rods are marked with the cylinder number in which they are installed, replacement rods are not. Therefore, unmarked rods should be suitably identified with punch marks, as removed.

PISTON & ROD, ASSEMBLE

1939-46: Assemble the connecting rod to the piston so that the oil spurt hole in the rod will face the camshaft side of the engine.

The top of the piston is designed to control combustion by concentrating the mass of air at the center of the combustion chamber where the fuel is injected. These lobes or raised surfaces must register with the depressions in the cylinder head so that the widest distance between the lobes face toward the injection nozzles.

PISTONS, RENEW

1939-46: NOTE—A variation of 10 degrees between the temperature of the pistons and cylinder bores is sufficient to produce a difference of .0005". Therefore, both the pistons and cylinder bores should be at normal room temperature (about 70 degrees) when fitting pistons. This is particularly important because the clearances given in the PISTON & RING CLEARANCES table are minimum and pistons must not be fitted with less than specified.

Before any attempt is made to fit new pistons, cylinder bores should be carefully indicated and refinished. If bores do not require refinishing, be sure to remove the ridge at the top of each bore. If refinishing is required, it is good practice to do so in alternate cylinders due to the localized temperature build-up. Cylinder bores should not be out-of-round or tapered more than .0005".

Before fitting pistons, wipe the cylinder walls and pistons to remove all chips, dirt or other foreign matter. The feeler ribbon used to check piston fit should be about 12" long and ½" wide. Consult the PISTON & RING CLEARANCES table for the thickness of shim to use, as well as the recommended pounds pull on a spring scale required to withdraw the feeler ribbon past the piston.

Insert the piston in the bore upside down and in its running position (see PISTON & ROD, ASSEMBLE). Place the feeler ribbon between the cylinder wall and the thrust side of the piston (opposite slotted side) in a position at right angles to the piston pin hole.

After assembling the piston to the connecting rod, check the assembly for alignment on a suitable jig.

PISTON RINGS, RENEW

1939-46: NOTE—To prevent the possibility of bending or breaking the second ring land—thus ruining the piston—the ridge at the top of the cylinder bore should be cut away before removing the piston and rod assemblies. If the available ridge reamer has no provision to control the depth of the cut, it is good practice to bring the piston far enough up into the cylinder to allow the reamer to rest on top of the piston. This will serve to prevent cutting down into the ring travel area.

CAUTION—Never cut down into the ring travel area more than 1/32"—or more than half the depth of the top ring.

New rings should be fitted with end gaps and groove clearances as given in the PISTON & RING CLEARANCES table. Ring grooves must be clean and free from carbon, and must show no perceptible wear.

NOTE—Ring end gaps given in the PISTON & RING CLEARANCES table are for cylinder bores without taper. Fit rings in tapered bores with not less than the maximum dimension given. Pay particular attention to the installation instructions which are usually included in the ring package. This applies to clearances, position in grooves, etc.

When rings are properly fitted to the pistons, be sure to stagger the ring gaps so they are spaced equal distances around the circumference of the piston. However, see that no gaps are over the piston pins.

PISTON PINS, RENEW

1939-46: The correct fit of piston pins should be one which, at normal room temperature, requires a hard push with the palm of the hand to install the pin. However, to facilitate fitting pins, heat the piston in water to about 130 degree F. after which, the pin should enter the piston easily.

These pins are of the full-floating type, being held in place by snap rings in the grooves of the piston bosses.

PISTON PIN BUSHINGS, RENEW

1939-46: New bushings should be pressed in place and reamed to provide a light push fit of the pin with the parts at normal room temperature. When installed, be sure the oil hole in the bushing lines up with the hole in the connecting rod.

CONNECTING ROD BEARINGS, RENEW

1939-46: These engines are equipped with the precision insert type bearing which may be replaced by simply taking off the bearing cap and slip the old shells out and the new ones in. Bearings should be replaced in sets and under no circumstances should rods or caps be filed, altered or mutilated in any way in an attempt to obtain proper bearing fit.

NOTE—Before replacing bearings, make sure that the crankpins are not nicked or scored, and that all parts are thoroughly clean. This is particularly important because the presence of one small particle of metal, carbon or other foreign matter, lodged between the back of the bearing and the rod, or between the face of the bearing and the crankpin, will very likely cause a hot spot due to the elimination of the oil clearance at that point, eventually resulting in a bearing failure or a scored crankpin.

CAUTION—These bearings are designed for use without shims and under no circumstances should shims be used in an attempt to obtain a bearing fit, because the proper "crush" fit of the bearings in the connecting rod bores will not be obtained.

To check the fit of new bearings, use a piece of brass shim stock ¼" wide, the length of which should be ¼" less than the length of the bearing, while the thickness should be approximately the same as the minimum allowable clearance.

CAUTION—To avoid damaging the bearing material, smooth down the edges of the shim stock on an oil stone so that no sharp edges remain. Install the shim between the bearing and the crankpin, in the center of the bearing, then tighten the cap bolts to the recommended torque tension. When fitted properly, it should not be possible to move the rod endwise by hand, but a light tap with a hammer should cause the rod to more endwise. Then remove the checking shim and re-install the cap, tightening the cap bolts with a torque wrench, after which the rod should move endwise by hand. If the rod is too loose with the checking shim in place, the crankpin should be turned down and undersize bearings fitted.

MAIN BEARINGS, RENEW

1939-46: NOTE—Before replacing bearings, make sure that the crankshaft journals are not nicked or scored. Use care also, to see that all parts are thoroughly clean. This is particularly important because one small particle of metal, carbon, dirt or other foreign matter, lodged between the back of the bearing and the rod, or between the bearing face and the crankshaft journal, will very likely cause a hot spot due to the elimination of the oil clearance at that point, eventually resulting in a bearing failure or a scored journal.

When bearings become worn, they can be replaced without removing the crankshaft in the following manner: Remove the bearing cap and take out the worn lower shell. A suitable tool can be made to remove the upper shell by using a cotter pin with the rounded end flattened to form a T shape. Insert the long end of the pin in the oil passage hole in the crankshaft journal and, by rotating the crankshaft in the reverse direction, the T-shaped head will contact the bearing and force it out.

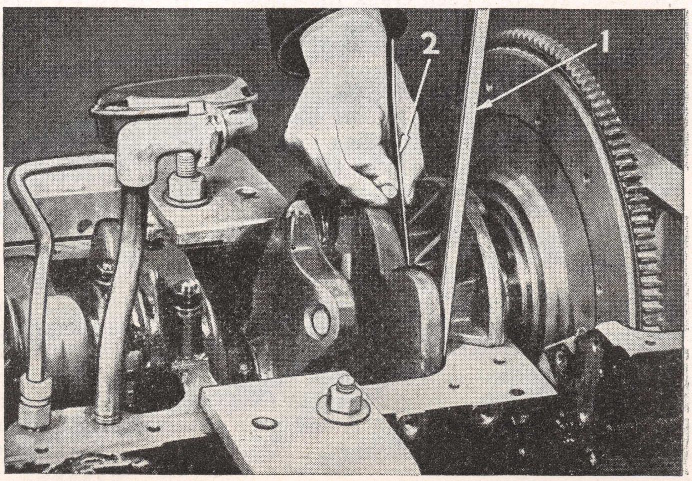
To install, place a new upper shell on the crankshaft journal with the locating notch in the correct position and rotate the shaft to turn the shell in place. Then install the lower shell in the cap and replace the cap, tightening the cap bolts to the recommended torque tension which will be found in the ENGINE BEARING SPECIFICATIONS table.

NOTE—Bearings should be replaced in sets and under no circumstances should any attempt be made to shim, file, alter or otherwise mutilate the bearing caps to obtain proper bearing fit.

To check the fit of new bearings, use a piece of brass shim stock ¼" wide, the length of which should be ¼" less than the length of the bearing, while the thickness should be about the same as the minimum allowable clearance.

CAUTION—To avoid damaging the bearing material, smooth down the edges of the shim stock to remove sharp edges or turned over corners. And before inserting it in place, coat the shim on both sides with a light film of engine oil.

Then lay the shim lengthwise in the center of the bearing and install the bearing cap to the crankshaft, tightening the cap bolts to the recommended torque tension. Test the fit of the bearing by rocking the



Checking crankshaft end play. 1939-46.

1—Pry bar. 2—Feeler gauge

flywheel through an arc of 2"—not more than 1" in either direction. The bearing may be considered fitted properly if the shaft is movable with a fairly heavy drag.

NOTE—Remove the checking shim and replace the cap, but do not tighten the cap bolts, as this bearing must be loose in order to check the fit of the other bearings. It is good practice to fit bearings by starting at the center, then the rear bearing, front bearing, and finally, the intermediates.

CRANKSHAFT END THRUST

1939-46: Crankshaft end thrust is controlled by flanges on the rear main bearing. Through normal wear, the end play will seldom become excessive but whenever new bearings are fitted, the clearances should be carefully checked and, if required, the bearing flanges may be dressed down to obtain the desired end play.

REAR MAIN BEARING OIL SEAL

1939-46: The rear main bearing support is provided with packing which forms an oil seal at the outer end of the shaft. In addition, an oil slinger, integral with crankshaft, deflects the major portion of the oil into the groove of the bearing cap and support.

NOTE—If it is necessary to replace the packing in the upper half of the rear main bearing, the crankshaft must be removed from the engine and the packing installed in the same manner as described below for the lower half of the bearing.

To install, insert the packing in the groove of the bearing cap and use a smooth, rounded tool to work the packing from each end towards the center of the cap, to force and shape the packing in the groove. Then cut off the overlapping ends of the packing **flush** with the surface of the cap.

NOTE—Make sure that the packing is not pulled out of the groove when cutting off the ends. A special seal compressor, or a round block of wood of the same diameter as the crankshaft flange may be used to hold the packing firmly in position.

ENGINE OILING

OIL PUMP

1939-46: If the oil pressure drops to zero suddenly or fluctuates violently while the engine is under load, check the oil level and examine the condition of the oil. If these conditions are not the cause, check the oil gauge by using another gauge known to be accurate, before attempting to tear down the engine. If the checking oil gauge shows a pressure drop, then remove and clean the oil pan thoroughly. At the same time, disassemble, clean and inspect the oil pump. The correct gauge pressure should be between 30 and 45 pounds at speeds above 30 miles per hour.

Before taking down the oil pan, it is good practice to remove the protecting cap from the oil pressure regulator and see if an adjustment of the oil pressure release valve affects the oil pressure. If foreign matter is lodged in the release valve, it may be removed by this change in adjustment. If adjustment does not correct the pressure, then take the valve out and clean it. It is rarely necessary to change the oil pressure adjustment. If the oil pressure is changed, be sure to determine the viscosity of the oil in the crankcase or use fresh oil before the final adjustment is made.

When the oil pan is down, check for any one of the following causes which may reduce the oil pressure: broken oil lines or tubes; leaky connection in oil tube or line; defective oil gauge; clogged oil pump or oil screen; worn oil pump parts; loose main or connecting rod bearings; improper viscosity of oil, or too thick a pump cover gasket.

OIL FILTER

1939-46: These filters are equipped with a by-pass valve which allows oil to by-pass around the filter when the oil is cold and thick, or when the filter is clogged.

Filters should be cleaned thoroughly every time the oil is changed. If the dip stick shows the oil to be very thick and dirty, it indicates that the filter element requires service.

At frequent intervals, it is good practice to drain the filter to get rid of any solid matter or water which may have settled in the filter sump. Whenever this is done, be sure to add an extra quart of oil to the crankcase to compensate for the oil drained. Of course, this also applies when the filter element is changed.

CRANKCASE VENTILATOR

1939-46: The crankcase ventilator breather is fitted with an oil-wetted air cleaner which should be removed and washed at least every 1000 miles. After the cleaner element is washed, blow it dry with compressed air, then dip it in SAE 50 engine oil. The outlet tube should be cleaned every 2000 miles.

NOTE—The interval at which the ventilator and air cleaner should be cleaned can only be determined by the type of service to which the vehicle is subjected. Vehicles operating in dusty or sandy areas require more frequent service than vehicles operating under more favorable conditions.

IMPORTANT—For vehicles operating in dust storm areas, cleaner should be cleaned immediately after such storms occur.

COOLING SYSTEM

WATER PUMP, REMOVE

1939-46: After draining the cooling system, loosen the generator bracket pivot bolt and remove the belt. Disconnect the water pump, by-pass hose, and engine radiator hose. Remove the cap screws and the two upper studs which hold the pump body to the cylinder block and lift out the water pump assembly.

To re-assemble, reverse the foregoing operation. Adjust the fan belt and fill the cooling system. In adjusting the fan belt, be sure that the generator is pulled out with a force of 40 to 50 pounds, and that the generator is clamped in place while this pull is on.

WATER PUMP, OVERHAUL

1939-40: To disassemble water pump after removal from engine, drive pin out of fan pulley hub and pull hub off shaft by means of puller. Remove cover plate screws and take off cover plate. Drive out pin which holds impeller to the shaft. Remove impeller by means of puller. Remove front bearing lock ring. Push or drive rear end of pump shaft through and out of the body. Use puller to remove bearings and spacer from pump shaft. Remove water thrower from pump shaft. Remove locking ring from bore of impeller hub and lift out thrust plate, seal and thrust spring.

To assemble pump reverse foregoing operations. Pin the hub of the impeller flush with the end of the shaft. Press the fan pulley solid against the bearing before drilling shaft for pin. Insert pin so neither end extends above the surface of the pulley hub.

1941-46: To disassemble water pump after removal from engine, drive pin out of fan pulley hub and pull hub off shaft by means of puller. Remove cover plate screws and take off cover plate. Remove impeller by means of puller. Remove front bearing lock ring and withdraw shaft, bearings and spacer.

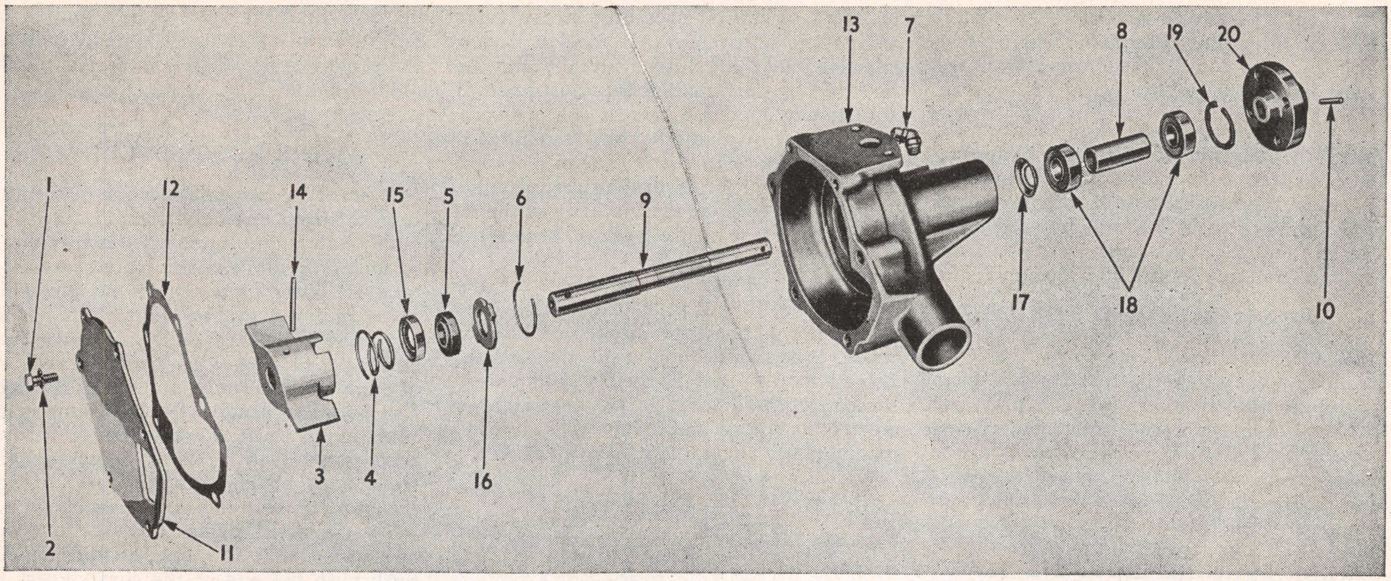
To assemble pump reverse foregoing operations. Reface the pump body where the seal retainer washer bears with a 90-degree cutter to form a perfectly flat face. Assemble new seal parts in a new (unused) impeller and press impeller on pump shaft. Install shaft with end-play .0025" to .0045" measured with a feeler gauge between the pump body and fan pulley hub.

CAUTION—A used impeller or pulley hub which has been pulled off a shaft may no longer fit tightly if replaced. It is important therefore to use a new hub and impeller.

ENGINE WATER THERMOSTAT

1939-46: If the thermostat is not functioning properly, remove the assembly from the water outlet and see if the bellows and valve are in good condition. If they are, test its operation by completely submerging it in water, heating the water gradually until it reaches the opening temperature of the thermostat, which is approximately 157 degrees to 162 degrees Fahrenheit. When the water reaches a temperature between 183 degrees and 187 degrees Fahrenheit, the thermostat should be fully open.

NOTE—When taking temperature readings, agitate the water thoroughly, and if the unit fails to function properly, it should be replaced rather than attempt to make a repair. Before installing a new unit, it is good practice to give it a test as directed above.



WATER PUMP. 1939-40. Exploded view.

1—Body cover plate screw. 2—Lockwasher. 3—Impeller. 4—Seal thrust spring. 5—Seal. 6—Seal retainer washer lock ring. 7—Lubricant nipple. 8—Bearing spacer. 9—Shaft. 10—Fan pulley hub pin. 11—Body cover plate. 12—Body cover plate gasket. 13—Body. 14—Impeller pin. 15—Seal retainer. 16—Seal retainer washer. 17—Water thrower. 18—Bearings. 19—Bearing lock ring. 20—Fan pulley hub.

FUEL SYSTEM

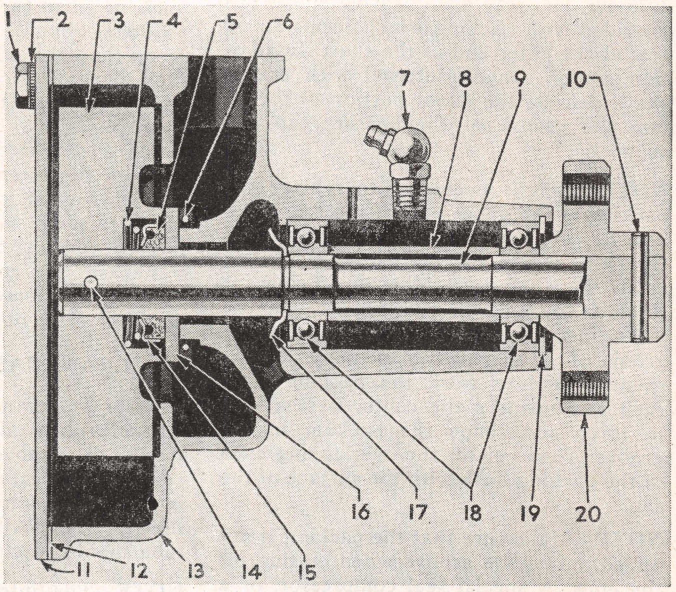
NOTE—For detailed information on Diesel Fuel Injection Systems, see the Table of Contents on page 1.

INJECTION TIMING

1939-46: Ordinarily, there is no need to remove the entire pump from the engine as the individual units which make up the pump can be taken off separately. However, if the pump assembly is to be removed, the following instructions should be observed. Before removing the pump, check the timing chain adjustment and if necessary, adjust the chain as described under TIMING CHAIN, ADJUST.

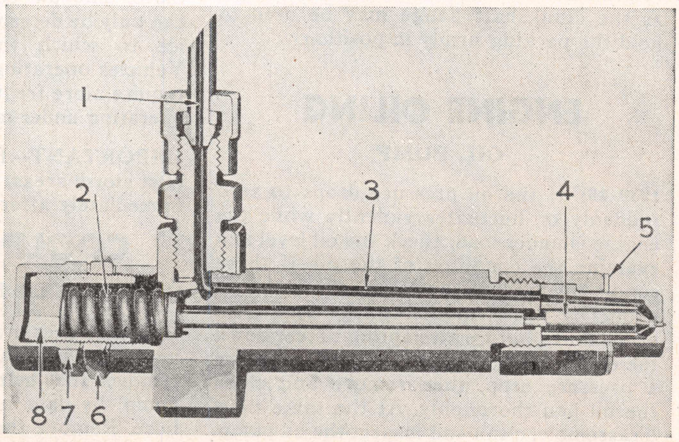
If the timing chain is adjusted, the pump timing must be set in the following manner after the unit is replaced. However, do not connect the fuel lines to the pump until after the timing is set. To set the timing, remove the "Timing Marks Cover" which is located on top of the pump between the mounting flange and the control unit. Crank the engine to bring No. 1 piston **near** the top of its compression stroke and stop when the timing mark on the vibration damper is in line with the pointer.

NOTE—On 1939-40 pump bearing the number 324 or a lower number, and 1941-46 pumps bearing the number BBB-286-RR-032 or a lower number, the timing should be set at the **4½° before TDC mark** on the damper. Pumps bearing number 325 or a higher number, or BBB-286-RR-043 or a higher number, set the timing at the **14° before TDC mark** on the damper.



WATER PUMP. 1939-40. Cross Sectional view.

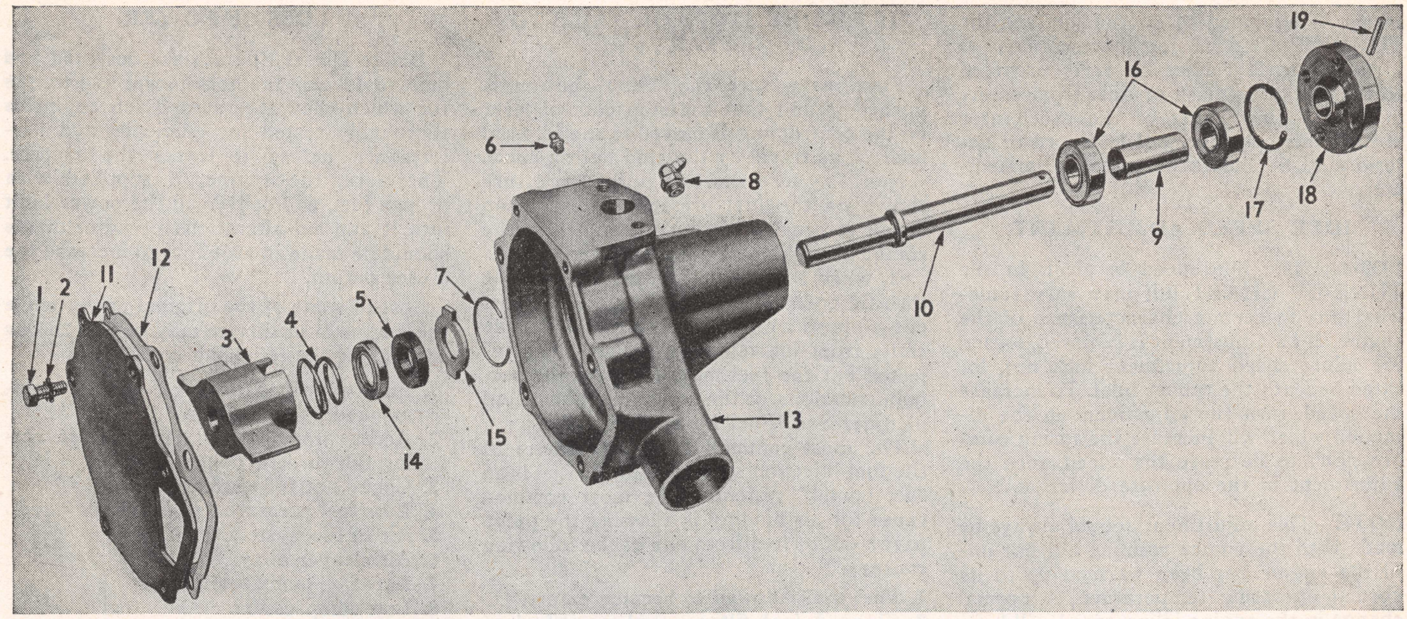
See exploded view above for identification of parts.



INJECTION NOZZLE. 1939-46. 1—Inlet connection. 2—Pintle closing spring. 3—Vein. 4—Pintle valve. 5—Gasket. 6—Adjusting screw lock nut. 7—Outer cap. 8—Adjusting screw.

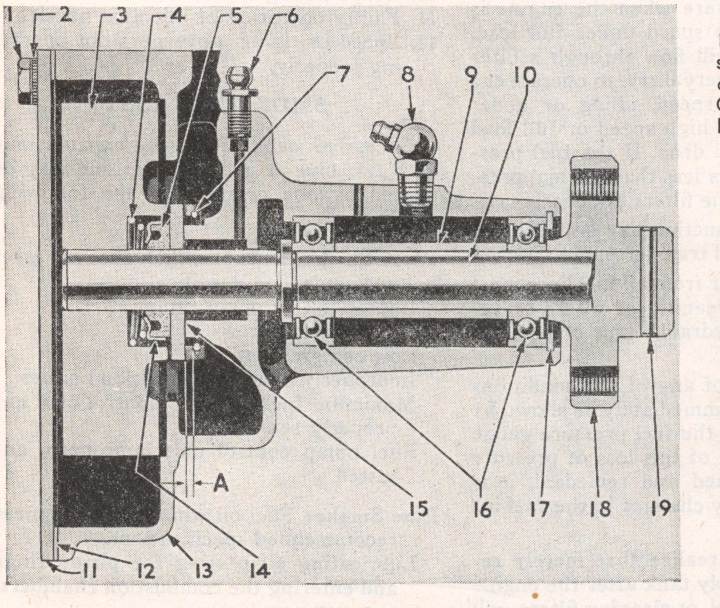
Both the pump and the crankshaft rotate in a clockwise direction and the pump will start injection from the topmost plunger of the hydraulic unit (No. 1 cylinder) when the timing mark "R" is in line with the stationary pointer.

NOTE—To overcome backlash when timing the pump, push the top of the pump toward the engine as far as the slots in the



WATER PUMP. 1941-46. Exploded view.

1—Body cover plate screw. 2—Lockwasher. 3—Impeller. 4—Seal thrust spring. 5—Seal. 6—Seal lubricant nipple. 7—Lock ring. 8—Bearing lubricant nipple. 9—Bearing spacer. 10—Shaft. 11—Body cover plate. 12—Gasket. 13—Body. 14—Seal retainer. 15—Washer. 16—Bearings. 17—Bearing lock ring. 18—Fan pulley hub. 19—Fan pulley hub pin.



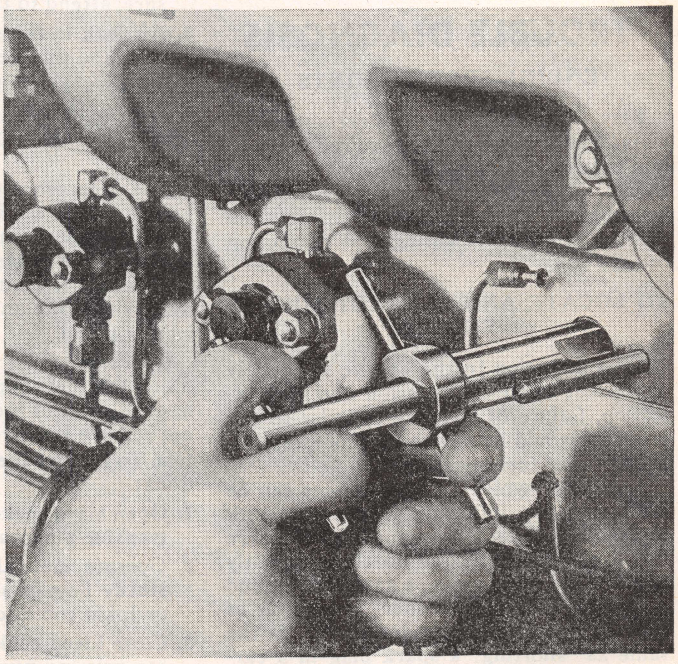
WATER PUMP. 1941-46.
NOTE—Dimension A should be a minimum of 3/32".
See exploded view above for identification of parts.

flange will allow, then bring it back until the timing mark "R" is in line with the pointer.

If the timing chain is not to be adjusted, or if the crankshaft is not to be moved while the pump is off the engine, proceed as follows:

NOTE—Before loosening the studs which pass through the slotted holes in the pump mounting flange, note any existing marks, or, make a punch mark on the pump mounting flange and a similar mark on the companion flange.

Then remove the "Timing Marks Cover" and turn the engine until the timing mark "R" is directly in line with the stationary pointer. Remove the pump assembly, being sure to leave the engine in the same position until the pump is replaced.



Reaming nozzle seat.
1939-46.

NOTE—When replacing the unit, be sure that with the backlash taken out, the timing mark "R" is exactly in line with the pointer, and the marks on the mounting and companion flange are in line.

MAXIMUM SPEED ADJUSTMENT

1939-46: The operation, adjustment and maintenance of the accelerator unit is described in detail in the "Diesel Fuel Injection Systems" chapter, "Excello" section of this book. See the Table of Contents on page 1.

These units are set up and sealed at the factory, but if it is suspected that a setting is unsatisfactory, under no circumstances should any attempt be made to change or alter the adjustments except by one who is thoroughly competent to do the job correctly. If equipped to do the job, see the TUNE-UP CHART for specifications.

An oil-proof rubber cover is provided to prevent dirt, splash or dust from entering the sliding joints of the accelerator unit. If this boot becomes lost, torn or deteriorated, it should be replaced immediately.

IDLE SPEED ADJUSTMENT

1939-46: The idle speed is given in the TUNE-UP CHART but may vary somewhat due to certain characteristics of the engine. If an adjustment is required, loosen the idling speed adjustment lock nut, located beneath the rubber boot. To increase the speed, turn the adjustment in the direction which will increase the spring compression; to decrease the speed, turn the adjustment in the opposite direction.

NOTE—This adjustment should always be made with the engine running but not until the engine has been warmed up to its normal operating temperature. A normal change in the engine idling speed will have a slight effect on the maximum speed adjustment.

ELECTRIC SYSTEM

NOTE—For service information concerning Generators, Generator Regulators, Starting Motors and Starter Switches, see the Table of Contents on page 1.

TROUBLE DIAGNOSIS

ENGINE SERVICE HINTS

Very little other than the recommended maintenance items will be required to maintain maximum engine efficiency. However, should unsatisfactory engine performance be experienced, the following information will be helpful in locating and correcting the difficulty.

TO LOCATE AND CORRECT MISS IN ENGINE

As combustion in the engine is entirely dependent upon compression and fuel injection, failure of any one cylinder to fire properly would be due to low compression, or improper fuel injection.

A cylinder which skips or misses can be located by the following procedure: With the engine idling, loosen one high pressure fuel line at the injection nozzle sufficiently to allow the fuel to escape at that point and not inject into the cylinder. The result of thus depriving the cylinder of fuel is the same as "shorting" a spark plug in a carburetor type engine.

When the faulty cylinder has been definitely located, test the compression and if it is less than 300 lbs. at cranking speed the following items should be checked in the order listed.

1. Valve tappets for proper clearance.
2. Cylinder head gasket for leaks.
3. Valves for sticking or poor seats.
4. Piston rings for being stuck in grooves or scored.

IF ENGINE STOPS OR FAILS TO START

First make sure the "Stop" button is pushed in and that the stop control lever on the control unit is moved to the forward limit of its travel by the stop button cable.

Next, be sure there is normal pressure shown on the fuel pressure gauge. Then check for fuel oil being injected into the combustion chambers of the engine.

If, when the engine is cranked with the throttle open and the choke button pulled out, a bluish white vapor resembling smoke emits from the tail pipe, fuel is being injected but the fuel may not meet the recommendations, or the fuel pump may be out of time. See "Fuel Pump Timing."

The most common cause for failure of the fuel injection system to inject fuel is an "air bound" system. The most common cause for air binding is allowing the pump to run out of fuel from one of the following causes:

1. Fuel tank allowed to become empty.
2. Clogged fuel filters—evidence of clogging will first appear in the form of reduced fuel pressure when the engine is operating at top speed under full load. Sufficient fuel will flow through a filter even when it is very dirty, to operate the engine at slow speed, idling or under light load but at high speed or full load the pressure will drop. If the fuel pressure gauge shows less than normal pressure, attend to the filters at once.
3. Air leak in the suction line between the tank and the fuel transfer pump.
4. Removal of all air from all fuel lines must always follow cleaning of filters or removal of line, hydraulic unit or transfer pump.

The occurrence of any of the conditions just described will immediately be shown by loss of pressure on the fuel pressure gauge and until the cause of this loss of pressure has been determined and remedied, it is useless to make any changes in the fuel injection pump.

Operators must realize that merely refilling the fuel supply tank after the engine has run short of fuel, or cleaning filters, will not remove the air which has filled the system. To remove the air follow these instructions:

1. Open bleed cocks on top of filter between transfer pump and hydraulic unit.
2. Operate manual priming pump until a steady flow of solid fuel free of bubbles or foam comes out of the bleed cocks.
3. Close bleed cocks and continue to operate priming pump until 20 lbs. pressure appears on gauge, to fill hydraulic unit.
4. Loosen all high pressure line nuts at nozzles about 1 turn and crank engine with throttle open and choke pulled until fuel discharges around the nuts, then tighten.

If, after all air has been removed from the system and the fuel pressure is normal, no fuel is injected into the engine, see instructions for testing under the heading "Test of Hydraulic Unit" in the "Ex-Cell-O" chapter.

LOSS OF POWER

Dodge Diesel Engines are designed and built to develop the horsepower and torque for which they are rated. Each engine is thoroughly tested for efficiency and performance before it leaves the factory. Therefore, the engine, if supplied with proper fuel, will deliver all the power built into it and no alterations or adjustments should be made in an effort to increase the power output.

Loss of some of the original power while the engine is in service may be due to one or more of the following conditions:

1. Fuel oil which does not meet recommended specifications.
2. Accelerator pedal interference preventing full throttle opening.
3. Choke not fully released.
4. Low fuel pressure.
5. Air in fuel system.
6. Air cleaner dirty.
7. Late fuel pump timing.
8. Low compression.
9. Valve tappets improperly adjusted.
10. Loose timing chain.
11. Faulty operation of injection nozzles.
12. Speed or timing governors not operating properly.

SMOKY EXHAUST

Excessive smoke from the exhaust may be black, blue or grey in color and may be caused by one or more of the following conditions:

Black Smoke: Fuel oil which does not meet recommended specifications.
Improper fuel pump timing.
Dirty air cleaner.
Low compression.
Improperly operating injection nozzles.
Maximum fuel quantity control cam improperly set.
Fuel pump control unit improperly adjusted.

Blue Smoke: Fuel oil which does not meet recommended specifications.
Lubricating oil passing the piston rings and entering the combustion chambers.

Grey Smoke: Cold engine, as when first started.
Early fuel pump timing.

NOTE—When checking for loss of power or smoky exhaust, it is recommended that the following special tool equipment be used:

Injection Nozzle Tester....	No. DD-821
Injection Nozzle Seat Reamer Set	No. DD-816
Compression Gauge	No. DD-815
Complete Set (all of the foregoing)	No. DD-822

LOW FUEL PRESSURE

The most common causes of low fuel pressure are:

1. Filters clogged by dirt or wax from fuel oil. Certain fuel oils which meet the recommended specifications and are satisfactory for use in moderate tempera-

tures, may contain sufficient wax to repeatedly clog the filters at low temperatures. Only fuel oil which has a sufficiently low cloud point should be used at low temperatures.

2. Air leak in fuel or filter between the fuel supply tank and the transfer pump, or fuel oil leak in the lines or filter between the transfer pump and the hydraulic unit.
3. Faulty hydraulic unit **bleed valve** or transfer pump, see "Tests for Faults in Fuel Transfer Pump" in the "Ex-Cell-O" chapter.

TO START ENGINE

At temperatures above 40°F., all that is necessary to start the engine is to be sure the stop button on the instrument panel is pushed in; turn the key in the lock; open the throttle, and then step on the starter pedal.

At temperatures below 40°F., before attempting to start the engine by cranking, the air intake heater control should be turned clockwise against the stop and allowed to operate until the pointer returns to the red line. Then with the stop button pushed in, open the throttle and release the clutch, step on the starter pedal and the engine should start. If the engine does **not** start within 15 to 20 seconds, stop cranking and again apply the air intake heater as outlined above. Then pull the choke button **all the way** out and, with the throttle open and the clutch released, step on the starter. As soon as the engine starts, the choke button should be pushed **all the way in,** because with the engine running, the choke decreases rather than increases the amount of fuel supplied by the fuel pump.

Year	Engine Model	Number Cylinders and Valve Arrangement	Bore and Stroke	Displacement Cubic Inches	Compression Ratio	Taxable H. P.	Brake H. P. at R. P. M.	Maximum Torque at R. P. M. Pounds Feet	Oil Capacity Quarts
1938-46	3-71	3-I	4¼x5	212.69	16	21.67	83@2000	262@1000	12.5① 8.5②
1938-46	4-71	4-I	4¼x5	283.58	16	28.90	110@2000	350@1000	16.25① 10.5②
1938-46	6-71	6-I	4¼x5	425.31	16	43.35	165@2000	525@1000	22① 15.5②

① For dry engine. ② Refill.

ENGINE SPECIFICATIONS

CRANKCASE AND CYLINDER BLOCK

Cylinder Bore	4.6275"-4.6265"
Cylinder Liner	
Type	Dry
Inside Diameter	4.2507"-4.2492"
Out of Round—Not over	.001"
Taper—Not Over	.001"
Fit of Liner in Cylinder Bore	.000"-.002" Loose

CRANKSHAFT

Out of Alignment—Not Over	
3-71	.003"
4-71	.004"
6-71	.006"
End Play	.0025"-.0075"
Thrust Taken	At Rear

Main Bearing Journals

Diameter	3.499"-3.500"
Out of Round—Not Over	.0003"
Taper—Not Over	.0005"

Crankshaft Pin

Diameter	2.749"-2.750"
Out of Line with Main Journals—Not Over	.0005"
Out of Round—Not Over	.0003"
Taper—Not Over	.0005"

CAMSHAFT AND BEARINGS

Number of Camshaft Bearings	
3-71	4
4-71	5
5-71	7
Shaft Bearing Diameter	1.498"-1.4985"
Bearing Clearance (Diameter)	.0025"-.004"
Side Clearance	.003"-.006"
Thrust Taken	At Rear
Reamed Bearing Sizes	
Front and Rear	1.501"-1.500"
Intermediate	1.502"-1.501"

MAIN BEARINGS

Number of Main Bearings	
3-71	4
4-71	5
6-71	7
Bearing Diameter	3.502"-3.503"
Bearing Clearance	.002"-.004"
Worm Limit—Not Over	.008"
Shims	None

CONNECTING RODS

Length—Center to Center	10.126"-10.124"
Bushing Bore (in rod)	1.7501"-1.7500"
Bushing Inside Diameter	1.5020"-1.5015"
Bore for Bearing—Lower End	3.0630"-3.0625"
Bearing Inside Diameter	2.7530"-2.7520"
Bearing Clearances	
Diameter	.002"-.004"
Worn Limit	.007"
Side Clearance	.004"-.012"
Shims	None

PISTONS

Clearance Top of Skirt	.0080"-.0078"
Clearance Bottom of Skirt	.0080"-.0078"
Out of Round—Not Over	.001"
Ring Location	
Compression	Above Pin
Oil	Below Pin
Weight—Balanced Within	.02 Lbs.
Piston Bore for Piston-Pin Bushing—	1.688"-1.6875"
Piston-Pin Bushing	
Length	.880"-.870"
Inside Diameter	1.5013"-1.5022"
Piston-Pin Outside Diameter	1.5000"-1.4998"
Piston-Pin Clearance	.0013"-.0024"

PISTON RINGS

Compression Rings

Gap	.020"-.025"
Ring Width	.124"-.1235"
Thickness	.170"-.158"
Clearance in Grooves	
Top	.011"-.0125"
2nd	.008"-.0105"
3rd and 4th	.006"-.0085"

Oil Rings

Gap	.010"-.020"
Width	2 Pieces
Thickness	.145"-.155"

VALVES AND MECHANISM

Exhaust Valve Location	In Cylinder Head
Exhaust Valves	
Number (in each cylinder)	2
Material	Sil-chrome
Clearance Between Stem and Guide	.002"-.004"
Worn—Not Over	.001"-.0025"
Length Overall	6.4375"
Seat Angle	45°
Stem Diameter	.3425"-.3415"
Clearance Diameter Head	1-9/16"
Valve Lash—Hot	.012"
No Go	.013"
Valve Lift	.385"

Valve Springs

Free Length	2⅜"
Load—Closed	44 Lbs. @ 2-3/16"
Load—Open	135.5 to 144.5 Lbs. @ 1-51/64"

Rocker Arm and Shaft

Shaft Clearance	.001"-.0025"
Worn—Not Over	.006"

Cam Follower and Bore

Clearance	.001"-.003"
Worn—Not Over	.006"

Follower Spring

Free Length	2-31/32"
Load—Closed	60 Lbs. @ 2-27/64"
Load—Open	134-5 to 144.5 Lbs. @ 2-7/64"

Cam Follower Roller

Max. Radial Movement	.005"

TIMING GEARS

Idle Gear

Teeth	54
Pitch	10
Type	Helical R or L
Bearing	(Depends Upon Rotation)
Diameter	2.7490"-2.7495"
Hub Diameter	2.7465"-2.746"
Bearing Clearance	.0025"-.0035" Loose
Worn—Not Over	.006"
End Play	.003"-.006"
Worn—Not Over	.008"

Camshaft Gear

Teeth	62
Pitch	10
Type	Helical

Balance Shaft Gear

Teeth	62
Pitch	10
Type	Helical
Backlash of Timing Gears	.003"-.005"
Balance Shaft Diameter	1.498"-1.4985"
Bearing Diameter	1.500"-1.501"
Bearing Clearance	.0015"-.003"
End Play	.002"-.005"

Blower Drive Gear

Teeth	32
Pitch	10
Type	Helical
Hub Clearance	.003"-.006"
Worn—Not Over	.010"
Bushing Clearance	.001"-.002"
Worn—Not Over	.005"
Clearance Between Balance Weight and Hub	.010"-.016"

LUBRICATING OIL PUMP

Type	Spiral Gear
Location	In Oil Pan
Drive	Chain No. 40
Drive Sprocket	On Crankshaft
Teeth 3-71	19
4-71 and 6-71	25
Drive in Sprocket—Teeth	
3-71	24
4-71	18
6-71	15

Pump Gears

Backlash	.003"-.006"
End Play	.001"-.0025"
Radial Clearance	.002"-.0045"

OIL PRESSURE RELIEF VALVE

Clearance Between Plunger & Housing	.0025"-.0045"

Spring

Free Length	2-11/64"
Load—Valve Open	19½ to 21½ Lbs. -@ 1-51/64"

OIL COOLER AND STRAINER BY-PASS

Valve Spring

Free Length	2-21/64"
Load	3 to 4 Lbs. @ 1-3/64"

BLOWER ROTOR GEARS

Teeth	27
Pitch	10
Type	Helical
Backlash	.0005"

AIR CLEANER

Make	AC
Type	Heavy Duty
Location (truck applications)	
3-71	1 on Blower
4-71	2 on Blower
6-71	3 on Blower

FUEL-OIL FILTER

Make	AC
Type	Ceramic

OIL COOLER

Make	Harrison
Model 3-71 and 4-71	HE450-407
6-71	HE450-406

LUBRICATING OIL STRAINER

Make	Motor Improvements
Model	5151467
Type	Cleanable Elements—Full Flow

LUBRICATING OIL FILTER

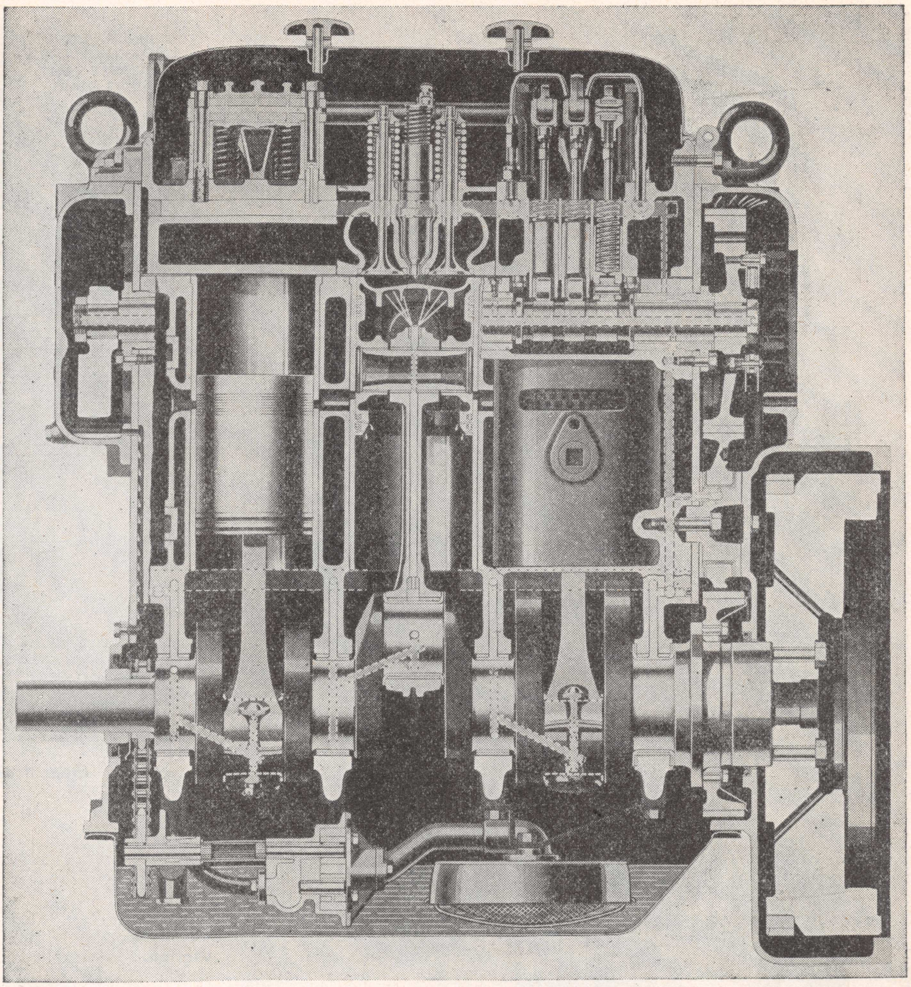
Make	AC
Element	853709

Vacuum Pump (When Used)

Make	B-K
Model	R
Size	6 Cu. Ft. @ 1000 R.P.M.
Drive	Belt
Belt Size	11/16" x 42°

ENGINE

NOTE—All GMC diesel engines are of the same general type, differing only in the number of cylinders used. There are three sizes: a 3-cylinder, a 4-cylinder and a 6-cylinder engine, designated as models 3-71, 4-71 and 6-71 respectively. The service instructions for all these engines are the same, except for slight details due to the additional number of cylinders. These differences will be considered by themselves wherever they occur. For detailed information on the fuel injection system, see the Table of Contents on page 1.



ENGINE. Side cross section.

TWO-STROKE CYCLE ENGINES

1938-42: All GMC Diesel engines are of the two-stroke cycle type. It is important to understand that this is not a four-stroke cycle engine, and, therefore, differs considerably in its arrangement and operation. In a four-stroke cycle engine, mixture is taken into the cylinder on one stroke, compressed on the next upstroke, fired on the third or down stroke, and exhausted on the fourth or upward stroke. In a two-stroke cycle engine, all of these functions take place in two strokes, intake and exhaust taking place during part of the compression and power strokes. A two-stroke cycle engine, therefore, does not function as an air pump, so an external means of supplying the air must be provided. On these engines, a specially designed blower is bolted to the side of the engine for this purpose. It forces air into the cylinder in order to expel the exhaust gases and fill the cylinders with fresh air for the next combustion.

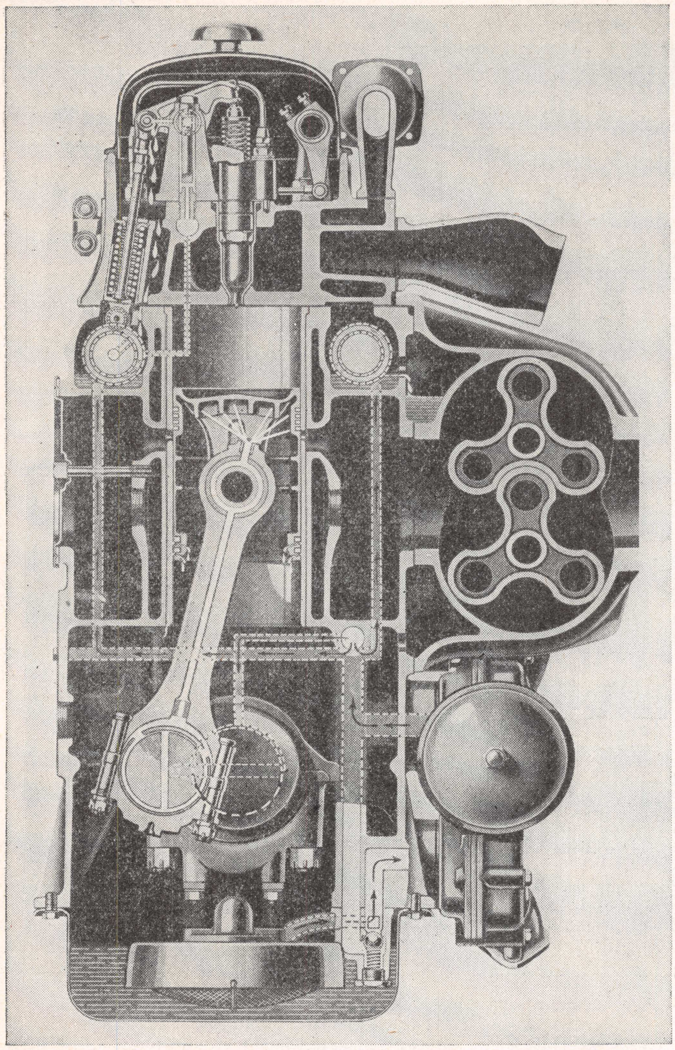
GEAR TRAIN

1938-46: There are five helical gears in the train which drive the camshaft and the blower. They are all located at the rear end of the engine. The drive is from a gear bolted to the end of the crankshaft. This drive is transferred through an idler gear to one of the camshaft gears at the top of the engine. Meshing with the camshaft gear is a balance shaft gear. A fifth gear, meshing with the camshaft gear, drives the blower. All of these gears have marks on their periphery except the blower gear. When these marks are lined up with one another, the engine will be in proper time.

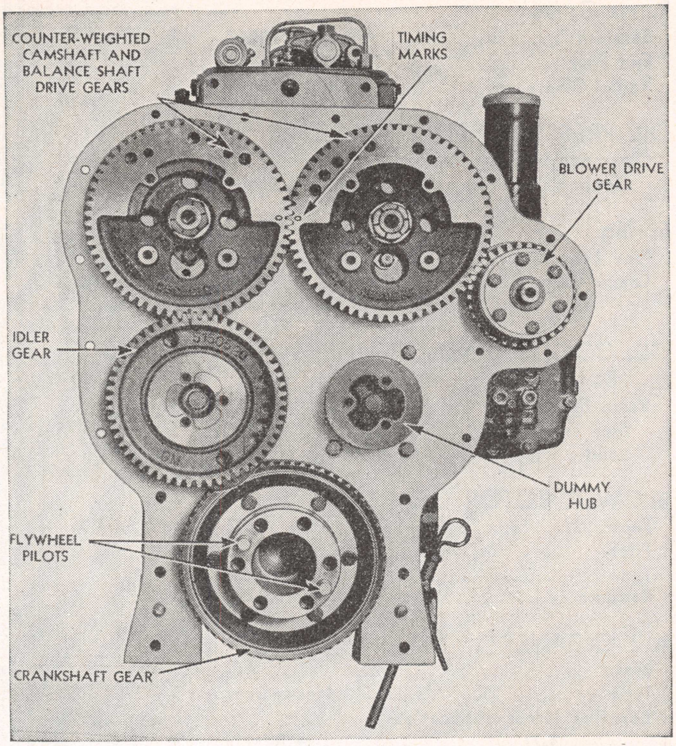
The camshaft gear and the balance shaft gear mesh with each other and run at the same speed as the crankshaft. These gears do not change positions for either direction of rotation of the engine. While the camshaft and balance shaft may be placed on either side of the cylinder block, the right hand gear always remains on the right side and the left hand gear on the left side.

The engine is designed so that the idler gear can be used in either of two positions. The idler gear rotates on a stationary hollow stub shaft. The other idler gear position is covered by a dummy hub when not used.

NOTE—Do not disturb the dummy hub when disassembling the engine so that there will be no liability of putting the idler gear on the wrong hub. The crankshaft gear and idler gear are also different for right and left hand rotation engines.



ENGINE. End cross section.



Gear train and timing marks. Right hand rotation shown.

The gear train will be quiet if it has been properly set up and the gears and bearings are in good condition. The back lash between the various mating gears in the train ranges from .004" to .006" on a new engine. Worn bearings, or chipped or burred gear teeth caused by careless handling, are usually the only cause for a noisy gear train.

To remove the timing gear train, it is necessary to remove the transmission and clutch cover plate in order to get at the clutch and flywheel. The flywheel is bolted to the crankshaft flange with six screws which are held in place by a locking wire. As soon as these have been removed, "T" head studs should be screwed into the clutch screw holes on the periphery of the flywheel at points diametrically opposite and the flywheel pulled off of the crankshaft. Next remove the cap screws holding the engine lifting bracket to the gear housing cover. Remove the oil pan. Last, remove cap screws which attach the flywheel housing and gear train cover to the rear end of the cylinder block and take off the housing.

Remove blower drive gear: The blower drive gear housing is bolted to the front face of the cylinder block rear end plate and the gear hub is locked in position at the front end of the hub.

Since the blower drive cover slides over the inner end of the blower drive gear housing and also the blower end plate cover, the blower must be slid forward before the blower drive gear housing and hub assembly can be removed from the cylinder block end plate.

With the blower assembly forward, the lock nut on the inner end of the blower drive gear is exposed. Before loosening this nut, check the clearance between the gear hub bushing and the thrust washer. The specified end clearance here should be from .003" to .006" and should not exceed .010". If the end clearance is excessive, this condition requires the renewal of the housing and inner babbitt bearing assembly.

NOTE—Loosen the lock nut while the gears are still in mesh. If the gears have been removed previously, then it will be necessary to hold the assembly in a bench vise in order to loosen the lock nut.

Be sure to loosen the nuts at each end of the oil line leading from the cylinder block to the blower drive gear bearings. Disconnect the oil line to the assembly. After removing the holding cap screws, the entire assembly can be easily removed towards the front.

If it should be necessary to change the blower drive shaft, it is only necessary to remove the locating ring from the flexible coupling and slip the shaft out.

Six cap screws secure the drive gear drive coupling and retainer to the gear hub.

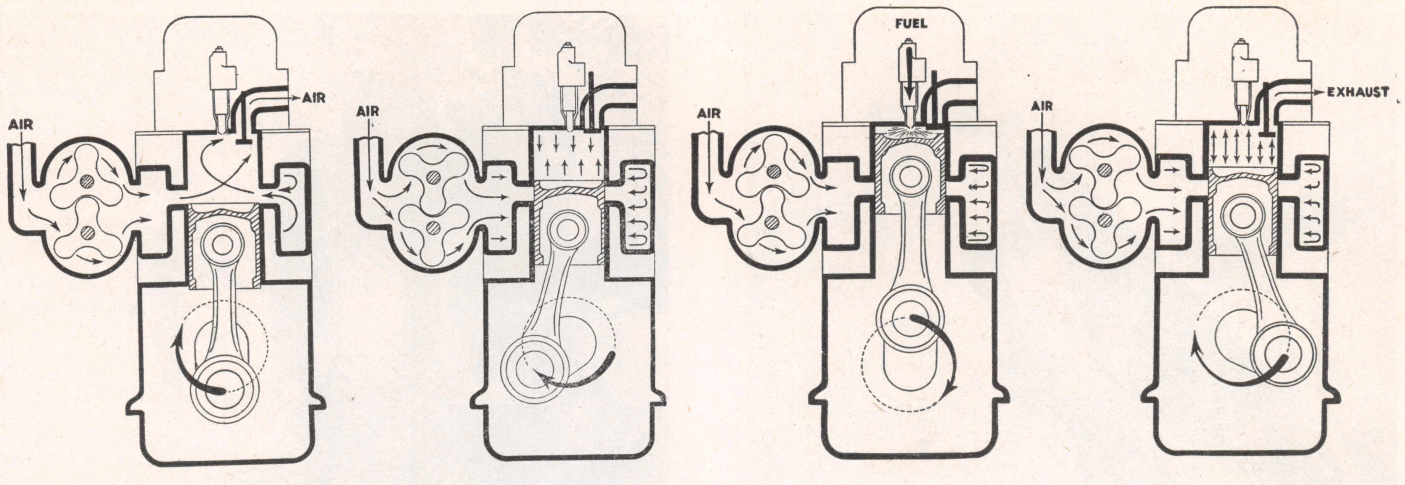
The bushings which carry the blower drive gear hub, are diamond bored in place, therefore, in case of bushing failure, the housing and bushing assembly must be replaced together.

The proper clearance between the bushings and the hub journals is from .001" to .002" and must not exceed .005".

There should be no appreciable back lash between the flexible coupling or the blower timing gear drive flange and the blower drive shaft. If there is, the shaft should be replaced.

Inspect the driving springs and cams of the flexible coupling to see that none are broken and that the cams are not worn.

Assemble blower drive gear: Smear oil over the outside of the drive gear hub and then slide it into the housing from the rear. Install the locking ball in the gear hub and slide the thrust washer in place over the ball with the large diameter face of the washer against the thrust face of the gear housing bushing. Next, prevent the hub from turning by inserting a couple of bolts in the hub and using a bar between them. Install a new lock washer next to the thrust washer and then tighten up the lock nut. The outer end of the flexible coupling is counterbored about ¼" on the inside diameter of the hub. With this counterbore away from the face of the gear, place the coupling against the gear and over it the stamped steel shield. This shield has a



FUNCTIONS OF TWO-STROKE CYCLE ENGINE.
From left to right. Air Intake. Air Compression. Fuel Injection. Exhaust.

flange at the center and the flange should point away from the coupling. Now insert the cap screws with their lock washers and tighten up against the face of the gear. Install shaft locating rings inside of the coupling after the shaft is in place. Apply engine oil at each thrust shoulder of the bushings and then check clearance to see that it comes between .003" and .006".

The blower drive gear coupling may then be attached to the front face of the cylinder block rear end plate. A new paper gasket should be placed between them. Two capscrews will hold the blower drive gear coupling in place. Replace the oil line from the gear bearing to the cylinder block and tighten the connections at both ends.

NOTE—Only the two cap screws, specified for holding the blower drive gear assembly, should be used. If they are too long, they will interfere with the gears. The other four bolt holes are for the through bolts which hold the gear train cover as well as the blower drive gear assembly. Replace the blower after the drive gear assembly is completely installed.

Idler gear: The idler gear is mounted on a hard steel stationary hub. This hub is prevented from rotating by a hollow pin, one end of which is driven into the hub. The other end of the pin enters the cylinder block and connects with one of the vertical oil passages to provide lubrication for the gear. Flanged bushings are pressed into the idler gear hub from each side. A steel thrust washer is placed on the idler gear hub after the idler gear is in place. This steel washer is prevented from turning by the hollow pin. End thrust is taken by the steel washer on the inside face of the idler gear and by a flange on the gear hub at the outside. The steel washer is hardened to resist wear.

To remove the idler gear, it is only necessary to take out the cap screw on the inside of the idler gear hub and withdraw the hub and gear assembly from the cylinder block.

The journal on the gear hub should be examined for scoring and the diameter checked. Check the inside diameter of the gear bearing also. The clearance between the gear bearing and the journal should be from .0025" to .0035" and should not exceed .006". If the clearance exceeds this amount, either the gear and bearing assembly or the gear hub or both should be changed. The replaced part depends on which is worn the most.

Examine the face of the steel washer and the thrust faces of the gear bushings for scoring and wear. The end play of the idler gear assembly should be between .003" to .006" and should not exceed .008". If necessary, replace worn parts.

NOTE—The idler gear bushings are not removable, therefore, in case of bushing failure the idler gear assembly must be replaced as an assembly.

Replace idler gear: First line up the camshaft gear and balance weight shaft gear so that the 0-0 marks are together. Turn the crankshaft until the "R" mark on the crankshaft gear teeth aligns with the point where the same mark should be on the idler gear. With all parts in their relative position, apply a small amount of cup grease to the back face of the steel thrust washer of the idler gear and stick the washer against the cylinder block end plate. Be sure the hole in the steel washer is in line with the oil hole in the cylinder block. The grease is used to hold the washer in place until the hub and gears can be installed. Now roll the idler gear into position between the crankshaft and the camshaft gears. Then slide the gear hub into place through the bore in the gear.

NOTE—Special care must be taken to have hollow pin in inner face of gear hub register with the hole in the end plate, for the hollow pin carries oil to idler gear bearing.

Be sure gear hub is tight against end plate before locking it into place with lock washer and cap screw at center of gear hub. Now check backlash between the various mating gears in the train. This should not be less than .004" nor more than .006" between each set of gears.

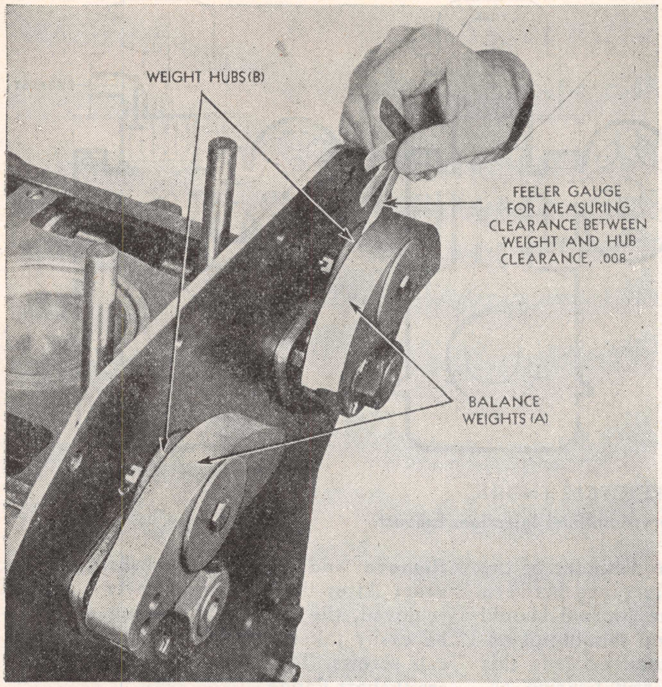
Remove and replace crankshaft timing gear: After the gear train cover has been removed, the crankshaft timing gear can be easily taken off by the removal of six cap screws. The gear then slides off the crankshaft flange.

To replace the crankshaft timing gear, slide the gear on to the crankshaft, with the flat finished face of the gear toward the cylinder block. Position the gear teeth so timing mark "R" on gear teeth aligns with the corresponding mark on the idler gear. Then slide the gear up against the flange on the crankshaft. Due to one off-set hole in crankshaft flange, the timing gear can be located in only one position on the crankshaft flange. Turn either the crankshaft or gear train so bolt holes in the gear web align with the six holes in the crankshaft flange. Then slip the oil deflector in position so it can be bolted to gear hub, with outside diameter laying against rim of gear. Then install six lock washers and cap screws and draw the gear and oil deflector tightly in place.

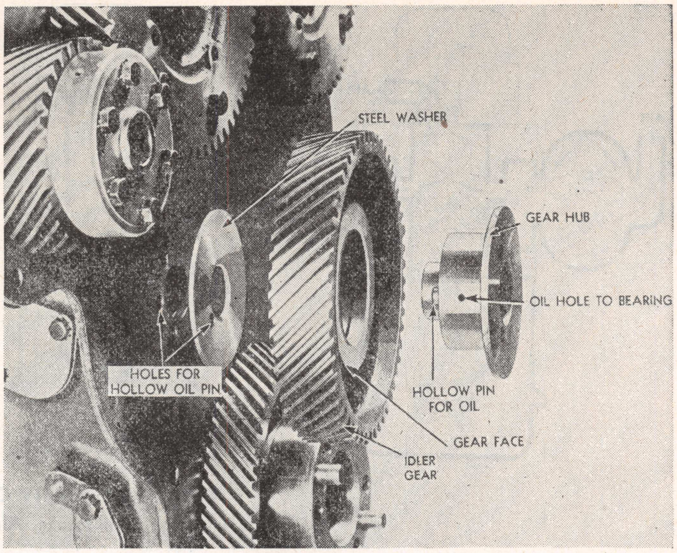
CAMSHAFT AND BALANCE SHAFT

1938-46: In these engines there are two parallel shafts at the top of the cylinder block. Viewing the timing gears from the rear of the engine, the one at the left drives the balance shaft, the one at the right, the camshaft. The camshaft is carried on four bearings, the balance weight shaft on two. The bearings nearest the gears are called the "short" while those at the front end are the "long" or "thrust" bearing cages. These "cages" form steel-backed copper-lead, one-piece bearings. The intermediate camshaft bearings are made in halves, each bearing held together by two retainer springs and locked in place by set screws in the top of the cylinder block.

At the front end of each of the parallel shafts are balance weights. These weights are different for the three, four and six-cylinder engines. The lightest balance weights are used on the three-cylinder and the heaviest on the four-cylinder engine.


WEIGHT HUBS(B)
FEELER GAUGE FOR MEASURING CLEARANCE BETWEEN WEIGHT AND HUB CLEARANCE, .008"
BALANCE WEIGHTS (A)

Measuring clearance between balance weight and hub on 6-71 engine.



Idler gear mounting details.

NOTE—If service on the camshaft gears or balance shaft gears necessitates removal of the gears from the shafts, the work should be performed after the shafts have been removed from the engine.

Remove camshaft and balance shaft: Before either camshaft or balance shaft can be removed, the cylinder head and gear train cover must be removed. Then proceed as follows: Loosen up the fan belt and take off fan and fan bracket from balance weight cover. Then loosen fifteen cap screws and remove the front balance weight cover. Straighten the tongue on the lock washer which fastens the front balance weight retaining nut on the end of the shaft. Loosen retaining nut on the end of each shaft.

NOTE—To prevent timing gears from rotating when these nuts are loosened, roll a clean rag and put it between the teeth of the timing gears.

Pull the balance weight off of both balance shaft and camshaft. Take out the special cylinder head lock screws from the top of the cylinder block over each camshaft intermediate bearing, then remove three cap screws from each of the rear end balance shaft and camshaft bearing cages, by means of a socket wrench inserted through holes provided in the web of the timing gears. Then withdraw both the balance shaft and the camshaft timing gears and bearing assemblies from the rear end of the cylinder block. Now remove the three cap screws which hold each bearing cage at the front end of the cylinder block and remove them from the engine block front end plate.

To remove the timing gears from the camshaft or the balance shaft, take off the castellated nut which holds them in place, and then supporting the shaft and gear assembly in an arbor press, push the shaft through the gear with an arbor. The rear bearing cages may now be slipped off the shaft. Intermediate bearing halves may be removed by taking off the spring retainers after the camshaft has been withdrawn from the cylinder block.

The radial clearance on the camshaft and balance shaft bearings is from .0015" to .003" and should not exceed .005". End clearance for these same bearings is from .002" to .005", and should not exceed .010".

NOTE—The camshaft is hollow and oil is fed to the intermediate bearings through this shaft. Therefore, all oil holes should be examined in both the shaft and the bearings and thoroughly cleaned out while the shafts are out of the engine.

NOTE—The camshaft gears and the balance shaft gears are the same for all engines. To use these gears on the four and six-cylinder engines, additional weights are attached to the gears for balancing purposes. No weights are attached to the gears for the three-cylinder engine.

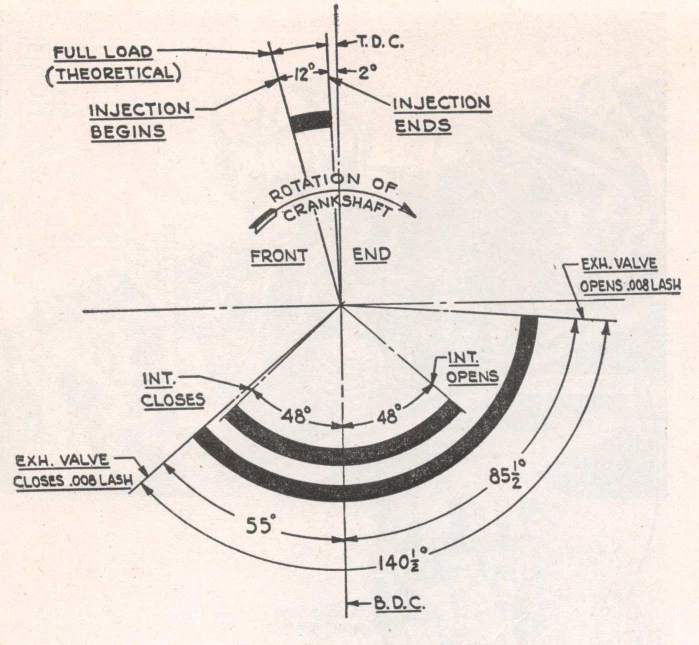
Install camshaft and balance shaft: Before the camshaft and balance shaft can be installed, the short bearing cages must be placed on the shaft end next to the timing gear. The intermediate bearings must be attached and in place on the camshaft. The gears should be keyed and pressed on to the shaft after installing the bearings. A tubular or hollow arbor should be used to press a gear in place on the shaft. The long bearing cages should be installed at the front end of the cylinder block.

Each cage is held in place by three cap screws with lockwashers. Start the camshaft, bearing, and gear assembly into position at the rear end of the cylinder block on the side of the block opposite the exhaust manifold.

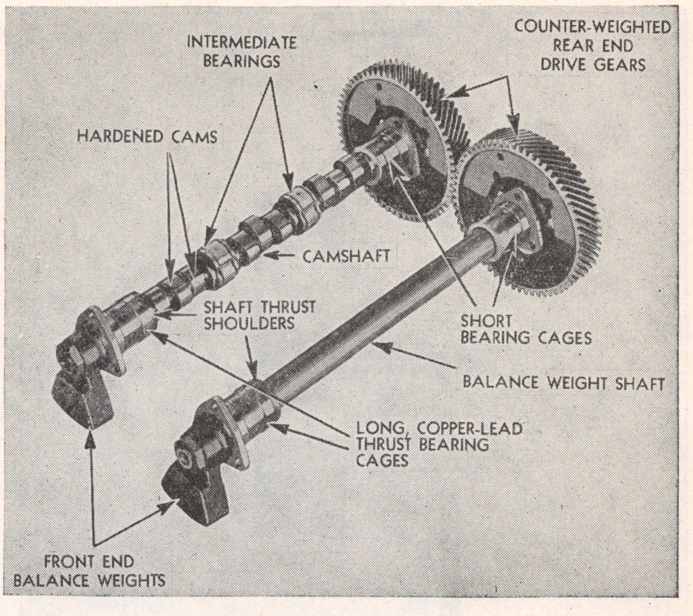
NOTE—Stop at the point where the gear teeth are just about to engage. Secure the short bearing cage next to the timing gear by three cap screws and lock washers. These cap screws must be inserted through the hole in the web of the timing gear. Next revolve the camshaft intermediate bearing cages so the locking hole in the cages will align with holes in top of cylinder block. Put lock screws in place and lock. Put Woodruff key in place on the front end of the camshaft, slide the balance weight on to the shaft with the overhanging section of the weight facing away from the cylinder block. Put on the special lock nut which holds the weight in place, but do not attempt to tighten it until the balance shaft has also been installed. The method of installing this is exactly the same as for the camshaft except that no intermediate bearings are required.

Now bring the timing marks "0-0" on the camshaft and balance shaft gears so that they face each other. When the "0" marks are together, the gear at the left on the balance shaft should have a letter "R" at the proper point to mesh with a similar letter on the idler gear. Another letter "R" on the idler gear lines up with a similar letter "R" on the crankshaft gear. When the gears are all properly meshed and installed, the front balance weight nuts can be drawn up and tightened. Jam the timing gears with a clean cloth rolled up as a wedge between them. Use, if possible, a 16" wrench to tighten the nut.

NOTE—Solid balance weights are used on the 3 and 4-cylinder engines. The 6-cylinder engine has an articulated balance weight. The articulated weight is carried on the hub of the fixed balance weight and supported by preloaded balance weight springs. When the outer floating balance weight is assembled, there should be a clearance of


FULL LOAD (THEORETICAL)
T.D.C.
12°
2°
INJECTION BEGINS
INJECTION ENDS
ROTATION OF CRANKSHAFT
FRONT END
EXH. VALVE OPENS .008 LASH
INT. OPENS
INT. CLOSES
48°
48°
EXH. VALVE CLOSES .008 LASH
85½°
55°
140½°
B.D.C.

Engine timing diagram.


INTERMEDIATE BEARINGS
COUNTER-WEIGHTED REAR END DRIVE GEARS
HARDENED CAMS
CAMSHAFT
SHAFT THRUST SHOULDERS
SHORT BEARING CAGES
BALANCE WEIGHT SHAFT
LONG, COPPER-LEAD THRUST BEARING CAGES
FRONT END BALANCE WEIGHTS

Camshaft and balance shaft assembly. 3-71 engine shown.

from .010" to .016" between the floating weight and the hub weight. If this clearance does not exist, the weights will not articulate on the hub and the engine may be "rough."

ENGINE TIMING

1938-46: When the engine is properly timed, the markings on the gear train will appear as shown on the illustration of the gear train. The timing diagram shown here is the cycle in which the opening and closing of the intake ports, the operation of the exhaust valve, and the injection of the fuel, takes place. Due to one off-set bolt, the flywheel can be attached to the crankshaft flange in only one position.

CYLINDER HEAD

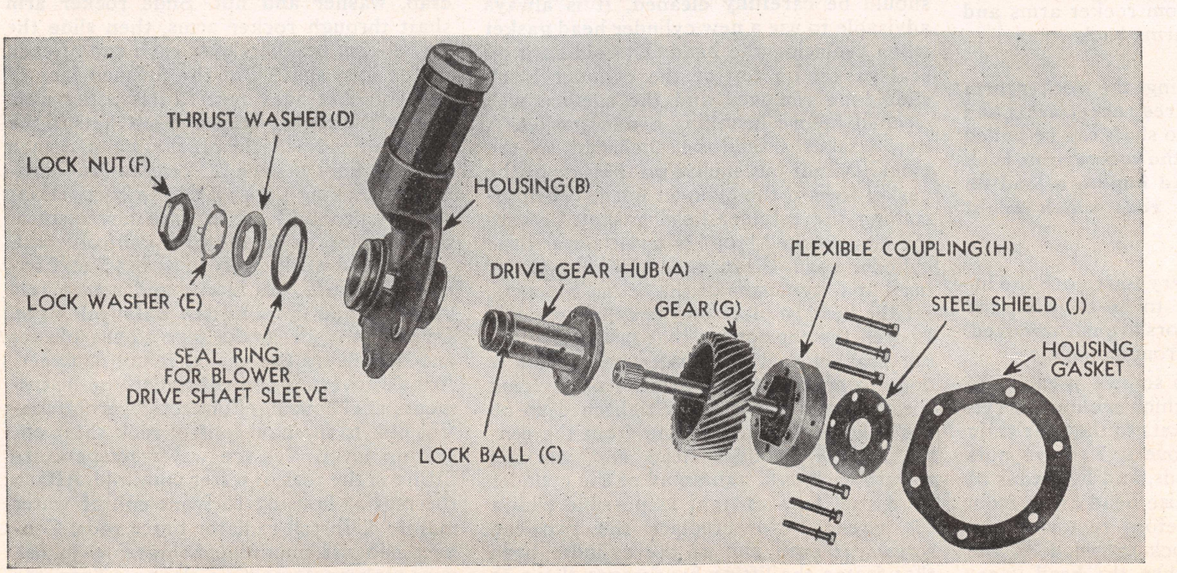
1938-46: The cylinder head is a one-piece alloy iron casting containing cam followers, guides, rocker arms, and valves. The head is securely held to the top of the cylinder block by steel studs. Lifting lugs are provided at each end of the cylinder head.

Unlike the 4-cycle gasoline engine, there are no intake valves in the cylinder head. However, there are two valves and a fuel injector. Both the valves are for exhaust. Three rocker arms are provided for each cylinder. The center rocker arm operates the fuel injector, the other two operate the exhaust valves.

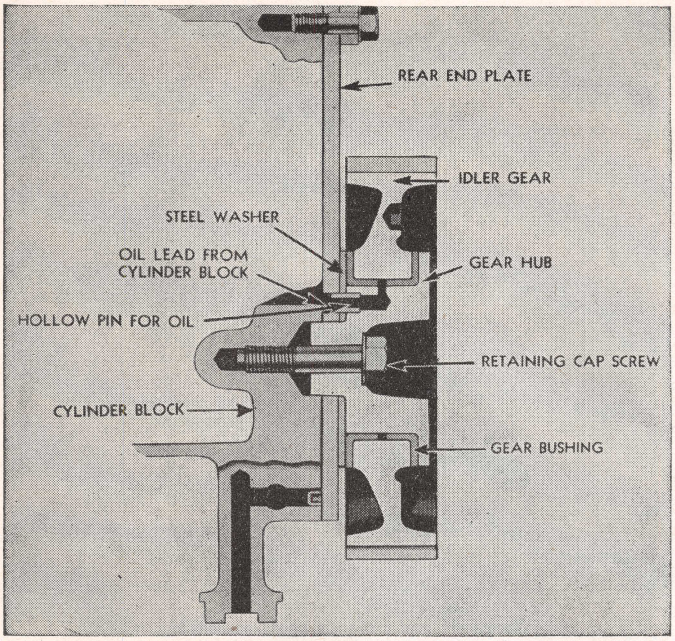
To insure efficient cooling, each fuel injector is inserted into a thin-walled copper tube attached to the water space in the cylinder head. The lower end of the copper tube is pressed into the cylinder head and spun over. The upper end is flanged and sealed with a Neoprene seal.

Remove cylinder head: First remove the valve rocker cover which is held on top of the cylinder head by two or more hand nuts and studs.

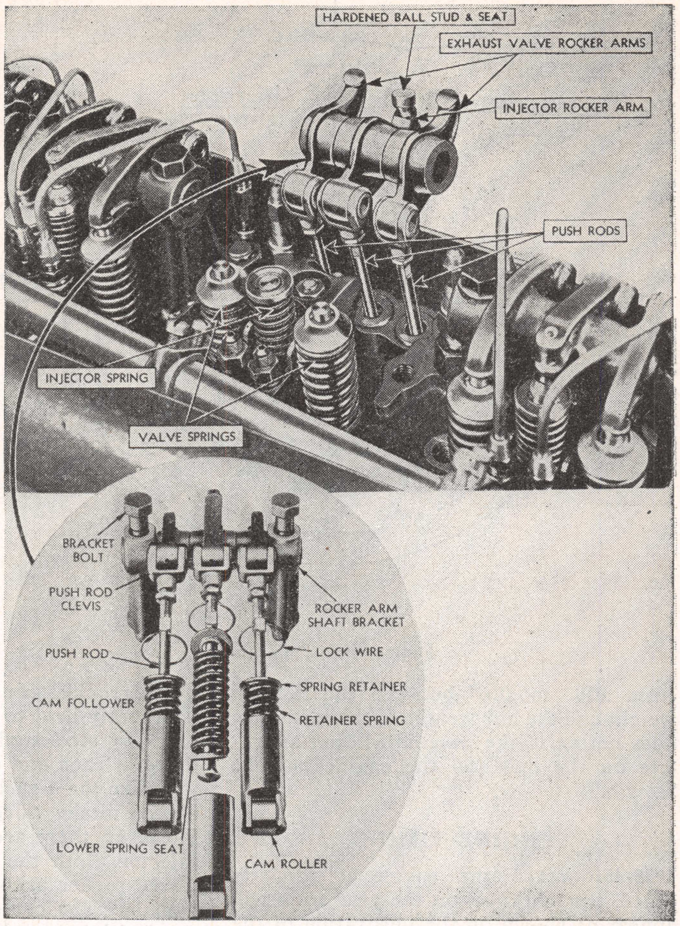
Drain the cooling system below level of cylinder head. Remove manifold retaining nuts and washers and pull exhaust manifold away from cylinder head. Remove air cleaner. Remove radiator brace rods. Remove the two cap screws and separate water by-pass pipe from bottom of thermostat housing at front end of water manifold. Then remove three cap screws holding thermostat housing to front end of water manifold and pull housing to one side. Loosen and remove water temperature fitting from rear end of water manifold. With engines having a mechanical governor, the following procedure is followed: Remove the two cap screws that attach breather pipe to rear end of cylinder head and roll pipe back away from head. Remove four cap screws from governor control housing cover and remove cover and gasket. De-


THRUST WASHER (D)
LOCK NUT (F)
HOUSING (B)
LOCK WASHER (E)
SEAL RING FOR BLOWER DRIVE SHAFT SLEEVE
FLEXIBLE COUPLING (H)
DRIVE GEAR HUB (A)
GEAR (G)
STEEL SHIELD (J)
HOUSING GASKET
LOCK BALL (C)

Blower drive gear.



Idler gear mounting.



Valve operating mechanism.

tach governor control rack link from governor and control rack shaft, and remove link. Remove governor control housing tube. Now take the two cap screws out which attach governor control housing to cylinder head. Remove four cap screws holding control housing to governor weight carrier housing and remove cover and gasket.

Remove two cap screws from each end bracket and pick injector rack control shaft assembly straight up away from the cylinder head. Disconnect the fuel feed lines from injectors and fuel connectors and remove fuel lines. Fuel injector openings should be protected with shipping caps, after disconnecting the fuel lines, to prevent any dirt from getting into the injectors. Next remove the two cap screws at each cylinder, holding rocker arm brackets to the cylinder head and slip the brackets off the shaft, the shaft from rocker arms and then turn the rocker arms back.

NOTE—When removing the rocker arm shaft, hold back the three rocker arms and shaft just far enough so shaft can be pulled endwise. **Do not force the rocker arms back with shaft in place and impose a load on the rocker arm push rods which might cause them to bend.**

NOTE—It is unnecessary to remove the injectors unless work is to be done on the cylinder head. If injectors are not removed, protect the spray tips from damage.

Next remove the cap screws at each end of the cylinder head which secure the cylinder head lifting brackets to the gear train and balance weight covers. Remove nuts from cylinder head studs, and by means of the lifting brackets, raise head away from the cylinder block. Before removing the head, put a 2-inch block of wood on the work bench so that when the head is removed it can be set face down on this block. This block protects the cam followers and rollers which project beneath the face of the cylinder head.

Replace cylinder head: In replacing the cylinder head, the removal procedure is reversed. A few precautions, however, must be taken in re-assembling the cylinder head.

The tops of the pistons and cylinder head should be carefully cleaned. It is always advisable to use a new cylinder head gasket when replacing the head. The old cork oil seal gasket on top of the cylinder block should be removed and the surface well cleaned before installing a new gasket. A new gasket should be shellaced to the block. Do not put shellac on the side of the gasket toward the cylinder head. When installing the cylinder head gasket, be sure the side marked "top" is up or toward the cylinder head. Clean underside of cylinder head and, by means of the lifting brackets, set the head in place on the cylinder block. Loosen the cap screws that fasten the lifting bracket to the cylinder head. This is done to prevent the brackets from holding the head while it is being tightened up on the cylinder block. Starting from the center of the cylinder head and working toward each end, tighten all of the cylinder head stud nuts as tight as possible with a 20" wrench. Now replace the two cap screws at each end of the cylinder head that fasten the lifting brackets to the gear cover and balance weight cover. Then tighten the screws which attach the lifting brackets to the cylinder head. If injectors were not cleaned and tested when removed, they should be before installing in the cylinder head. See "Testing Injectors" in the special section on Diesel Fuel Pumps.

After cleaning and testing injectors, place each one in position with locating dowel in injector body registering with holes in the cylinder head. Lock them in place with crab, washer and nut. Slide rocker arm shaft through rocker arms, then slide the rocker arm brackets over each end of each rocker arm shaft. Put the finished face of each bracket boss next to its rocker arm. Secure the rocker arms and brackets to the cylinder head with the bracket bolts. Attach two fuel lines to each injector and fuel connector, making sure all of the connections are leak proof. Check the free movement of the injector rack and the control shaft. This should work freely in its bracket. Connect fuel lines, the intake and return fuel manifold and **draw up the nuts leak tight.** Connect the air intake pipe to the blower and make sure the gasket is not damaged. Attach governor control rod to the instrument panel housing. Connect governor control link to injector control rack shaft operating lever. Replace water temperature fitting in the rear of water manifold. Attach thermostat housing to front end of water manifold. Install radiator brace rods. Connect exhaust manifold, being sure to use new gaskets. Install air cleaner. Turn engine over with throttle in "off" position and observe if all parts function properly. At the same time check the lash of the exhaust valves. This setting should be .012" when the engine is hot. When using a "Go"—"No Go" gauge, the gauge reading should be. 011" go and .013" no go. The .012" hot clearance is equivalent to .015" when the engine is at normal room temperature.

NOTE—Before replacing valve rocker arm cover, open engine throttle to idle position. Before starting engine, operate it with the starter and see that all fuel line connections are tight. **There must be no fuel oil leaks into the cylinder head to dilute the lubricating oil.** If the lubricating oil is diluted with fuel oil, the engine bearings may be seriously damaged.

VALVE & INJECTOR MECHANISM

1938-46: Three drop-forged rocker arms are provided for each cylinder. The center one operates the fuel injectors, the others operate the exhaust valves. The rocker arm assembly is supported by two cast iron brackets that are held in place by bolts. Removing the bolt from each bracket releases the bracket, allows the rocker arm shaft to be withdrawn, and the rocker arms to be folded back out of the way of the valve springs. The rocker arms are operated from the camshaft through short push rods and cam followers that are tipped with a case hardened steel roller. These rollers are carried on needle bearings. The cam followers are guided in the cylinder head. On the bottom of the cylinder head is bolted a forged steel guide for each cylinder. This guide keeps the follower rollers in line with the cam and also serves as a retainer during assembly and disassembly of the cylinder head. A separate coil spring is provided inside of each hollow cam follower. It is held in place in the cylinder head by a retainer washer and a wire locking ring.

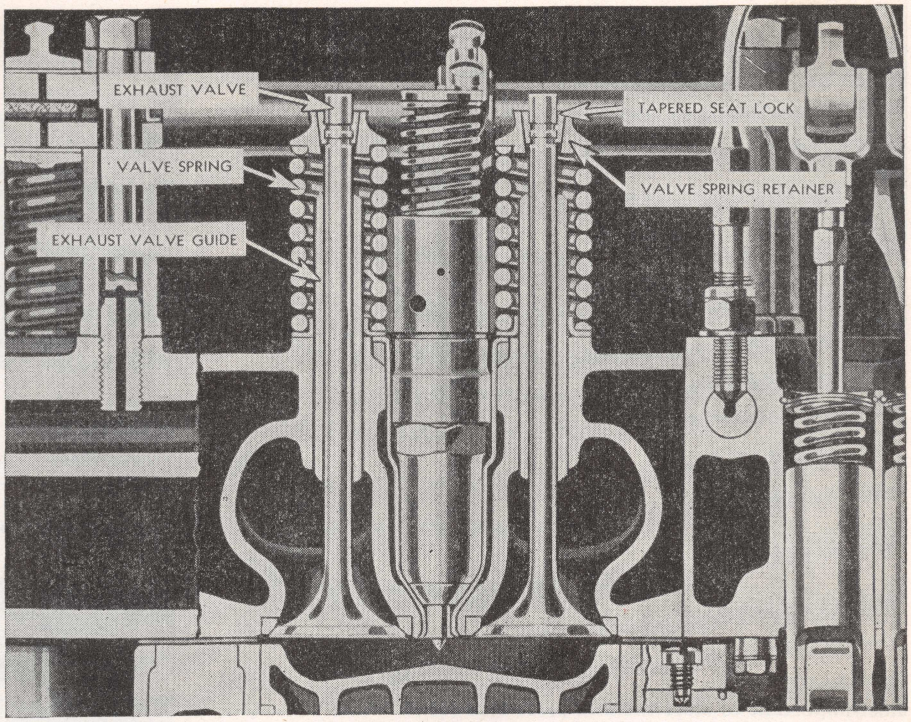
VALVE ADJUSTMENT

1938-46: Correct valve clearance is very important in a high compression Diesel engine. Too little clearance causes a loss of compression, missing cylinders, and eventual burning of valves and valve seats. Too much clearance between the valve stem and the valve rocker arm results in noisy operation of the engine, especially in the idling range. The correct valve clearance for all exhaust valves is .012" with engine hot.

The adjustment of valve clearance is made by means of the threaded upper part of the push rod, which is screwed into the push rod clevis and secured by a lock nut.

NOTE—The valve lash should be taken on any cylinder when the injector arm is depressing the injector plunger for that particular cylinder.

CAUTION—Whenever a push rod has been disconnected from the push rod clevis, the rod must be screwed back into the clevis flush with the top of the threaded portion of the clevis before the valve clearance is checked. **If this is not done, the piston may hit the heads of the valves when the engine is being timed,** owing to the unusually small clearance between the valves and the piston head when the latter is in the upper position.



Exhaust valves and guides.

VALVE SPRINGS

1938-46: On these Diesel engines, the valve spring may be removed or replaced without removing the cylinder head.

Take off the valve rocker arm cover. Crank the engine until the piston is at the top of the stroke. This can be observed by the position of the injector plunger. The plunger will be approximately 3/16" downward on its stroke when the piston is at the top of its stroke. Disconnect and remove fuel feed line from injector. Remove the two cap screws holding the rocker arm shaft bracket to the cylinder head and take the bracket and rocker arm shaft off. Turn the rocker arms away from the valves. A special valve spring removing tool is available which utilizes one of the rocker arm shaft bracket cap screws. Using this tool, compress the spring and remove the retainer.

NOTE—Do not install the valve rocker arm cover until after the engine has been started and all fuel oil line connections have been checked for leakage.

EXHAUST VALVES & GUIDES

1938-46: The exhaust valves can be removed after the head has been taken off of the cylinder block.

NOTE—Be sure to place the cylinder head on a block of wood at least two inches thick. This will hold the valve heads in place and prevent any damage to cam followers, as these project through the lower side of the cylinder head. Release the valve springs as directed under "Valve Springs." With the springs removed, take out the exhaust valves by turning the head on edge.

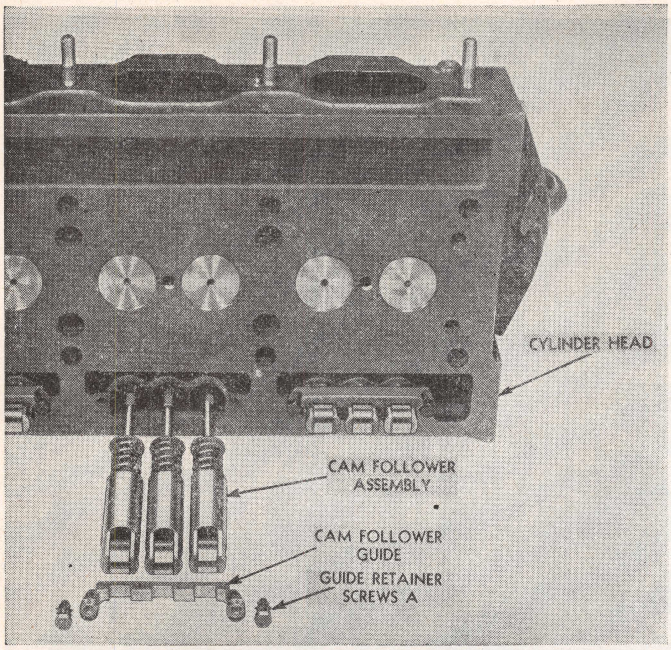
With the exhaust valves removed, the valve guides may be inspected and, if necessary, changed. The valve stem diameter is from .3425" to .3415," and the clearance of the stem in the guide is from .001" to .002" and should never exceed .005".

If the valve guide shows wear and must be removed, it should be driven out from the top of the cylinder head with a special drifting tool provided for that purpose. When installing the valve guide, be sure it is driven into place from the bottom of the cylinder head with the same driver used to remove it. **New valve guides must be reamed to size after they have been pressed into the cylinder head.**

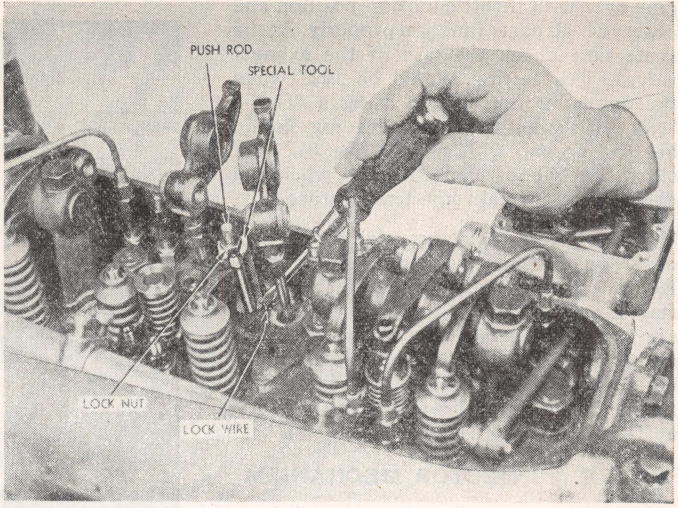
VALVE SEAT INSERTS

1938-46: With the cylinder head removed, clean thoroughly with gasoline and dry with compressed air. Replace cylinder head on bench with upper side down. Insert a collet beneath the valve seat insert so that the lip at the bottom of the collet flange is flush with the bottom side of the valve seat insert. Holding the collet in this position, expand it by turning the nut at the top of the tool. Be sure the flange of the collet is firmly entered just below the valve seat insert. Then with the special tool provided for this operation, put the valve seat puller body on the face of the cylinder head. Put thrust bearing over top of collet and on top of puller body. Start screw thread of tool head onto collet. Then turn the screw head until the valve insert is pulled out of the cylinder head.

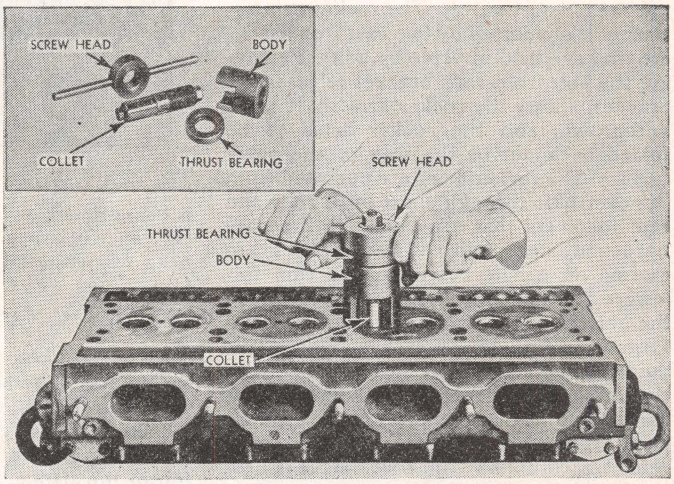
Great care must be exercised when replacing valve seat insert. The inserts are installed with a drive-shrink fit and it is



Cam followers and retainer assembly.



Removing push rod from upper side of cylinder head.



Refacing valve seats.

most important to start them in place true with the counterbore in head.

The first step is to clean the head perfectly, particularly the counterbore for the inserts. Immerse the cylinder head for 30 minutes in water at a temperature of 180 deg. to 200 deg. Fahrenheit. Cool inserts in dry ice for 45 minutes. Place the cylinder head bottom up on a bench, blow out the counterbores for the inserts with compressed air. Lay an insert on the counterbore, valve side up. Then using a special locating and driving tool, insert the pilot end of the driver into the valve guide and drive insert down tight into its counterbore.

CAUTION—This operation must be done quickly, before the valve seats get warm. Finally check the valve seat for concentricity with valve guide and, if necessary, recondition the new seat as directed in the next paragraph.

RECONDITIONING VALVE AND VALVE SEATS

1938-46: Before either a new or used valve is installed, the valve seat should be examined for proper seating. Before an old valve is re-installed, the valve stem should be cleaned and the seat reground to a true angle of 45 deg.

NOTE—If the bore in the valve guide is worn oblong, or if valve heads are warped relative to the stem, the defective parts should be replaced.

The width of the valve seats in the cylinder head should not exceed 3/64". When new valve seat inserts are installed, or old ones are refaced, the work must be done with a grinding wheel since the valve seat insert material used is too hard to be refinished by ordinary grinding methods.

Two grinding wheels are needed to do the job properly. A 45 degree grinding wheel is used for refacing the valve seats. A 70 degree wheel is used for narrowing the seats to standard 3/64" width. The concentricity of the valve seats should always be checked relative to the valve guides after they have been ground.

All valves should be lapped in place after the seats have been trued up, both in the cylinder head and on the valve head.

CAM FOLLOWERS

1938-46: If the cylinder head has been removed from the cylinder block, it is very easy to take the cam followers out from the lower side of the cylinder head. First remove the rocker arms by loosening lock nuts and unscrewing from the push rods. Next lay the cylinder head edgewise on the bench and remove the screws that attach the valve follower guides to the cylinder head. Remove the guides. The cam follower retainer springs, spring retainers and push rods, as an assembly, can be removed from the lower side of the cylinder head.

It is also possible to change a push rod from the upper side of the cylinder head. A special tool is provided to place between the lock nut on the push rod and the cam follower spring. Using this tool, the spring can be compressed so that a screw driver will dislodge the locking ring wire from the groove in the cylinder head. With the lock wire dislodged, the push rod may be removed and the cam follower may be pulled out of the top of the cylinder head.

Cam rollers in push rods must always be checked. They should rotate smoothly and freely on their needle bearings. If the bearings or pins have worn sufficiently to allow more than .005" radial movement of a roller, the follower assembly should be renewed. The roller should be checked for flat spots or scuff marks. If these exist, or if the rollers do not turn freely, it is important to check the camshaft also and see if it is worn or scuffed. If so, it should be replaced.

PISTONS

1938-46: The top of the piston is designed to form the combustion chamber and, therefore, must be fitted very carefully to the cylinder. Two bronze bushings pressed into the piston pin bosses provide a bearing for the hardened floating piston pin. After the piston pin has been installed, the hole in the piston at each end of the pin is sealed with a tight seal cap and locked in place with a steel spring clip. A balancing rim is provided on the inside of the bottom of the piston skirt. By using this design, all pistons

can be balanced to within .02 pound, whether the piston is standard or oversize. Because of this feature, one or more over-size pistons may be installed in an engine in which the other pistons are standard size, without upsetting the engine balance.

Six cast iron piston rings are used. Four ⅛" wide compression rings are placed above the piston pins and two 3/16" wide oil control rings scrape off excess lubricating oil at the lower end of the piston.

PISTON & RING INSPECTION

1938-46: Gummy deposits on the piston walls and piston ring grooves are not easily removed. Simonize-Chrome cleaner or its equivalent has been found best to remove this gum. **Then the pistons should be carefully dried with compressed air.**

The coating on the piston skirt is about .0007" thick, and the presence of this coating of soft metal will, therefore, indicate the practical absence of wear. If the coating is worn off, the cylinders and the pistons should be carefully inspected for score marks. A badly scored piston should never be used again. The standard clearance between cylinder liner and piston skirt is from .006" to .008". All measurements of pistons and cylinder liner bores should be taken at room temperature or 70 degrees F.

All measurements of piston skirts should be taken lengthwise and crosswise through the piston. The piston should be round to within .001". The cylinder bore should be round and straight to the same limit. In checking piston clearance with a feeler, the standard .006" clearance between the piston and the liner will be indicated by a free pulling of a .005" feeler.

Three sizes of pistons are available: standard size, .010" and .020" oversize.

Cylinder liners are furnished in standard sizes only. The installation of oversize pistons is only necessary when standard liners have been rehoned.

The ring land lying above the top compression ring is not plated as it does not touch the cylinder wall. If this part of the piston shows a coating of hard carbon, the top ring should be removed and the piston surface as well as the ring grooves should be thoroughly cleaned.

Any thick coating of carbon on the parts indicates failure of cooling oil supply and necessitates the cleaning of orifice at lower end of connecting rod, spray jet at upper end of connecting rod, and oil passages in connecting rod.

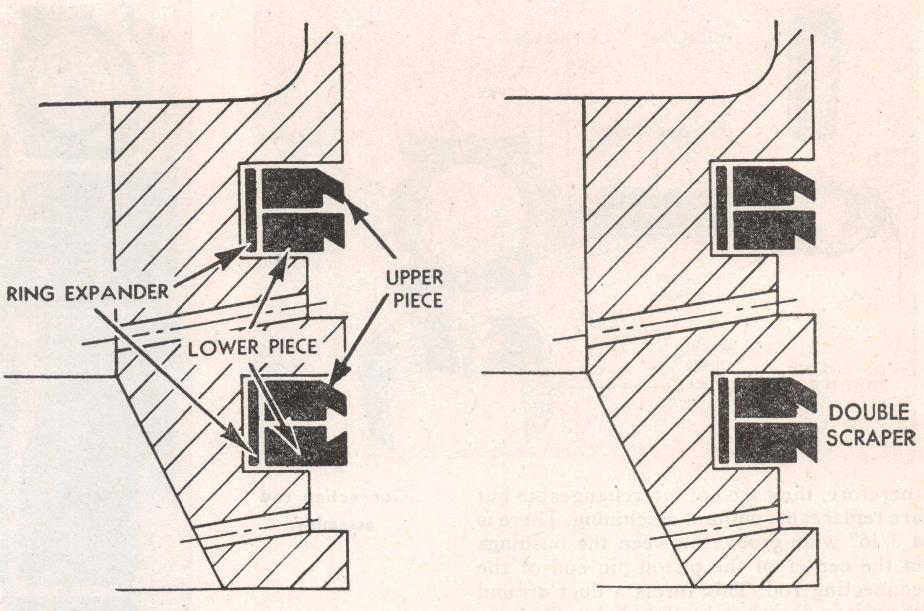
To avoid any ring breakage, it is advisable to use a special tool for removing or replacing them.

NOTE—Never over-stretch the piston rings by spreading the ends further than is necessary to slip them off and on the piston. New piston rings should always be used with new pistons. It is always advisable to use new rings when installing old pistons again.

FITTING PISTON RINGS

1938-46: When fitting pisotn rings, the gap between the end of the rings should be measured with the rings inserted in the bore parallel with the top of the cylinder block.

The specified gap on the compression rings is from .018" to .020" and on the oil control rings at the bottom of the piston, from .013" to .018".



Revised piston ring arrangement. Left view shows the old assembly with the bottom ring inverted. Right view shows the bottom ring hook down—forming a double scraper. See text for engine number break when this latter assembly became effective.

REVISED PISTON RING ARRANGEMENT

Effective with engine serial numbers 3713834, 4714786 and 6719873, all production engines will have the two oil control piston rings installed in the double scraper position, i.e., all hooks facing down in place of the No. 5 ring in the double scraper position and No. 6 ring in the hydraulic position (bottom half inverted). See sketches for differences between old and new method of piston ring installation.

In line with the above production change, it is recommended that field service follow the same procedure for installing piston rings in the field at time of engine reconditioning, since this new arrangement has proved to be the most satisfactory for more effective oil control.

PISTON PIN BUSHINGS

1938-46: If the occasion requires, piston pin bushings may be removed from the piston and new bushings installed. Usually the piston needs to be renewed before the bushings are worn.

A special tool is needed to remove the piston pin bushings. The piston should be placed on a V-block with the piston pin hole in alignment with the hole in the center of the block. Through the bottom of the piston insert a driver block on the inside of the piston pin bushing. Then through the opposite piston pin opening, drive the rod and bushing out of the piston boss. Reverse this operation for the bushing on the other side of the piston.

Installing piston pin bushings is done exactly the opposite way, except that they are inserted from the outside of the piston. A stop block should be provided on the inside of the piston to prevent inserting the bushing too far. It is very important that these bushings be reamed to exact size and absolutely square with the piston surfaces. This is something that can only be done with a special reaming fixture. The correct diameter of the reamed bushing should be 1.5025" plus .0005" minus .000". These limits are so close that the bushings should be rough-reamed first and then finish-reamed. When the work has been done properly, the piston pin will slip smoothly through both bushings with no perceptible shake.

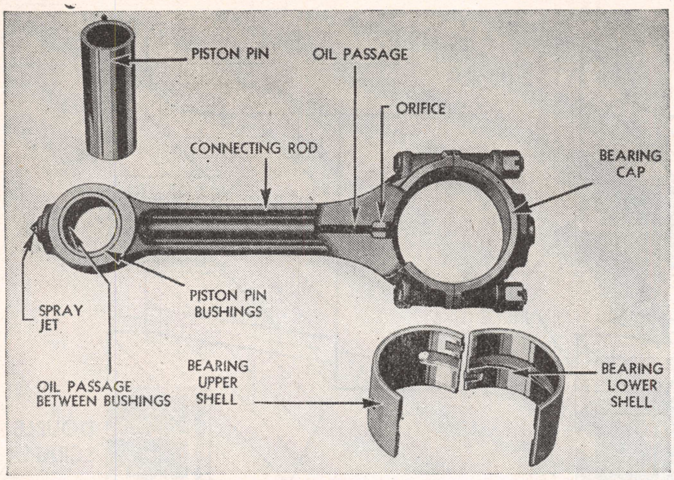
PISTON & RODS, REMOVE

1938-46: The piston and connecting rod assembly can be removed from the top of the cylinder block after removal of the other necessary engine parts listed below: remove cylinder head; remove oil pan; remove the lubricating oil pump and discharge line assembly, where necessary, remove the carbon from the upper inside diameter of the cylinder liner; remove the cotter pins, nuts and bearing cap from the lower end of the connecting rod and push the piston and rod assembly out through the top of the cylinder block.

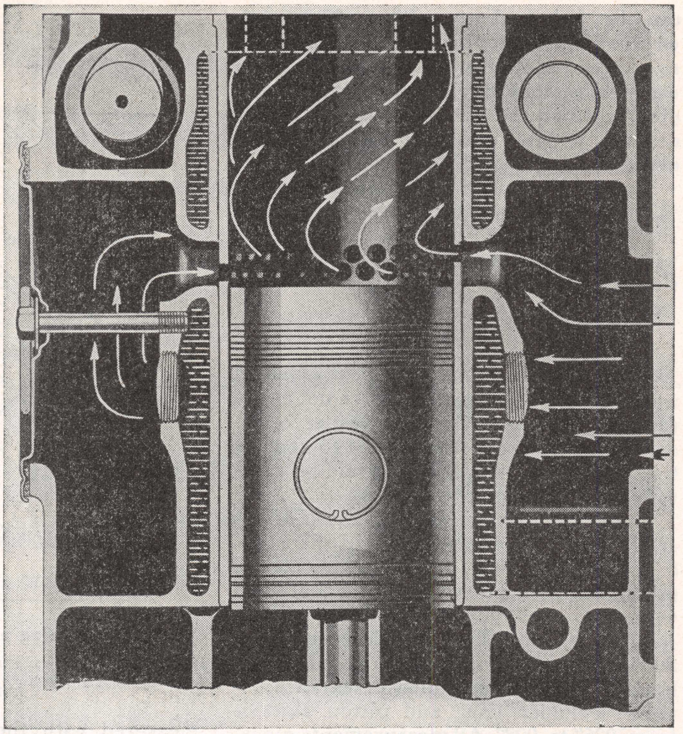
CONNECTING RODS

1938-46: The rod is rifle drilled for lubrication of the upper end and is equipped with an oil spray jet for cooling the piston head. The lower end of the connecting rod shank is fitted with an orifice which meters oil to the rifle drilled connecting rod. The crank pin bearings are steel-backed, lead-bronze lined shells of the precision type without any shim adjustment.

NOTE—The upper and lower halves of the connecting rod bearing shells are different,



Connecting rod assembly.



CYLINDER. Showing air and water passages.

therefore, they are not interchangeable but are replaceable without machining. There is a 3/16" wide groove between the bushings in the center of the piston pin end of the connecting rod. This forms a duct around the piston pin whereby the pin bearings are lubricated, and oil can be forced to the spray jet above it. The upper connecting rod bearing floats on the piston pin the same way as the pin floats in the piston bushings.

The orifice and spray jet in the connecting rod are not removable. The lower end bearing shells, upper and lower halves, are replaceable without machining, and the upper end piston pin bushings are also replaceable. If the connecting rod piston pin bushings are removed and replaced, they must be reamed before use. To remove the piston pin bushings, it is necessary to use a special driver block, a driving bar, and a V-block designed for this purpose. The same tools are used in replacing the piston pin bushings. Each bushing is pressed into the rod until the outer end of that bushing is flush with the outer edge of the rod. This will leave an oil space approximately 3/16" in width between the inner end of the bushings, for the passage of oil to the spray jet. Then the newly installed piston pin bushings must be reamed parallel to the bearing bore at the lower end of the connecting rod.

To insure a good job, it is necessary to rough ream the bushings first, and then complete with a finishing reamer. If the work has been done properly, the pin will slip through the bushings with no perceptible shake.

In servicing the connecting rods, the piston pins should not show any appreciable wear. If they do, they should be replaced. The oil holes in the orifice at the lower end and the spray jet at the upper end of the connecting rod, should be thoroughly cleaned out and then blown dry with compressed air.

The connecting rod bearing load is on the upper half of the shell only. Any wear, therefore, will show on the upper half of the shell. If connecting rod bearing trouble is suspicioned from the running of the engine, the upper half of the shell should be first examined for scoring, chipping, cracking, or signs of overheating. The backs of these bearing shells should also be inspected for any bright spots. Bright spots on the back of the shell will indicate that shells have been moving in their supports and are unfit for further use. If any of these conditions exist, they must be renewed and the lower half of the shell also changed.

If crankshaft journals have been badly scored, they may be reground to accommodate .010", .020" or .030" undersize shells.

INSTALL PISTON AND ROD ASSEMBLY

1938-46: The lower end of each connecting rod, as well as the caps, are stamped on one side, 1, 2, 3, etc. These numbers identify the caps with the rods and show the particular cylinder in which each rod is used. These positions should always be maintained when rebuilding an engine. The marked side of the rod always faces the blower side of the cylinder block.

Before inserting the pistons and connecting rods, be sure the ring gaps around the pistons are staggered. Apply clean engine oil to the piston and rings and then slide the piston ring compressor tool over the lower end of the piston skirt with the flared end toward the top of the piston. Turn the piston and rod assembly so that the identification mark on the lower end of the connecting rod is toward the blower side of the cylinder block. Then by tapping the upper end of the piston with a wooden block, drive the piston into the cylinder bore. Wipe, clean and lubricate each connecting rod crankshaft journal. Install bearing shell with the **one short groove** at each parting line in the connecting rod and position rod on **crank shaft journal**. Next install a bearing shell with the one continuous groove—from parting-line-to-parting-line, into bearing cap. With lip of shell in groove of cap, put cap and shell in place on the journal. Be sure the marks on the bearing caps and connecting rods are together. Lock caps securely in place with bearing cap bolts and nuts and install cotter pins. Install lubricating oil pump. Attach oil pan and fill to prescribed level. Attach cylinder head.

NOTE—When using new pistons, rings, main bearings, or connecting rod bearings, operate engine for ten (10) hours on a run-in schedule.

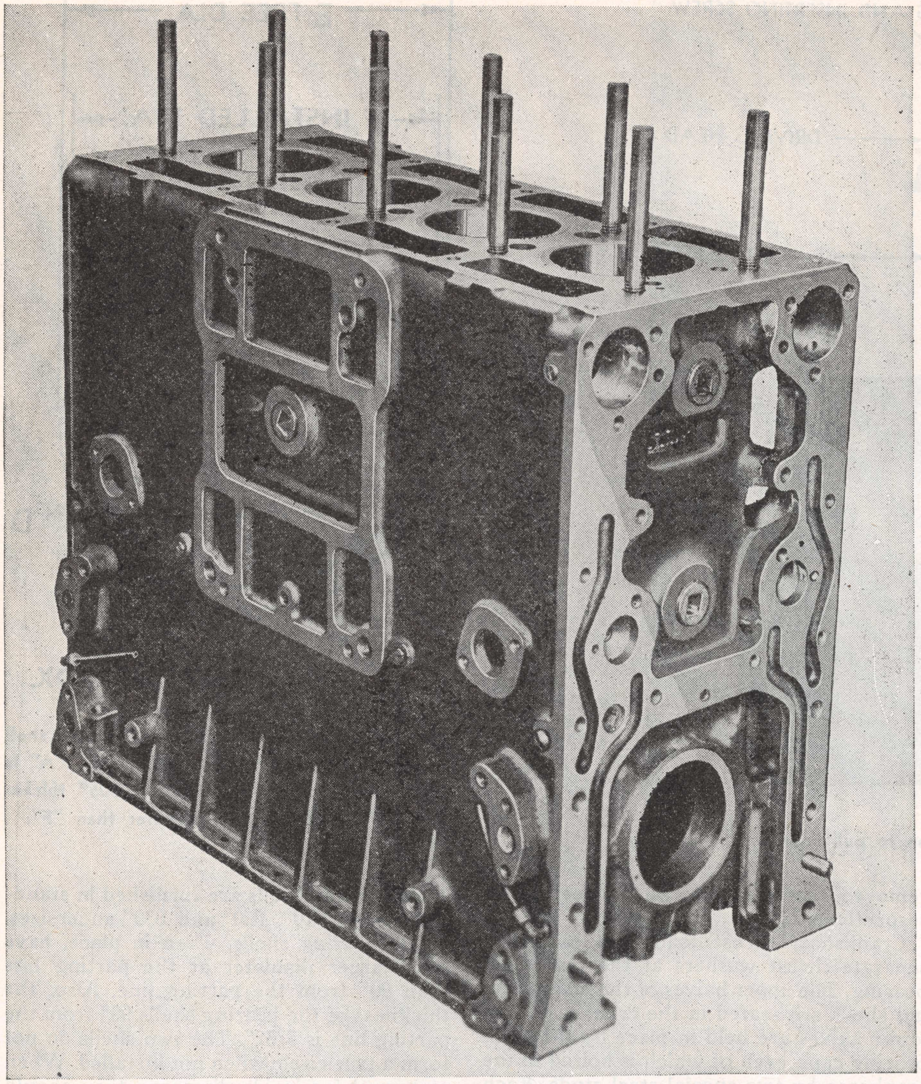
CYLINDER BLOCK

1938-46: The cylinder block and crankcase are in one structural piece. The two ends of the block are absolutely identical so that the same flywheel housing and gear train could be put on either end of any one of the three models. Hand-hold plates on the side opposite to the blower permit access to the air chamber, and inspection of pistons and rings through the air intake ports in the cylinder walls. The six-cylinder engine has two hand-hold plates on the blower side.

REMOVE & REPLACE CYLINDER LINER

1938-46: The replaceable cylinder liner is made of hardened cast alloy iron and accurately honed to a smooth finish. The flange at the top of the liner fits into a recess in the cylinder block, insuring proper positioning in the cylinder block. To permit introduction of fresh air into the cylinder, sixty-four 5/16-inch ports are drilled into the circumference of each cylinder liner. These ports are arranged in two rows, thirty-two holes to a row, and are equally spaced and staggered around the cylinder.

NOTE—Starting with engine numbers 3711474, 4712187 and 6712455, the cylinder



CYLINDER BLOCK. Four-cylinder shown.

liners were fitted loosely in the cylinder block. Engines built previous to these numbers have a pressed-in liner. Such engines are not serviced in the same way as those with loose liners.

All cylinders liners are honed to a standard size and are ready for use in the cylinder block when obtained.

When a cylinder liner change is indicated due to wear or scoring, the old liner may be removed from the cylinder block and a new liner installed, or the old liner may be honed to either a .010″ or .020″ oversize and reinstalled.

REMOVE CYLINDER LINER

(Loose Fit)

The following preliminary operations are necessary before removing a cylinder liner: Remove the cylinder head; remove the oil pan; remove the lubricating oil pump and discharge line assembly, together with the pump drive shaft; remove pistons and connecting rod assemblies;

NOTE—Before attempting to remove the pistons from the cylinder block, scrape the carbon from the upper inner diameter of the cylinder liner.

Since the cylinder liners are a loose fit, they may be removed easily from the top of the cylinder block by hand after loosening with a tool that has been especially designed for this purpose. This is called a liner puller tool.

REMOVE CYLINDER LINER

(Press Fit)

The cylinder liners used for either a press fit or for a loose fit in the cylinder block are identical. It is the bore in the cylinder block that is different. When a liner removal is necessary from a press fit job, it is recommended that a loose rather than the original press fit liner be installed. To make this change, the bores in the cylinder block for the liners must be honed to a larger diameter to provide for the looser fit.

NOTE—A cylinder block should never be used with some liners loose and others a press fit. All liners must be removed before an old cylinder block is honed for loose liners.

As hone grit will ruin an operating engine, **the recommended practice is to strip the cylinder block completely, remove all liners, hone, and then thoroughly clean the block in a solution of hot soda or its equivalent.**

There is only one difference in removing a pressed-in liner. With the loose fitting liner the puller is only needed to start the liner. With a tight liner the puller tool must pull the liner its entire length.

HONING CYLINDER BLOCK

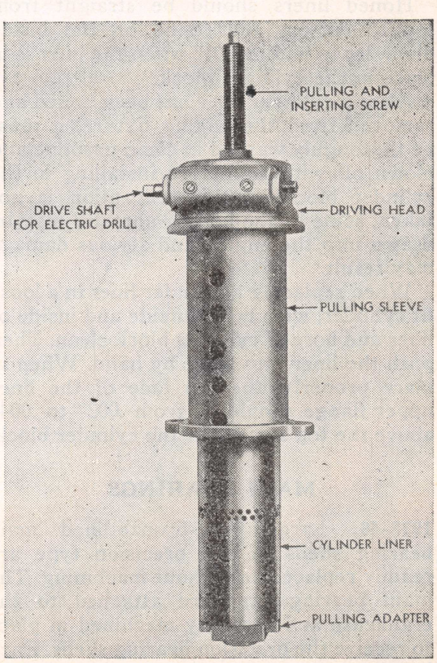
1938-46: All cylinder blocks that have had a pressed-in liner should be honed before new liners are installed. The procedure is as follows: remove oil, dirt and grease from the bore and inlet port openings. Measure the bore for high spots at the most narrow section. Liners are fitted from .000″ to .002″ loose. The first clearance produces a firm and push fit. The .002″ clearance allows the liner to slide freely into place. A straight, round bore of 4.6265″-4.6275″ diameter in the block produces a factory fit.

NOTE—Distortion may cause low spots that will not clean up on the bore of a cylinder. A low spot is not objectionable above the port if it does not exceed the size of a half dollar. Below the ports, larger spots are permissible.

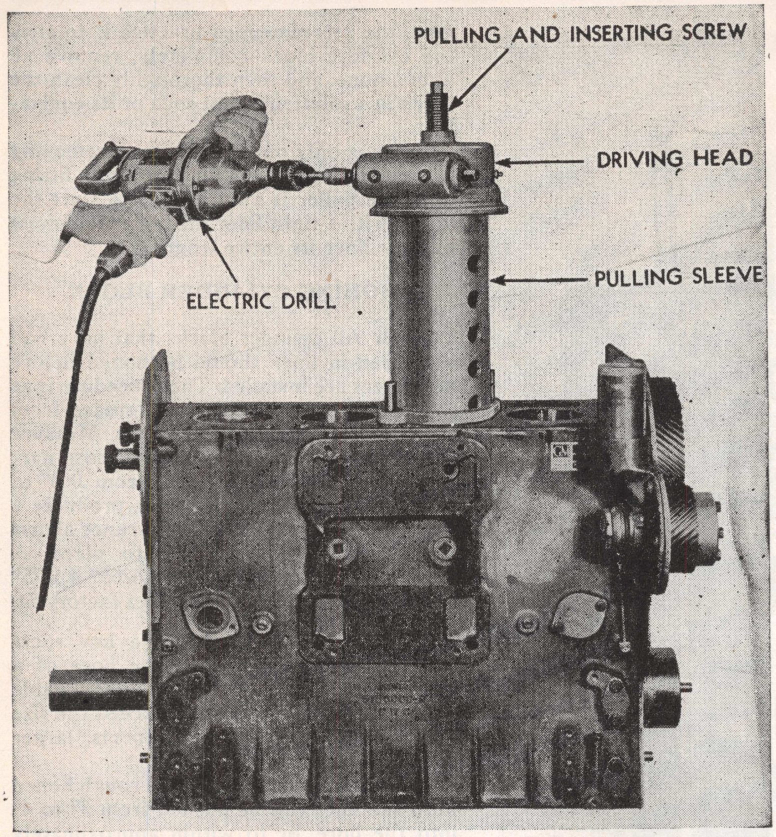
The cylinder block should be rough honed until the liner can be pushed from 3″ to 4″ into the bore, or to within approximately .0005″ of the outside diameter of the liner. Do not expect finishing hones to remove more than .001″ of stock, or to true up the bore to any extent. When the bore has been properly honed, the liner should enter the bore either with a light push slip or a free slip in.

HONING CYLINDER LINERS

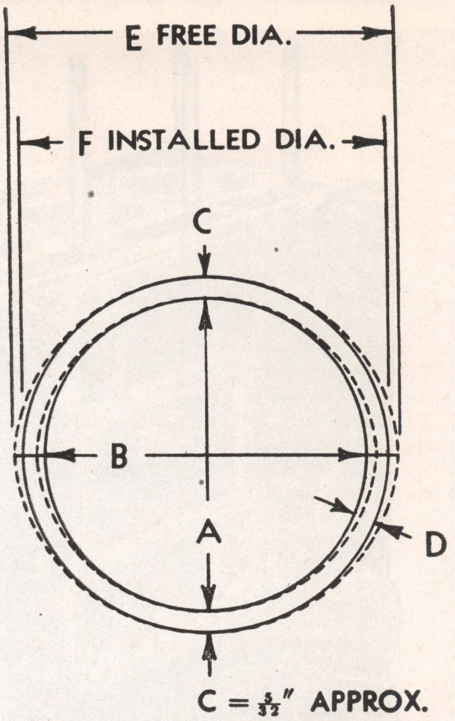
1938-46: A cylinder liner may be honed on the inside diameter and used again if the



Cylinder liner removing tool.



Showing cylinder liner tool in position to pull liner.



Showing inside diameter of main bearing shell at parting line and 90° to parting line. "A" is .001" smaller than "B". "C" is .0005" thicker than "D". "E" is .030" greater than "F".

honing operation is carefully done in the proper manner. The safest way of honing cylinder liners, to be sure that none of the abrasive used gets into the air box or ports, is to remove the liners from the cylinder block itself and place them in a special honing fixture. Then hone to the proper size. After honing, the liners may be replaced in the cylinder block.

Honed liners should be straight from top to bottom and round on the inside diameter to within .001" when the liner is in place in the cylinder block.

After a cylinder liner has been honed and removed from the honing fixture, it must be thoroughly washed in clean gasoline and blown off with air before installing in the cylinder block. If this precaution is not taken, some of the honing abrasive may be drawn into the engine and serious damage may result.

When replacing a cylinder liner in a loose fit cylinder, wipe both outside and inside of liner and bore in cylinder block clean. Then push the liner into place by hand. When in place properly, the top face of the liner upper flange should be from .002" to .004" above the top surface of the cylinder block.

MAIN BEARINGS

1938-46: Large, lead-bronze-lined main bearing shells of the precision type are readily replaceable without machining. The main bearing caps are attached to the crankcase and carefully machined in place to receive the precision bearing shells. Each bearing cap is marked 1, 2, 3, etc., and when removed should always be replaced in its respective position.

Crankshaft thrust loads are taken by separate thrust washers at the rear main bearing. The upper halves of the main bearing shells are seated in the crankcase. The lower halves are held in place by the main bearing caps, each of which is bolted to the crankcase by two special steel studs. Each half of the bearing shell is prevented from endwise or radial movement by a tang at the parting line on one side of the bearing. Each bearing cap is locked from sidewise movement by a milled slot in the crankcase.

MAIN BEARING SHELLS

1938-46: All upper halves of main bearing shells are alike. These shells carry a circular groove midway between the bearing edges which runs from parting-line-to-parting-line, and furnishes registration with the oil holes in the crankshaft journals at all times. An oil hole in this groove midway between the parting lines provides oil registry with holes in the cylinder block, by way of the bearing shells, and to the drilled passages in the crankshaft leading to the various connecting rod bearings.

NOTE—All lower halves of the main bearing shells are alike **but have no oil grooves;** consequently, the upper and lower halves of these bearing shells are not interchangeable.

The clearance between the main bearing shells and the crankshaft journals is from .002" to .004" and should not exceed .008". Main bearing shells are furnished in standard, also in .010", .020" and .030" undersizes.

The bearing shells, when in place, have .001" larger diameter at the parting line than 90° from the parting line. Also, the thickness of the bearing shells 90° from the parting line is 5/32". The two shells do not form a true circle when not installed. When measured for inside diameter, they should be installed in the caps and block, with caps bolted in place.

The two halves of the shells have a squeeze fit in the case and cap, and must be tight when the cap is drawn down. The shells may be measured with micrometers at the points marked "C" (see cut), and any variation from 5/32" will show the amount of wear on the particular shell being measured.

MAIN BEARING SHELLS, REMOVE

1938-46: When removal of upper half of main bearing shells becomes necessary and the removal of the crankshaft is undesirable, this operation can be performed by using the following procedure:

NOTE—All main bearing journals except the rear are drilled for an oil passage. The procedure, therefore, for removing the upper half of the shells, with crankshaft in place, is somewhat different on the drilled journals than on the one that is not drilled.

On the three and four cylinder engines, the lubricating oil pump assembly is bolted to one of the main bearing caps and the pump drive sprocket and bearing assembly is bolted to the front main bearing cap. If necessary, remove the oil pump and discharge pipe assembly, or the drive sprocket bearing, and then the bearing cap.

Two-piece thrust washers are used each side of the rear main bearing. These washers will be removed when removing the rear main bearing cap.

The bearing cap having been removed, insert a 1/4" x 1" bolt with a **1/2" diameter and a 1/16" thick head** into the crankshaft main bearing oil hole, then revolve the shaft to the right (clockwise) and roll the bearing shell out of position. The head of the bolt should not extend beyond the outside diameter of the shell.

The upper half of all the main bearing shells may be removed in the above manner except the rear main. On this bearing, the upper shell must be removed by driving on the edge of the bearing shell with a small curved rod, at the same time revolving the crankshaft, thus rolling the shell from position.

MAIN BEARING SHELLS, INSTALL

1938-46: To install a main bearing shell with the crankshaft in place, reverse the sequence of operations for removal.

NOTE—The upper and lower halves of the main bearing shells are not alike. The upper half is grooved for lubrication and the lower half is not. Be sure always to install the grooved shell in the crankcase and the non-grooved shell in the bearing cap, otherwise the oil supply to the bearing will be cut off.

When replacing the upper half of main bearing shells with crankshaft in place, start the end of the shell having no tang around the crankshaft journal, so that when shell is in place tang will fit into groove in the shell support.

With lower half of bearing installed in bearing cap, replace cap and draw tight. The caps should first be drawn up snugly, then rapped sharply to align the bearing shell. The cap stud nuts may then be tightened and locked.

NOTE—Since the bearing shells have a squeeze fit in the cap and block, bearing cap nuts should be drawn tight so shells will not shift.

If bearings have been installed properly, the crankshaft will turn freely with all main bearing caps bolted tight.

Install lubricating oil pump or drive sprocket bearing assembly if removed.

NOTE—Locate oil pump and drive sprocket assembly so that pump drive shaft does not bind at either end. All the main bearing load of these engines is carried on the lower half of the bearings only. If main bearing trouble is suspicioned from the running of the engine, remove the oil pan; then, remove the main bearing caps—one at a time—and examine the bearing shells. As no load is imposed on the upper half of the shell, this half may not require changing. Bearing shells are furnished as upper or lower halves separately.

CRANKSHAFT

1938-46: If main bearing or connecting rod trouble is suspicioned, the oil pan and the main bearing caps, as well as the connecting rod bearing caps, should be removed one at a time and the lower half of the main bearing shells and the upper half of the connecting rod bearing shells inspected for scoring, chipping, cracking, or signs of overheating. If crankshaft has been overheated, examine the journals for cracks. The backs of the bearing shells should also be inspected for any bright spots. Bright spots on backs of the shells will indicate that shells have been shifting in their supports, and are unfit for further use.

If the crankshaft journals do not show signs of scoring, overheating, or abnormal wear, it will be unnecessary to remove the crankshaft as the condition may be corrected by changing the worn half of the bearing shells only.

Loose main bearings will be evidenced by the wobbling of the flywheel or a drop in oil pressure.

NOTE—If the crankshaft journals show signs of over-heating or are badly scored, then the crankshaft must be removed from the engine and either changed or reconditioned. The journals may be reground to either .010", .020" and .030" undersize and undersize main bearing shells used. If the crankshaft journals have been over-heated, the heat-treating will be destroyed and a new crankshaft should be used.

CRANKSHAFT, REMOVE

1938-46: When crankshaft removal becomes necessary, the operation may be performed as follows:

Drain the cooling system and oil pan. Remove the oil pan. Remove the lubricating oil pump, discharge pipe and drive shaft assembly. Remove the lubricating oil pump driven sprocket and bearing assembly from the front main bearing cap on three and four-cylinder engines. On the six-cylinder engine, the sprocket is keyed to the pump shaft and will be removed together with the oil pump assembly. Remove the flywheel. Remove the combination gear train cover and flywheel housing. Remove the crankshaft front cover from cylinder block end plate. Remove the connecting rod bearing caps. Remove the main bearing caps. Remove the thrust washers from each side of the rear main bearing. Remove the spacer (next to oil slinger) from front end of crankshaft. Remove the crankshaft, timing gear, oil pump drive sprocket and drive chain as an assembly.

The crankshaft must be installed by reversing the sequence of operations for removal as described above.

After the bearing upper shells have been placed in the crankcase, apply some clean engine oil to all crankshaft journals and set crankshaft in place. When setting the crankshaft in place with the timing gear bolted to the crankshaft flange, be sure the timing marks on the gears align as explained under TIMING GEARS.

Next install the two-piece thrust washers on each side of the rear main bearing.

The main bearing caps are numbered 1, 2, 3, etc., indicating their respective positions. The marked side is always toward the blower side of the cylinder block.

NOTE—When tightening bearing cap bolts, rap caps a couple of sharp blows with a hammer to assist in positioning shells.

NOTE—If bearing has been properly installed, the crankshaft will run freely with all main bearing caps bolted tight.

Shellac new gasket to bolting flange of crankshaft front cover, and attach to cylinder block with lock washers and cap screws —finger tight only. Do not tighten cap screws until after front spacer is put in position.

Replace the spacer on front end of crankshaft next to the oil slinger, as shown. If harmonic balancer is used, spacer is not used.

NOTE—This spacer must not be put in place until after the front cover is in place, otherwise the oil seal in the cover may be destroyed.

Use assembly tool and install the combination gear train cover and flywheel housing by:

(a) Shellac new gaskets to bolting flanges of flywheel housing.

(b) Install the oil seal assembly tool on the two dowels at rear end of crankshaft, put housing in place and secure with lockwashers and cap screws.

NOTE—The tool shown, or its equivalent, must be used when locating flywheel housing; otherwise the leather of the oil seal will be destroyed.

Using two "T" head studs, set flywheel in place over the two dowels and secure with six cap screws. Omit lock washers, but lock cap screws with a continuous wire through head of each screw with ends of wire twisted together.

OIL SEALS

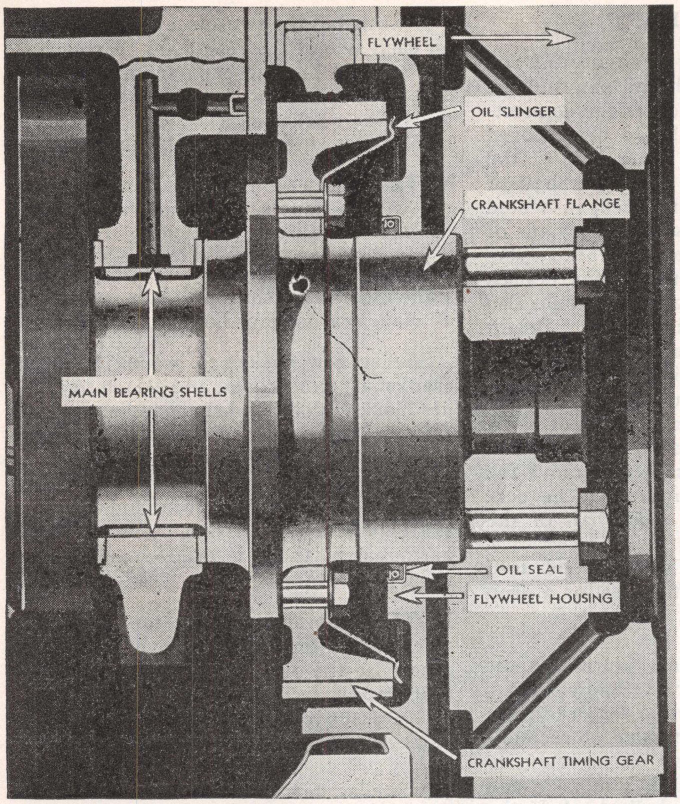
1938-46: An oil seal is incorporated in the rear main bearing. This seal consists of a special treated leather ring (seal) and an oil slinger attached to the rear face of the crankshaft timing gear. The leather is held snug against the crankshaft by a coil spring and prevents oil from creeping along the journal into the flywheel compartment. The leather ring and coil spring are readily replaceable.

An oil seal of the same design is used forward of the front main bearing. New seals should be soaked in engine lubricating oil for at least an hour before installation.

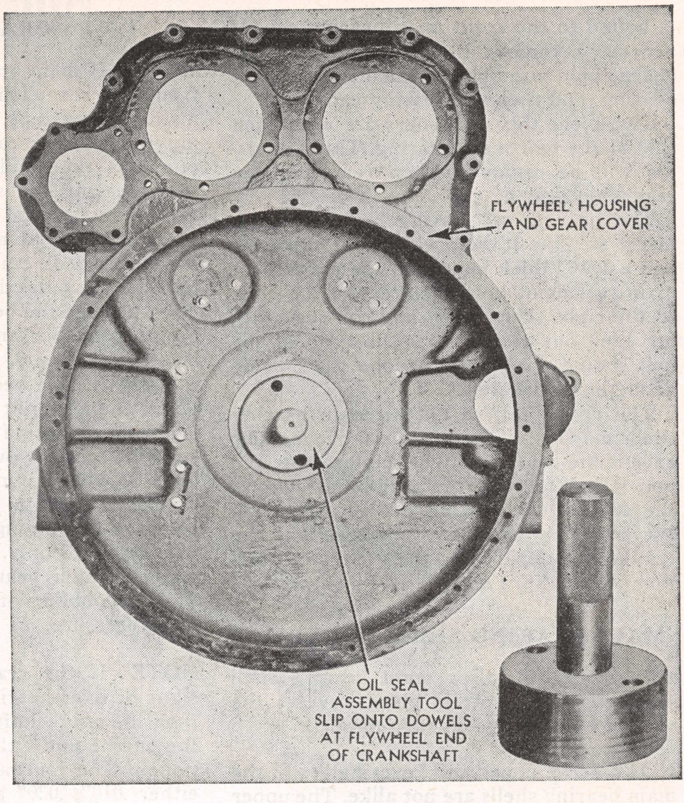
FLYWHEEL

1938-46: The flywheel is bolted securely to a flange on the crankshaft and doweled in two places. One of the bolting studs being off-set, the flywheel can be attached to the crankshaft flange in only one position.

A starter ring gear made from heat-treated steel is shrunk onto the rim of the flywheel. The ends of the teeth are cham-



Rear main bearing oil seal.


FLYWHEEL HOUSING AND GEAR COVER
OIL SEAL ASSEMBLY TOOL SLIP ONTO DOWELS AT FLYWHEEL END OF CRANKSHAFT

Installing crankshaft rear oil seal.

tered on both sides, so the same flywheel can be used on either a right or left-hand rotation engine.

To replace a ring gear, the flywheel must be removed, the old gear removed by grinding notch through ring at root of tooth, and a new gear shrunk onto the flywheel.

The ring gear is shrunk onto the flywheel by uniformly heating the gear to 450° F. (red heat visible in the dark), and then placing it in position on the flywheel, which should be at room temperature.

The clutch or any other parts attached to the flywheel housing having been removed, the flywheel may be removed from the crankshaft flange by removing the lock wire and six capscrews, and sliding the flywheel off the two dowels by means of "T" head studs.

ENGINE OILING

OIL CIRCULATING SYSTEM

1938-46: The lubricating system consists of an oil pump, an oil strainer, an oil filter and an oil cooler, with a suitable relief valve in the oil pump, and a by-pass valve between the oil pump and the oil strainer, to insure positive engine lubrication.

The oil strainer, of the double screen type, is introduced directly into the lubricating system between the oil pump and the oil cooler. All the oil from the pump passes through the strainers.

NOTE—On early engines, a spring-loaded by-pass valve, placed in the line between the oil pump and oil filter, by-passed oil directly from the pump to the lubrication system in the engine if the pressure at the filter inlet becomes from 25 to 30 pounds greater than the pressure at the oil cooler outlet. On later engines, a plunger type valve is used in place of the ball type and the nominal opening pressure of the plunger type valve assembly is 40 pounds per square inch.

The oil (sludge) filter, of the replaceable pack type, is introduced into the lubricating system beyond the oil cooler, and only a portion of the oil delivered from the pump, passes through this unit. Oil entering the filter is bled off one of the oil passages in the cylinder block, forced through the filter packs, and returns directly to the engine crankcase.

Oil circulation is effected by a gear pump which delivers the hot oil through the strainers, then through the oil cooler. After leaving the cooler the stream divides; a portion of the oil is then delivered directly to the main gallery in the cylinder block, the remainder passes through the sludge filter.

OIL PUMP

1938-46: The gear lubricating oil pump is mounted on one of the engine main bearing caps inside the oil pan. On the three and four-cylinder engines, a drive sprocket and bearing assembly is supported on the front main bearing cap and driven by a chain from the crankshaft. A self-aligning coupling connects the drive sprocket shaft with the oil pump shaft. On the six-cylinder engine, this coupling is unnecessary inasmuch as the drive sprocket is keyed directly to the pump shaft, and the outer end of the shaft is supported at the sprocket from a continuation of the oil pump body casting.

An integral plunger-type relief valve, by-passes excess oil to the inlet side of the pump when the pressure in the oil lines exceeds 60 pounds per square inch. This corresponds to about 40 pounds per square inch at the rear end of the oil manifold where the oil pressure gauge is attached.

To protect the oil pump gears, and as an insurance against pump losing its prime, a screen of ample size is attached to the oil pump suction pipe, and partially immersed in the lubricating oil contained in the oil pan.

OIL PUMP, R&R

1938-46: To remove the lubricating oil pump: Drain oil pan and remove pan. Unfasten oil pump screen retainer and remove screen from cover. Loosen nuts from two bolts holding screen cover to supports and pump inlet pipe and two cap screws holding inlet pipe to pump body. Remove screen cover, intake pipe and gasket at pump body.

Remove two cap screws and lock washers retaining by-pass valve housing to cylinder block, also two cap screws and lock washers retaining oil outlet pipe to pump body. Remove oil outlet pipe and by-pass valve assembly, together with two gaskets.

On the six-cylinder engine, remove four cap screws and lock washers holding pump assembly to main bearing caps, and slip pump shaft sprocket from beneath drive chain. If engine is bottom-side up, support chain to prevent its dropping down inside crankshaft front cover.

On the three and four-cylinder engines, loosen pump assembly from main bearing cap and slip pump straight back off of drive shaft coupling. Remove coupling with pump.

With main bearing caps in place and the pump drive chain in position on the crankshaft sprocket, the lubricating oil pump may be installed as follows:

On the six cylinder, work sprocket on pump shaft under drive chain and secure pump assembly to main bearing caps with four lock washers and cap screws.

On the three and four cylinder, secure pump assembly to number two bearing cap but don't lock tight. Pump may need shifting later to align drive coupling.

Using new gasket, attach by-pass valve housing to cylinder block with two lock washers and cap screws.

Using new gasket at each end, attach oil outlet pipe to by-pass valve housing and oil pump body, with two lock washers and cap screws at each end.

NOTE—The two cap screws for oil outlet pipe to pump body must not exceed ⅞" in length.

When tightening cap screws on oil outlet pipe, shift drive coupling endwise at the same time. If coupling binds on shafts, loosen and shift sprocket bearing assembly, or perhaps outlet pipe, then retighten so coupling is free.

Position screen supports on the correct main bearing caps and with lock washers on cap screws, start them in place but do not tighten.

Using new gasket at pump end, secure oil inlet pipe to pump body for six cylinder, or pump cover for three and four cylinder.

Set screen cover—screen side facing oil pan—over casting at outer end of oil inlet pipe and bolt to outlet pipe casting and screen supports. Tighten screen supports to bearing caps. Attach oil screen and lock in place with wire retainer. Replace oil pan.

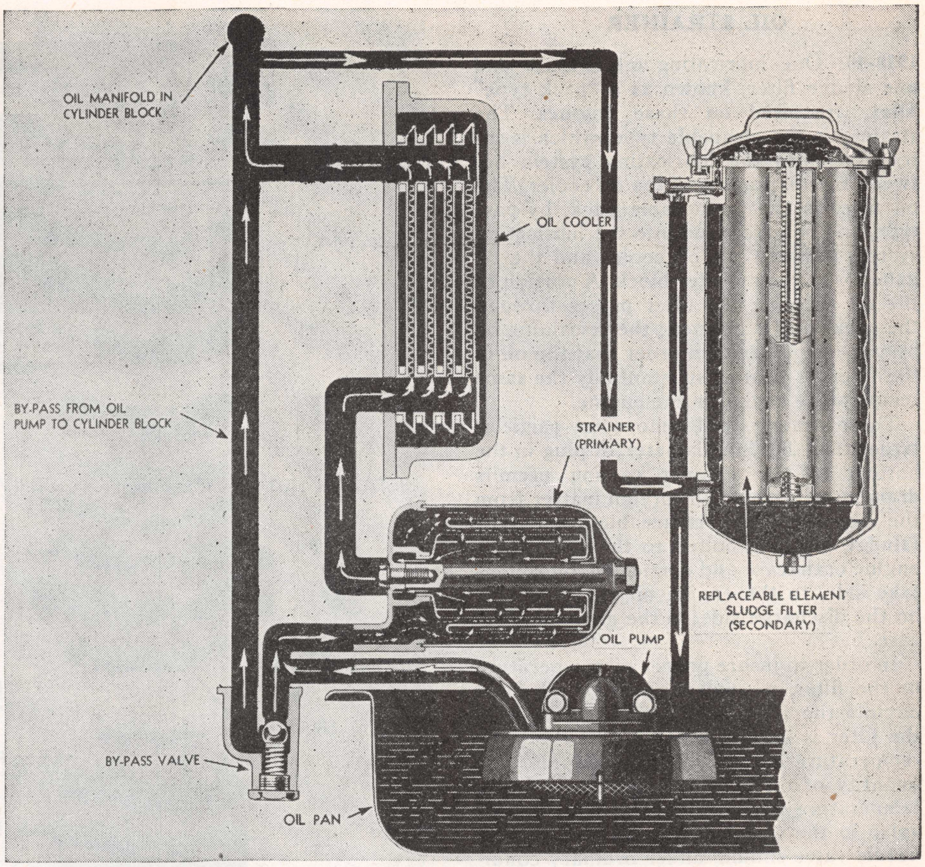
OIL PUMP, DISASSEMBLE

1938-46: Six-cylinder engines: If the oil pump is to be disassembled for inspection or repairs, the work may be carried out as follows:

NOTE—Time will be saved when assembling the oil pump if careful observation is made of the relative location of all pump parts when disassembling.

Remove the two retaining nuts and copper gaskets from each side of pump body, and jar relief valve assembly from body. Separate pump cover from body. Remove pump idler gear from stub shaft. Support pump body and drive shaft assembly, including sprocket, in bench vise; then by means of a gear puller, pull sprocket from pump shaft. Remove sprocket Woodruff key from shaft, and withdraw shaft and drive gear assembly from pump body.

Three and four-cylinder engines: Remove the two retaining nuts and copper gaskets from each side of pump body, and jar relief valve assembly from body. Separate pump cover from body. Remove pump idler gear from stub shaft. Support pump body and drive gear assembly on bed of arbor press—cover side up—and by means of arbor on gear end of pump shaft, press shaft through gear, thus removing gear and feather key from shaft.


OIL MANIFOLD IN CYLINDER BLOCK
OIL COOLER
BY-PASS FROM OIL PUMP TO CYLINDER BLOCK
STRAINER (PRIMARY)
REPLACEABLE ELEMENT SLUDGE FILTER (SECONDARY)
OIL PUMP
BY-PASS VALVE
OIL PAN

LUBRICATING OILING SYSTEM. Schematic diagram.

NOTE—Be careful not to cover key-way with arbor when removing gear, thereby preventing key from being removed with gear.

PUMP DRIVE SPROCKET & CHAIN

1938-46: With the oil pan removed, the oil pump drive sprocket, together with the chain, may be removed from the crankshaft as follows:

Remove cap screw holding dummy sleeve over front end of crankshaft, and remove sleeve. In the event any accessory drives are attached to front end of crankshaft, these drives will have to be removed before the following operations are performed.

Remove the cap screws which attach crankshaft front cover to cylinder block. Note different sizes and lengths of cap screws supporting this cover.

For the three and four-cylinder engines, disconnect oil outlet pipe from pump, and sprocket bearing assembly. Also loosen sprocket bearing assembly from front main bearing cap.

For the six-cylinder engine, remove lubricating oil pump and by means of a screw driver inserted back of drive sprocket, slide the sprocket, oil slinger and the spacer off end of crankshaft.

Note that the inner diameter of the crankshaft sprocket for driving the oil pump is chamfered at one end. When replacing sprocket and chain, the chamfered end must set next to the crankshaft main bearing. With Woodruff key in place, slide the sprocket into position over crankshaft, and drop chain over sprocket.

Slide the oil slinger over crankshaft with dished outer diameter away from sprocket.

NOTE—Do not put crankshaft front spacer next to oil slinger until after the front cover has been put in place. The oil seal in front cover may be damaged if slid over the spacer.

For the three and four-cylinder engine, install the pump driven sprocket and bearing assembly to front main bearing cap. Slide the crankshaft front cover into position over dowel pins and secure with lock washers and cap screws. Note different sizes and different lengths of cap screws are used in the cover. Use them in correct holes.

Slide the spacer over crankshaft, through the oil seal in cover, and up against the oil slinger. See that the outer diameter of the spacer is smooth, to prevent oil leaks through the cover, as this surface rubs on the oil seal.

Install the dummy sleeve, or accessory drive if used, over crankshaft stub, and lock in place with flat washer and cap screw.

OIL STRAINER

1938-46: One lubricating oil strainer and one sludge filter, known as a "pack type" filter, are used on these engines. The strainer is the cleanable type, which is introduced into the lubricating system between the oil pump and the oil cooler. The oil filter is the replaceable pack, by-pass type, and is introduced into the lubricating system between the oil cooler and the oil galleries in the cylinder block. A portion of the oil entering the filter passes through the packs and is cleaned; the remaining oil by-passes the packs in order that the oil in the filter be kept at substantially the same temperature as that in the engine.

These strainers will remove any particles larger than .005" in diameter. A plug in the bottom of the strainer casting permits draining of sludge and foreign matter from the housing. The replaceable pack type (sludge filter) is bolted to the side of the engine crankcase and connected, on the intake side, to the engine oil manifold and, on the discharge side, to the engine crankcase.

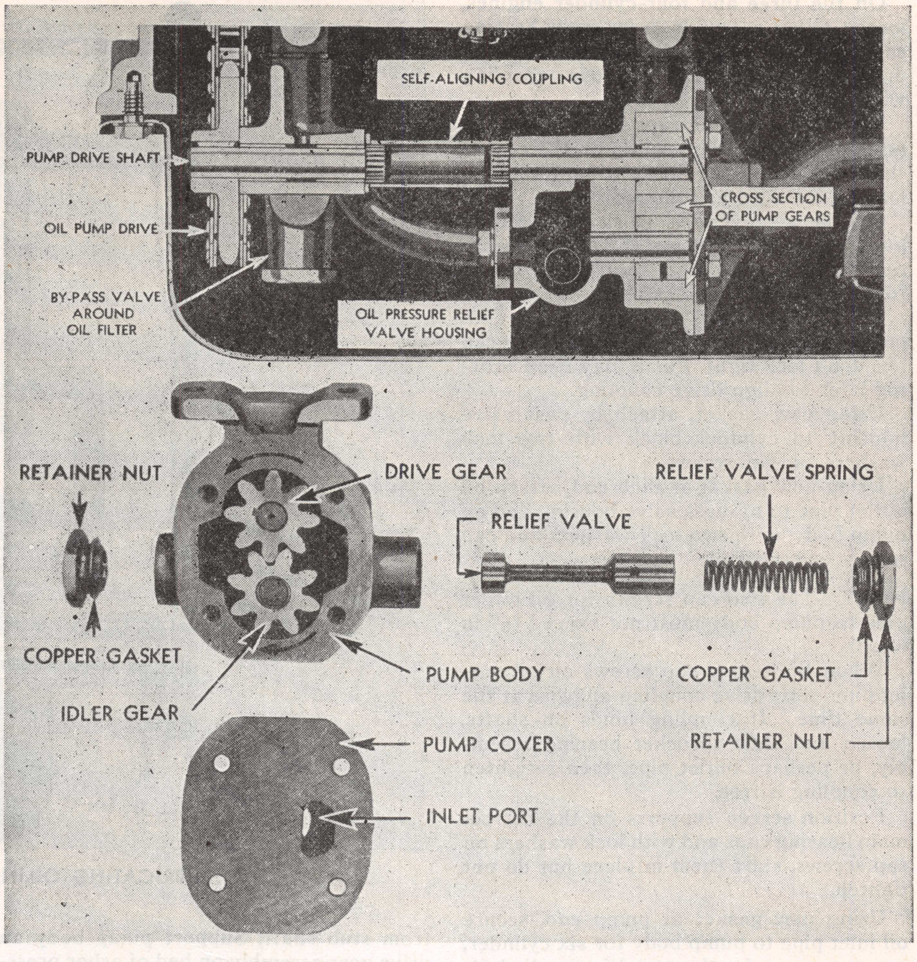
In order to insure proper oil temperature in the filter, a small amount of oil short circuits the filter packs so that the oil in the filter is kept at substantially the same temperature as that in the engine. The quantity of oil necessary to maintain this temperature is controlled by an adjustable valve in the outlet of the filter unit. This needle valve should, under ordinary conditions, be open one-half turn. If the filter runs cooler than the oil in the circulating system, the valve seat is clogged. In this event, close valve, then open ½ turn.

Cleaning oil strainers: The screens of the strainer should be cleaned after every 60, and not more than 75 hours (1,500 to 2,000 miles) of engine operation. It is very important that strainers be kept clean, because these units afford protection to the engine bearings. Proper cleaning of the strainers as directed will materially lengthen the life of the engine parts.

For cleaning the strainer elements, the unit must be removed from the engine. This is done by backing out the cap screw from the filter header casting and removing the filter and screen assembly from the header. After the screens have been removed, they should be thoroughly washed in carbon tetrachloride, or fuel oil. Simply washing the outside of the screen is not sufficient—the washing should continue until the sludge is removed from between the screen and the metal strip inside the screen. **Do not use wire or hard bristle brush or scraper as these methods will damage the straining elements.**

After the screens have been thoroughly washed, the unit may be assembled and mounted to the header. Be sure that all parts of the unit are assembled in their correct relative positions. When re-attaching the retaining cap screw, see that the copper gasket is under the head of screw to prevent oil leaks at the header.

All sludge filters: To clean the sludge filter: Shut off the oil intake valve at the bottom of the filtering unit (if one is used). Remove wing nuts at the top of the filter and lift the complete assembly out of the steel body.



LUBRICATING OIL PUMP. 3-71 and 4-71 engines.

(a) When air pressure is available, attach connection with a clip to the small oil outlet on the underside of the pack head, which is located between the filtering packs. Allow the air to blow through the filtering packs at least five or ten minutes. The cake of impurities will slide off the packs. When white foam appears the entire length of the packs, they are clean, and have been subjected to blowing for a sufficient length of time.

(b) If compressed air is not available, use scraper and brush furnished with the equipment. Scrape off the heavy cake of solids and other contaminations that have collected on the outer edge of the flexible paper discs. Then, using fuel oil, or kerosene, clean the outside of the packs, with the circular brush supplied so that the edge of the flexible paper discs are clean and free from any contaminations.

Replace filter and pack head assembly to filter.

NOTE—Be sure oil inlet valve is turned on again. If this valve is closed, no filtering of the oil takes place.

Normally, cleaning is advised every 50 to 200 hours of engine operation or every 1000 to 2000 miles.

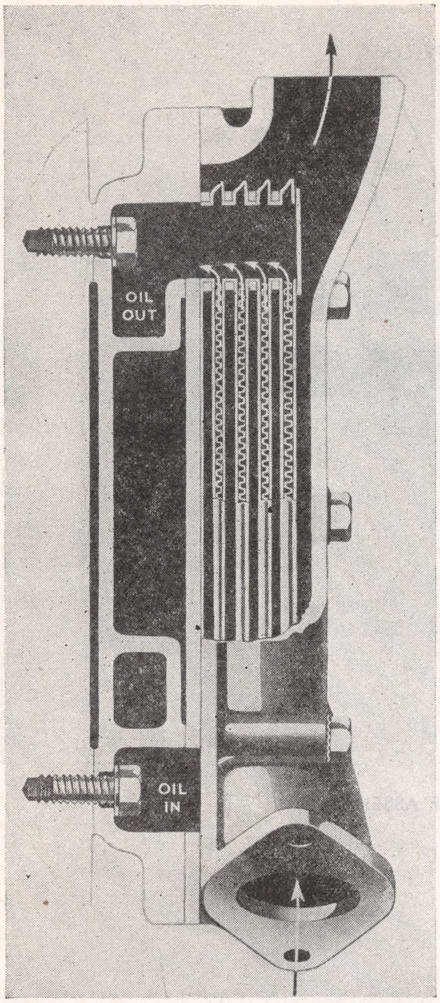
OIL COOLER

1938-46: Each engine is equipped with an oil cooler which not only cools the hot engine oil, but, by means of the cooling water temperature control, provides a means of rapidly raising the oil temperature during the warm-up period.

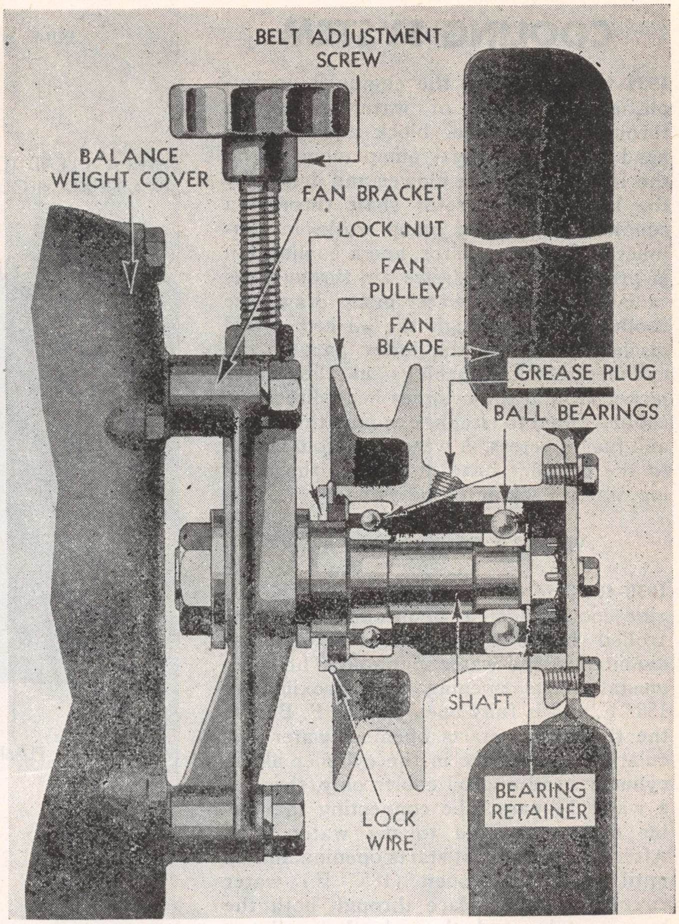
The hot oil enters the cooling unit at the bottom, flows through the inside passages and is discharged at the top into a vertical passage in the cylinder block.

NOTE—If occasion requires, the cooling unit may be removed from the cooler housing or the entire cooler assembly may be removed from the cylinder block. Since the element through which the oil passes, while being cooled, is surrounded by water inside a cast iron housing, the cooling element must be well sealed against water getting into the oil or oil getting into the cooling water. Whenever, therefore, the oil cooler is disassembled, special care must be taken at assembly to have the proper gaskets in place and the retaining cap screws tight.

To remove the lubricating oil cooler:



Lubricating oil cooler assembly.



FAN ASSEMBLY.

Drain cooling system and oil strainer. Disconnect water connection from radiator to lower end of oil cooler, at oil cooler. Break hose clamp connections between the water pump and oil cooler. Disconnect water tube from water manifold to oil cooler—at the cooler. Remove cap screws which attach the oil cooler cover casting to the combination adapter and oil strainer header, and remove the cover and oil strainer as an assembly.

NOTE—Be careful when withdrawing the assembly not to drop and damage the cooling element.

The function of the lubricating oil cooler is to lower the oil temperature by the surrounding water during the time the oil travels through the small passages within the cooling unit. If these passages are allowed to become choked with sludge, the oil flow will be restricted and the oil temperature will rise. If the passages become entirely plugged, no cooling of the oil can take place. It is absolutely necessary that the oil cooler unit be kept clean for proper oil cooling, as follows:

(a) If live steam is available, a jet of steam, mixed with a soapy substance, is a very effective cleaner. After cleaning, remove all traces of water by heating the cooler unit.

(b) If steam is not available, place the cooler unit in a vessel and fill with carbon tetrachloride, or with other suitable cleaner, to a level of at least one inch above openings in the unit plate. A force pump is suggested as a means of forcing the cleaning solution back and forth through the plates. This operation should be continued until unit is cleaned.

CAUTION—Cleaning with carbon tetrachloride is to be done in the open air or with adequate ventilation on account of the toxic qualities of the chemical.

The lubricating oil cooler is assembled and mounted by reversing the sequence of operations for removal. The order of the operation is:

Clean the old gaskets from the bosses where the oil cooler adapter sets against the crankcase, and affix gaskets to these bosses with shellac. Grease the other face of the gaskets. With the circular rubber gasket in place in the adapter, to receive the end of the oil filter steel body, slide the adapter into place and attach to cylinder block with the six cap screws. Put copper washer and cap screw in place at center of oil strainer. Clean the old gasket from both sides of the flange on the cooler element—from the finished face of the adapter and the finished face of the oil cooler cover, and shellac a new gasket to each flange of the cooler element. Grease the other face of these gaskets. Put the cooler element into position inside the cover, then set cover with element against adapter and secure with lock washers and cap screws. Replace water connections to oil cooler and fill cooling system.

CRANKCASE VENTILATION

1938-46: The crankcase and valve compartment are continually cleaned of harmful vapors by an automatic crankcase ventilating system.

A small vent pipe either connects the cylinder head to the blower intake or runs down the side of the engine and vents to the atmosphere, depending upon the type of installation. This pipe keeps the air inside the valve chamber and crankcase slightly below the normal outside atmospheric pressure.

In one case, the oil fumes and water vapors caused by condensation are sucked into the blower, burned in the engine and expelled through the exhaust system. In the other case, oil fumes and water vapors caused by condensation are discharged to the atmosphere.

A slight amount of scavenging air is forced past the oil control rings, keeping the drain holes free from sludge accumulations and providing clean ventilating air for the crankcase. As soon as the piston on its downstroke uncovers the ports, these fumes or fuel particles are blown back into the combustion chamber.

COOLING SYSTEM

1938-46: Cooling of the engine is accomplished by means of water circulation through the cylinder block and cylinder head by a centrifugal pump mounted on the front end of the blower and driven by the lower blower rotor shaft through a coupling. The water pump works in conjunction with a radiator, and a cooling fan is provided which draws air through the radiator core. The water pump draws the cooling water through the oil cooler and discharges it into the lower part of the cylinder block. Openings in the water jacket around the cylinder head direct the cooling liquid to circulate around the valves and fuel injectors. A water manifold bolted to the cylinder head discharges the cooling water back into the radiator.

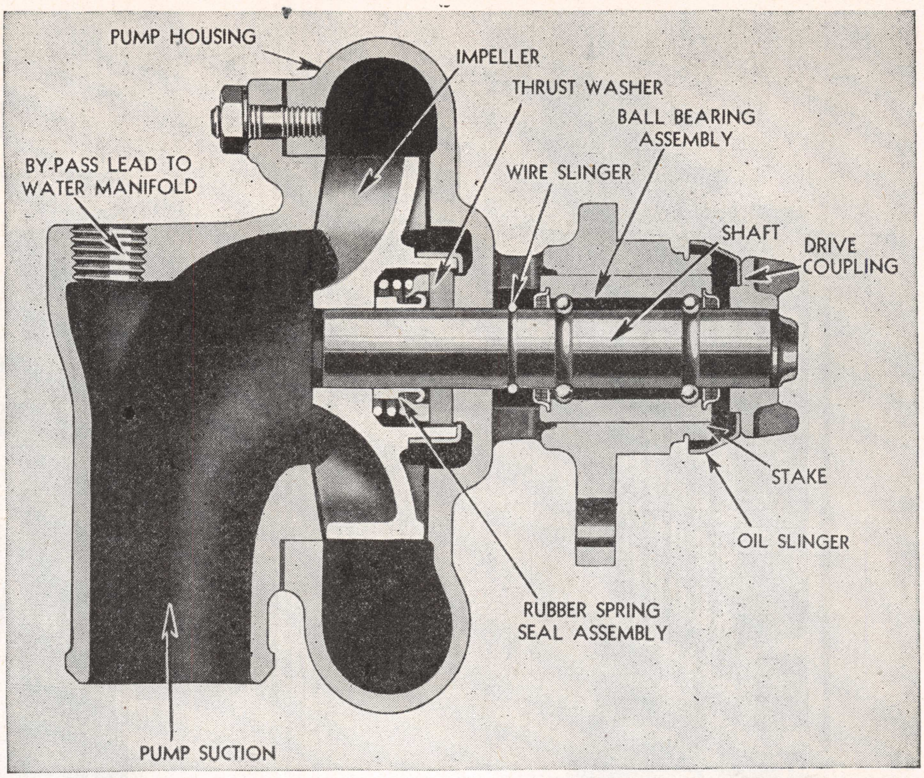
WATER THERMOSTAT

1938-46: The water temperature in the engine cooling system is automatically controlled by a by-pass type thermostat mounted in the water manifold. The thermostat starts opening at approximately 158° F. and is fully open at 185° F. Before the thermostat starts opening, water circulation takes place in the cylinder block, cylinder head and oil cooler only, through a water by-pass tube connecting the water outlet manifold to the water inlet. After the thermostat starts opening and up until it is fully open (185° F.) water circulation takes place through both the by-pass tube and through the radiator. After the thermostat has fully opened, water circulation takes place through the radiator and engine only—no circulation taking place through the by-pass tube.

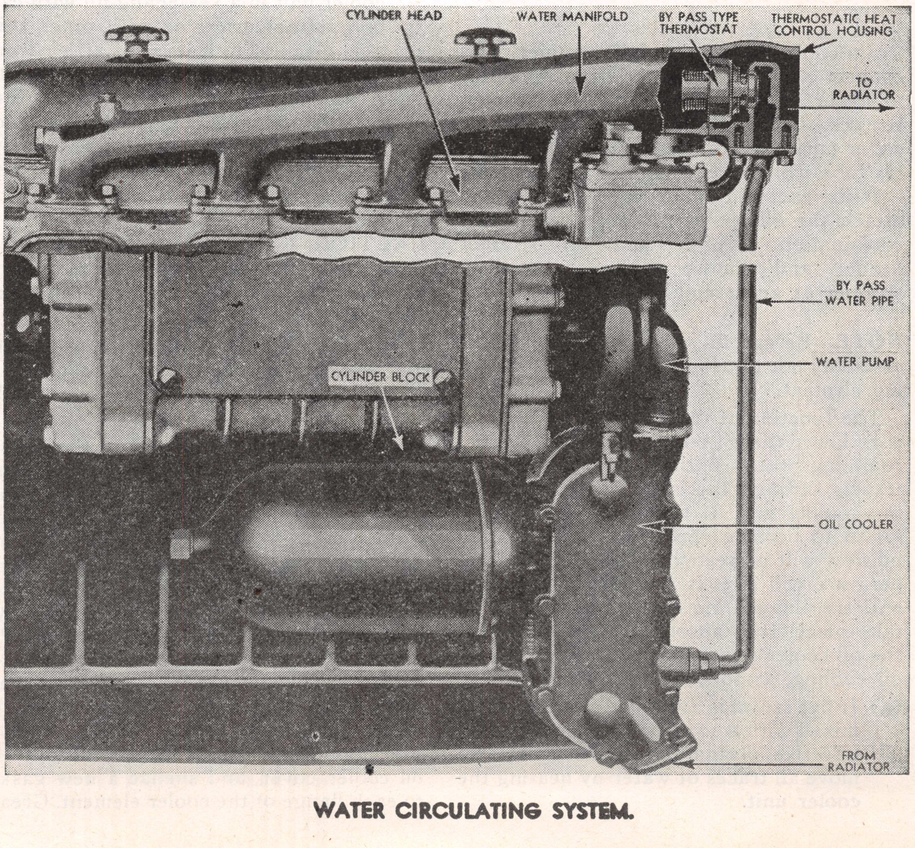
WATER PUMP

1938-46: A centrifugal type water pump is used for circulating the cooling liquid through the cylinder block, cylinder head, and the radiator. A bronze impeller is pressed onto one end of the case-hardened steel shaft and a pump drive coupling with an oil slinger is pressed onto the opposite end. The oil slinger shrouds the inner end of the pump body flange to prevent oil from creeping along the shaft and through the shaft bearing. The shaft is supported at the drive end on a sealed double-row combination radial and thrust ball bearing, and prevented from moving endwise by peening the pump housing at the inner end of the bearing.

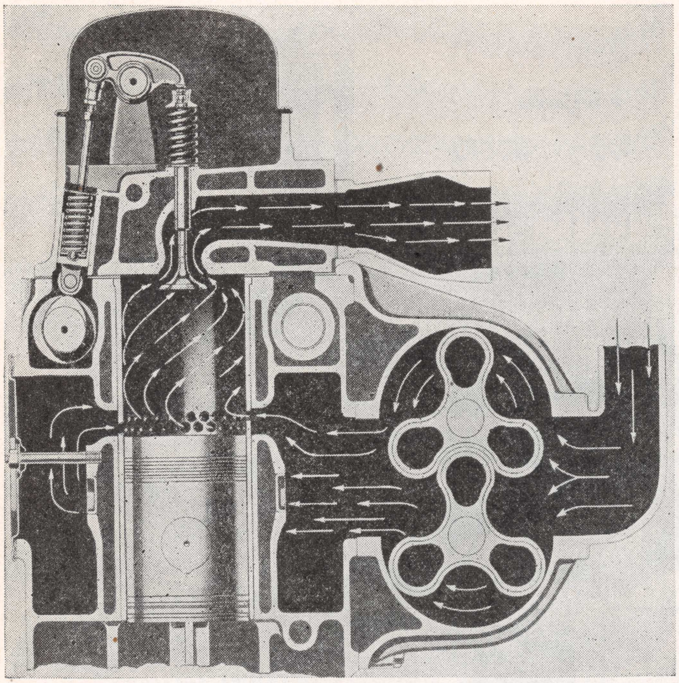
Overhaul: If removal of the spring seal assembly or the impeller is necessary, the following sequence of operations will apply: Remove pump cover. Support the water pump in an arbor press—flange down—and press the shaft out of the impeller. Shaft and bearing assembly will also be removed from the housing during this operation. If the water seal only is to be inspected or changed, no further disassembly is necessary and the new seal may be installed and pump reassembled. The water


PUMP HOUSING
IMPELLER
THRUST WASHER
BALL BEARING ASSEMBLY
BY-PASS LEAD TO WATER MANIFOLD
WIRE SLINGER
SHAFT
DRIVE COUPLING
STAKE
OIL SLINGER
RUBBER SPRING SEAL ASSEMBLY
PUMP SUCTION

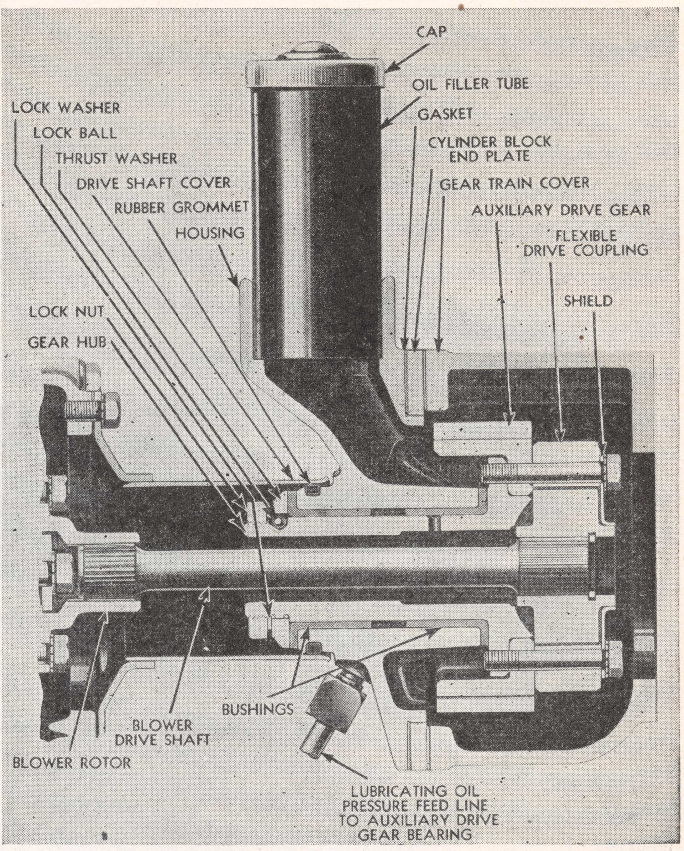
WATER PUMP ASSEMBLY.


CYLINDER HEAD
WATER MANIFOLD
BY PASS TYPE THERMOSTAT
THERMOSTATIC HEAT CONTROL HOUSING
TO RADIATOR
BY PASS WATER PIPE
WATER PUMP
CYLINDER BLOCK
OIL COOLER
FROM RADIATOR

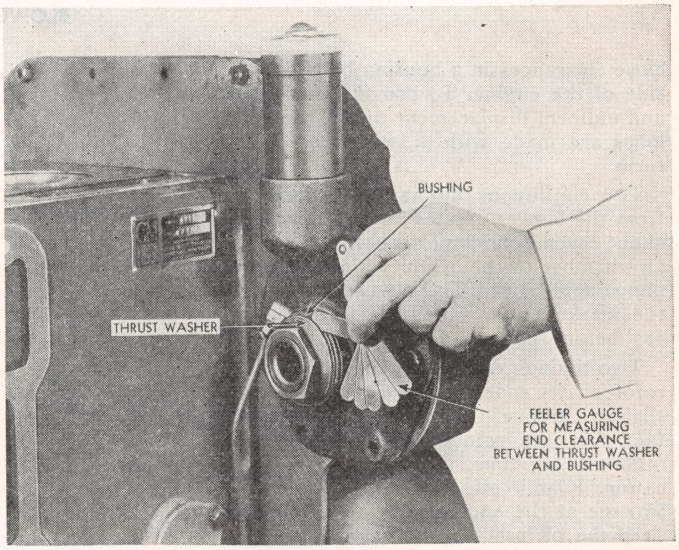
WATER CIRCULATING SYSTEM.



Air intake through blower and engine.


CAP
OIL FILLER TUBE
GASKET
CYLINDER BLOCK END PLATE
GEAR TRAIN COVER
AUXILIARY DRIVE GEAR
FLEXIBLE DRIVE COUPLING
SHIELD
LOCK WASHER
LOCK BALL
THRUST WASHER
DRIVE SHAFT COVER
RUBBER GROMMET
HOUSING
LOCK NUT
GEAR HUB
BUSHINGS
BLOWER DRIVE SHAFT
BLOWER ROTOR
LUBRICATING OIL PRESSURE FEED LINE TO AUXILIARY DRIVE GEAR BEARING

BLOWER DRIVE GEAR ASSEMBLY.


BUSHING
THRUST WASHER
FEELER GAUGE FOR MEASURING END CLEARANCE BETWEEN THRUST WASHER AND BUSHING

Checking end clearance of blower drive gear assembly.

seal is an assembly and is available with or without the impeller.

The water pump may be assembled by reversing the sequence of operations for disassembly. After the impeller or the drive coupling has been removed from the shaft, these parts cannot always be used successfully the second time. These parts are held onto the shaft solely by press fits and after they have been pressed onto the shaft, the metal stretches slightly and old impeller may turn on the shaft.

If a new shaft and bearing assembly is installed, the drive coupling may be pressed onto the outer end of the shaft before the bearing assembly is installed into the pump housing. The outer face of the coupling hub should be flush with outer end of shaft when in place.

COOLING FAN ASSEMBLY

1938-46: Fans for automotive applications are bolted to a fan pulley hub, which is carried on two annular ball bearings. A slotted bracket supports the fan shaft at the inner end. This construction permits vertical motion of the fan assembly and fan belt adjustment by means of the adjusting lock screw.

The two fan bearings are packed with grease when assembled and should need no further lubrication for the life of the bearings. The plug should be removed from the fan hub, however, before the engine is started to see that the bearings have been properly packed. If not, a good grade of fibre grease, such as is used in front wheel automobile bearings, should be introduced into the fan hub to fill completely the cavity between the two bearings.

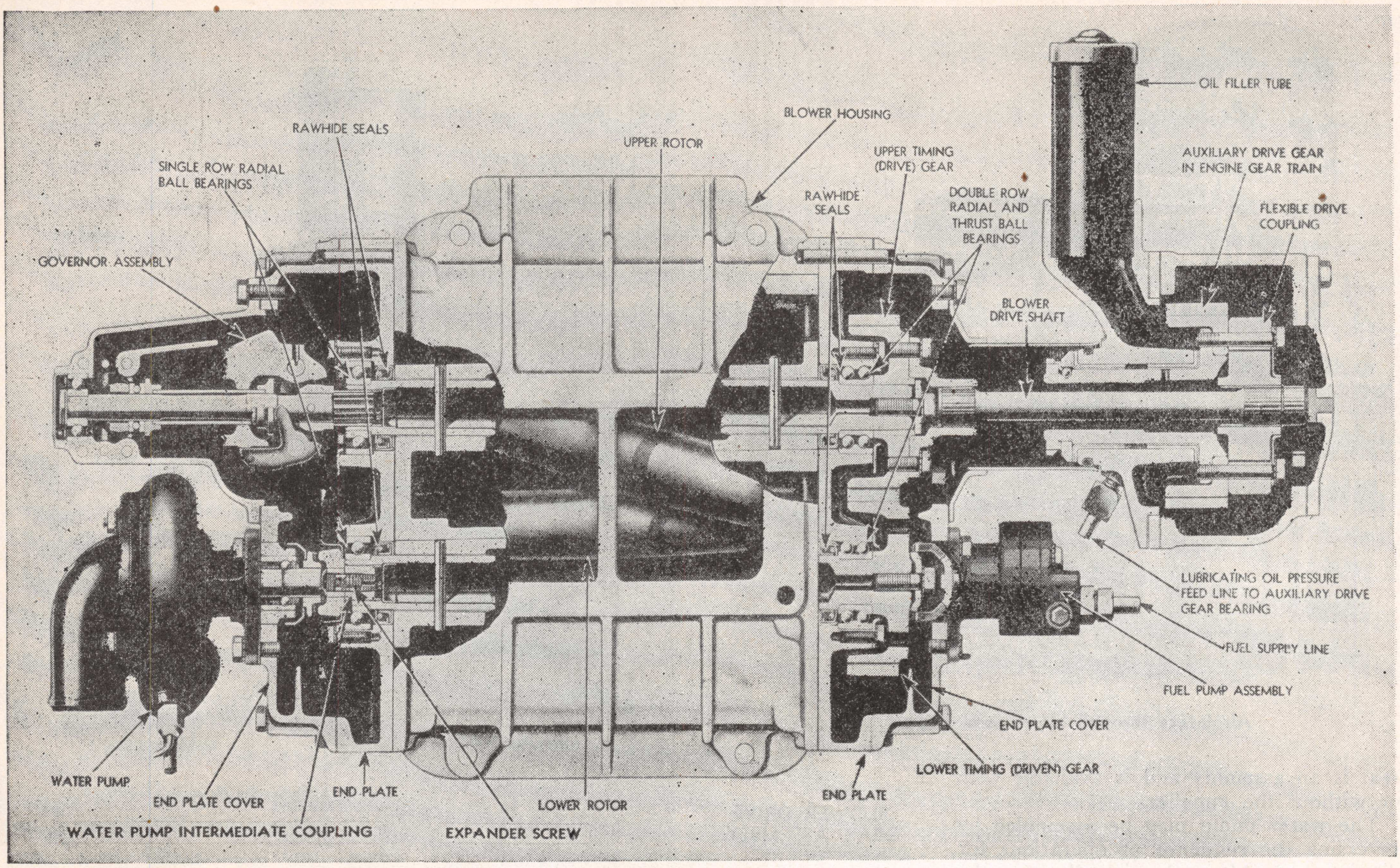
The V-type fan belt should be neither too tight nor too loose. Too tight a belt imposes undue load on the fan bearings and shortens the life of the belt. Too loose a belt allows slippage and lowers the fan speed. The belt may be adjusted by means of the adjusting screw at the front of the engine. To adjust the belt, loosen the large nut at the rear end of the fan shaft and the lock nut on the adjusting screw and turn the screw clockwise to tighten or counter-clockwise to loosen the belt. Lock both nuts tight after belt has been adjusted.

The belt should have enough slack so it can be pushed in approximately 1¼" from a straight line between the rims of the two pulleys, midway between the pulleys. This straight line can be determined by placing a straight edge on the rims of the pulleys.

AIR INTAKE SYSTEM

BLOWER

1938-46: The blower, designed especially for efficient diesel operation, supplies the fresh air needed for combustion and scavenging. Its operation is similar to that of a gear-type oil pump. Two hollow rotors, each with three lobes, revolve with very

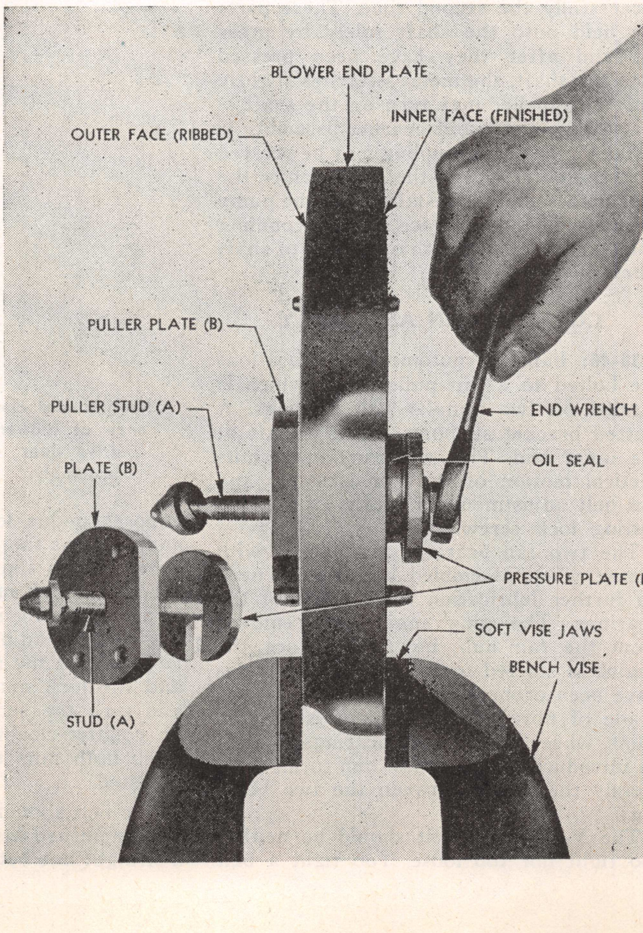

RAWHIDE SEALS
SINGLE ROW RADIAL BALL BEARINGS
GOVERNOR ASSEMBLY
UPPER ROTOR
BLOWER HOUSING
RAWHIDE SEALS
UPPER TIMING (DRIVE) GEAR
DOUBLE ROW RADIAL AND THRUST BALL BEARINGS
BLOWER DRIVE SHAFT
OIL FILLER TUBE
AUXILIARY DRIVE GEAR IN ENGINE GEAR TRAIN
FLEXIBLE DRIVE COUPLING
LUBRICATING OIL PRESSURE FEED LINE TO AUXILIARY DRIVE GEAR BEARING
FUEL SUPPLY LINE
FUEL PUMP ASSEMBLY
END PLATE COVER
LOWER TIMING (DRIVEN) GEAR
END PLATE
WATER PUMP
END PLATE COVER
END PLATE
LOWER ROTOR
EXPANDER SCREW
WATER PUMP INTERMEDIATE COUPLING

BLOWER ASSEMBLY.

close clearances in a housing bolted to the side of the engine. To provide continuous and uniform displacement of air, the rotor lobes are made with a twisted or helical form.

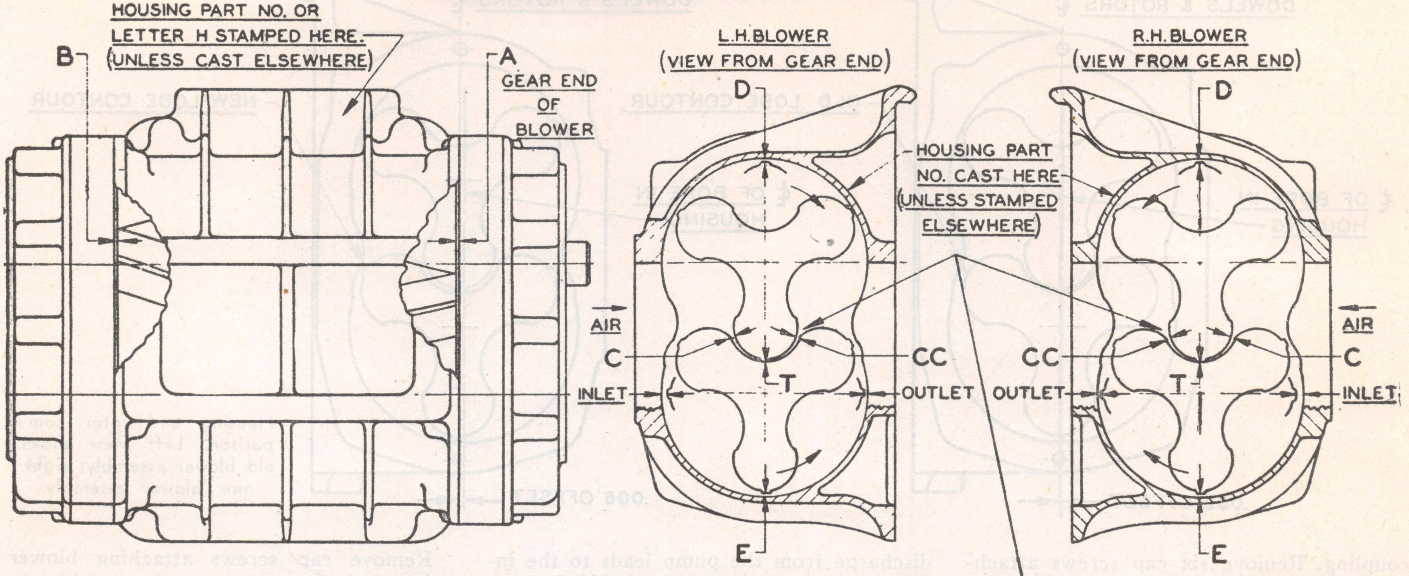
The continuous discharge of fresh air from the blower creates an air pressure of about seven pounds per square inch in the air chamber of the cylinder block at maximum engine speed. This air sweeps through the intake ports, which start to open at 48° before bottom dead center.

Two timing gears on the drive end of the rotor shafts space the rotor lobes with a slight clearance. Consequently, due to the fact that the rotors do not touch each other at any time, they require no lubrication. Highly effective seals prevent air leakage at the ends of the lobes, and also keep the oil used for lubricating the timing gears and rotor shaft bearings from entering the rotor compartment. The upper rotor is driven at 1.94 times engine speed by the blower drive shaft and the lower rotor is driven from the upper rotor through the timing gears. The flexible coupling which prevents the transmission of torque fluctuations to the blower is formed by an elliptical cam driven by two bundles of leaf springs, which ride on four semi-cylindrical supports. Each rotor is supported in the doweled end plates of the blower housing by a single-row radial ball bearing at the front, and a two-row pre-loaded radial and thrust ball bearing at the gear end.


BLOWER END PLATE
OUTER FACE (RIBBED)
INNER FACE (FINISHED)
PULLER PLATE (B)
PULLER STUD (A)
END WRENCH
OIL SEAL
PLATE (B)
PRESSURE PLATE (E)
SOFT VISE JAWS
BENCH VISE
STUD (A)

Installing blower oil seals.

BLOWER ROTOR CLEARANCE CHART



TIME ROTORS TO DIMENSION ON CHART FOR CLEARANCE BETWEEN TRAILING SIDE OF UPPER ROTOR & LEADING SIDE OF LOWER ROTOR (CC) FROM BOTH OUTLET & INLET SIDE OF BLOWER. (NOTE RELATION OF ROTORS AT THIS TIME.)

		A		B		C		CC	D		E		INLET		OUTLET		T	
		OLD	NEW	OLD	NEW	OLD	NEW	NEW	OLD	NEW	OLD	NEW	OLD	NEW	OLD	NEW	OLD	NEW
3-71	MIN.	.007	.007	.007	.007	.008	.012	.004	.008	⊕	.008	⊕	.009	.017	.005	.005	.010	⊕
	MAX.	.009	.009	.009	.009	.010	.018	.006	.010	⊕	.010	⊕	.011	.019	.007	.007	.012	⊕
4-71	MIN.	.007	.007	.009	.009	.008	.014	.004	.008	⊕	.008	⊕	.009	.017	.005	.005	.010	⊕
	MAX.	.009	.009	.011	.011	.010	.020	.006	.010	⊕	.010	⊕	.011	.019	.007	.007	.012	⊕
6-71	MIN.	.007	.007	.014	.014	.008	.016	.004	.013	⊕	.013	⊕	.014	.017	.010	.005	.010	⊕
	MAX.	.009	.009	.016	.016	.012	.022	.006	.015	⊕	.015	⊕	.016	.019	.012	.007	.012	⊕

⊕ - CHECKING DIMENSION NOT REQUIRED ON NEW ASSEMBLY.

CLEARANCE COMPARISON CHART

	—3-71—		— 4-71 —		— 6-71 —	
	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet
Old Rotors & Old Housing	.009-.011	.005-.007	.009-.011	.005-.007	.014-.016	.010-.012
Old Rotors & New Housing	.0135-.0155	.0015*-.0035	.0135-.0155	.0015*-.0035	.0185-.0205	.0065-.0085
New Rotors & Old Housing	.0125-.0145	.0085-.0105	.0125-.0145	.0085-.0105	.0125-.0145	.0085-.0105
New Rotors & New Housing	.017-.019	.005-.007	.017-.019	.005-.007	.017-.019	.005-.007

***This clearance insufficient. To correct, remove .004" from diameter of rotors.**

With the exception of the housing, rotors, and housing to cylinder block, and air inlet gaskets, which differ in length, the blower parts are identical for all engines and are completely interchangeable.

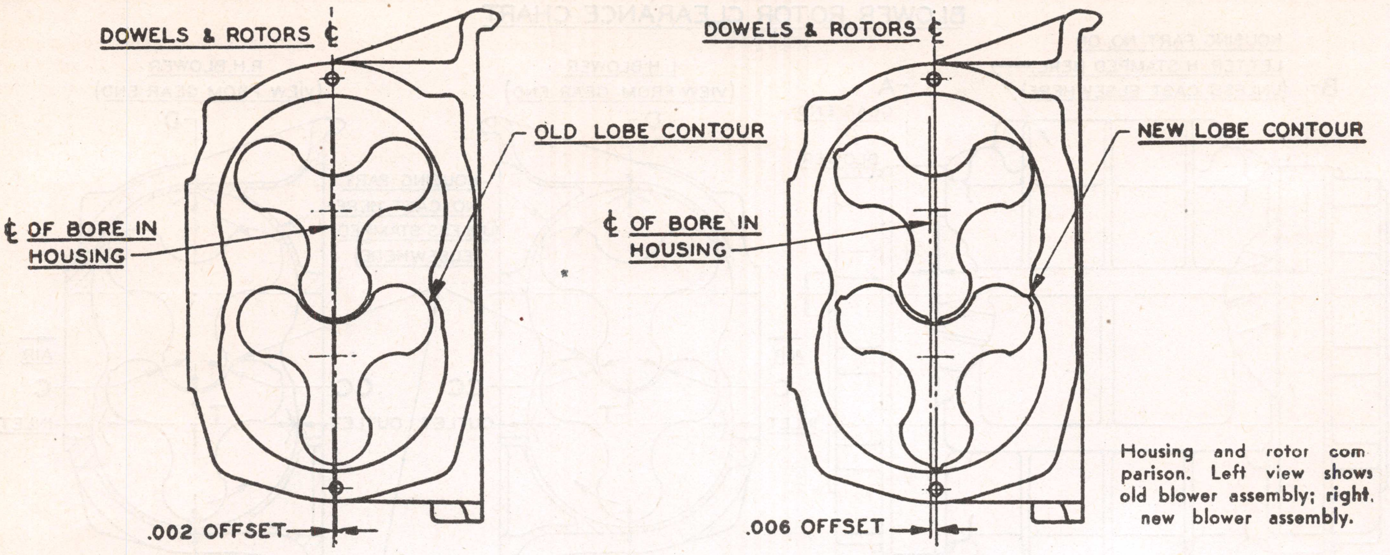
Blower inspection: The blower of a diesel engine should be inspected at regular intervals. These intervals would be after about 15,000 miles. A blower may fail to function properly because of any one, or a combination of the following reasons: Dirt or foreign matter having been drawn through the blower, thereby scoring the rotor lobes and housing. Worn oil seals permitting lubricating oil to be drawn into rotor compartment. Worn blower drive causing rattling noise inside blower. Loose rotor shafts or unsatisfactory bearings causing contact between rotor lobes, rotors and end plates or between rotors and housing. Out of time—that is, due to timing gear wear—the mating rotor lobes may not have sufficient clearance at one side and too much clearance on the opposite side.

Before examination of blower on the engine for any unusual conditions, remove air cleaners, blower air inlet housing, or any other parts interfering with the air inlet system.

CAUTION—When blower rotors are exposed and engine is in operation, keep fingers, clothing, and any loose parts away from the blower air inlet. Severe bodily injury, or damage to the blower may result.

CAUTION—Always disconnect starting battery cable to render engine starting equipment inoperative before starting work on a blower that involves use of the hands on blower rotors.

Remove & replace blower: In most cases, the removal of the blower assembly, together with the governor drive, the water pump, the fuel oil pump, and the blower drive shaft cover, will be found most advantageous. After the blower assembly has been removed from the engine, the various accessories may be removed as follows before the blower itself is disassembled: Remove three cap screws attaching fuel pump to blower rear end cover plate, and remove fuel pump and drive



Housing and rotor comparison. Left view shows old blower assembly; right, new blower assembly.

coupling. Remove six cap screws attaching blower drive shaft cover to the blower rear cover plate, and remove sleeve. Remove three cap screws attaching water pump to blower front cover plate, and remove pump by tapping pump housing lightly with copper hammer. Remove six cap screws attaching either governor drive or governor weight housing to blower front cover plate and withdraw governor drive shaft from blower rotor shaft.

To attach blower assembly to cylinder block (includes blower, fuel pump, blower drive shaft sleeve, water pump and governor drive):

Before attaching to engine, examine inside of blower for any foreign material and revolve the rotors by hand to check for smooth operation. Rough particles in the blower may score the rotors and impair blower efficiency. Shellac a new gasket to the cylinder block at the blower pad.

Install a new rubber grommet in the groove of the drive gear housing, which acts as an oil seal for the blower drive shaft sleeve. Apply some soap to the rubber. Slip water pump outlet packing flange—flat face out—and packing—flat face in—over pump discharge, also hose clamp and seal over pump inlet.

Avoid damage to gasket at blower pad on cylinder block, and slide the blower assembly into position with blower drive shaft registering with serrations in drive shaft flange and shaft sleeve sliding over rubber grommet in drive gear housing. Attach blower housing securely to cylinder block with lock washers and cap screws.

NOTE—The blower will slide into position easily if the blower drive shaft serrations are lined up with the mating serrations in the blower rotor shaft. Do not force the blower assembly into position and damage the serrations on the blower shaft.

Connect water pump intake to oil cooler casting. Connect water pump discharge to cylinder block.

The fuel line from the primary filter connects to the intake (opening closest to cylinder block) of the fuel pump and the discharge from the pump leads to the intake of the secondary filter. With these features in mind, apply some permatex, or its equivalent, to threads and attach fuel lines to pump.

Attach Blower Air Inlet Housing and Emergency Engine Shut-down. Since the function of the shut-down device is to choke off the air to the blower completely when the flap valve or valves are closed, the valves must set tight against the striker plate gasket when the Bowden wire control is pulled all the way **out** to close the valves.

Before attaching the shut-down assembly to the blower, therefore, lay a straightedge lengthwise of the finished bolt housing flange and close the valves against same. The finished pads at both ends of both valves must set flat against the straight-edge when the latter is moved from top to bottom of inlet housing pad. Now, turn straight-edge crosswise of pad and draw from end-to-end. Both the upper and lower finished pads of valves must rest against straight-edge throughout length of valves. Furthermore, when the lock ball within lever indexes with hole in lock plate or Bowden wire is pushed way **in**, the valves must recess back into the inlet housing so as not to restrict air passage to the blower.

Disassemble Blower: After blower is removed from the engine and accessories removed therefrom, it may be cleaned with gasoline and compressed air, then disassembled. Do not clean in hot solvents, as such practice will destroy the leather oil seals.

Remove cap screws in each end cover and pull cover off dowels at top and bottom of bolt flange. Do not pry between cover and end plate or gasket surfaces will be damaged.

Using a 3/16" Allen wrench, loosen expander screw, if one is provided, at center and front end of blower lower rotor shaft, and withdraw water pump intermediate coupling from shaft.

Remove cap screws attaching blower drive shaft flange to rear face of blower upper rotor timing gear, and tap flange free of gear.

Remove the cap screws and washers at center of rear end timing gears that lock the gears in place.

Pull Rotor Timing Gears: NOTE—The two timing gears must be pulled from the rotor shafts at the same time. This should be done with special pulling tools.

NOTE—Number and thickness of shims on each rotor shaft, if any are used, remove from shafts and replace accordingly when assembling blower.

Back out three cap screws at each bearing and remove rotor shaft bearing retainers at both ends of blower.

Remove Rotor Shafts from Rear Bearings and Front End Plate from Blower Housing: This procedure applies to blowers on which the rotors and housing have not been scored to the extent that withdrawal of rotors assembled to the front end plate will not further damage rotors. If rotors and blower housing are badly scored, rotor shafts should be pushed from bearings in front end plate before withdrawal.

Remove Rotor Shafts from Front End Plate Bearings: The rotor shafts are removed from the front end plate bearings with the same tool and in exactly the same manner as from the rear plate.

To remove bearings from end plates: Insert bearing removing tool through oil seal from inner face of blower end plate so pilot of tool enters bore in inner race of bearing and shoulder of tool rests against face of bearing inner race. Support end plate aproximately two inches off bench and drive bearing from position. Follow this same method on all four bearings.

NOTE—Inspection of oil seals for leaks while the blower was running on the engine largely determined if they should be changed. A further inspection may be conducted after blower has been disassembled. If the leather is scored so that a tight seal on shafts is impossible, or the leathers have become charred and hard, the seals should be changed. If change is necessary, the seals may be removed from the end plates at the same time the individual bearings are removed. This is done by continuing to drive down on the tool, until a collar on tool rests on and forces oil seal down and out of end plate.

After the blower has been disassembled, all parts should be washed in clean gasoline, blown off with dry compressed air and inspected before assembly.

Assemble Blower: All blower parts having been inspected, assemble blower by reversing sequence of operations for disassembly and using tools as follows:

Install Oil Seals in Blower End Plates: The oil seals should be assembled into the end plates with flat face of seals flush with inner, finished face of plates and sealing edge of leather pointing toward rotor bearings. The seals may be installed properly with the special tools that are available.

Support end plate between soft jaws in bench vise. Back out puller stud (A) (see cut) as far as possible and push stud through bore for bearing in end plate from the outer face (rib side with puller plate (B) resting against outer face of blower end plate.

With flat face of oil seal facing head of puller stud, slide seal over head of stud and start into bearing bore by hand.

Slip pressure plate (E) over body and next to head of puller stud and turn puller stud (A) clockwise forcing oil seal into seat until pressure plate (E) sets tight against inner face of blower end plate. Remove tool and install remainder of seals in the same manner.

Next Install Blower Front End Plate. The top of the blower may be identified by the flange which carries the entire length of the housing and provides a rest on top of the cylinder block. The end plate is semi-circular at the top, and is also marked "TOP" on outer, ribbed side.

NOTE—Even though the blower end plate is interchangeable front and rear, the plate at the front end of the blower should be assembled to the blower housing before the rear plate is assembled.

When viewing blower housing from cylinder block side, the end plate for the front will be assembled to the left-hand end.

Attach end plate to front end of blower housing, as follows:

(a) Start end plate dowel holes of blower housing. Rap dowels and end plate lightly with soft hammer to fit end plate to housing.

NOTE—No gaskets are used between end plates and housing, therefore mating surfaces must be perfectly flat, smooth and clean.

(b) Lock end plate securely to housing with two fillister head screws (no lock washers).

(c) Inspect and see that dowels project ⅛" beyond outer face of end plate.

NOTE—Before further assembly of the blower, certain checking operations are necessary to insure the proper relation of parts. The lobes on one of the blower rotors and the teeth on one of the timing gears form a right-hand helix and on the mating parts a left-hand helix. The rotor with the right-hand helix must be used with gear having right-hand helical teeth and vice-versa. Rotor and gear with right-hand helices are the upper units in the blower; and these parts with left-hand helices the lower units. Furthermore, for convenience in blower timing, one serration is omitted on the drive end of each blower shaft with corresponding omissions in the gear hubs. Gears must be placed on the shafts with the serrations in registration. Rotors must be assembled with the omitted serrations toward top on both rotor shafts.

To avoid confusion when assembling, place the right-hand rotor and right-hand gear together on the bench; likewise the left-hand rotor and gear.

Assemble Rotors into Housing: With foregoing checks in mind, as just outlined above:

Install one oil seal pilot over short end (non-splined) of each rotor shaft and with rotors in mesh and omitted serrations toward top of blower housing, slip rotors into housing. Then remove oil seal pilots.

Install Blower Rear End Plate: With rotors positioned in housing as per item above, install one oil seal pilot over serrated end of each rotor shaft.

Identify top and bottom of end plate as described in (note) above and start end plate dowels into dowel holes in blower housing. Tap dowels lightly to fit end plate to housing. Lock end plates securely to housing with two fillister head screws (no lock washers). Inspect and see that dowels project ⅜" beyond outer face of end plate. Remove oil seal pilots from shafts.

Install Rotor Shaft Front Bearings: Single-row ball bearings are used at the front end of the blower rotor shafts and double-row ball bearings at the rear (serrated) end. The bearing number is stamped at one end of the ball race only. **When assembled, the markings are toward the outside face of the end plate.**

Start the single-row bearings onto front end of rotor shafts (short end with internal splines). Using special bearing inserting tool, tap bearings into end plates.

NOTE—Bearing retainers for single-row bearings have 1 13/16" inside diameter and for double-row bearings 1 9/16" inside diameter.

Install front bearing retainers with flange at inner diameter of retainer directed toward bearing. Lock each retainer with three cap screws and lock washers.

Install Rotor Shaft Rear Bearings: Install the rear rotor shaft bearings exactly the same way the fronts were installed and, using the same tool, except, flange at inner diameter of retainer is directed away from bearing. Be sure markings on bearing race are toward blower end plate. Use only bearing No. 5150221 at these positions.

Rotor to housing and rotor to end plate clearances should be checked at this time.

Press Timing Gears Onto Rotor Shafts: If blower once used is being reassembled—shims were no doubt used back of one, or perhaps both blower timing gears, and if so, they should be installed in their original positions before pressing gears onto shafts. If new gears and shafts are used, install without shims, and use later if necessary, when timing rotors.

Be sure that both rotor shafts with the omitted serrations point toward top of blower; that the drive gear (timing gear) with six tapped holes in hub, is located on the upper rotor shaft; that original shims are placed on their respective shafts, start both gears onto shafts with omitted serrations on shafts and gears registering An "O" mark is indented into end of shaft at omitted serration to assist in locating gears properly.

NOTE—Gears must be pressed into position at the same time to avoid damage to gears and rotors. Do not pull gears up tight if rotors are in contact.

If ⅜" timing gear retainer bolts are used, lock gears in place with cap screws and lock washers, noting that small flat washer is located on upper shaft, and large washer, with driving lugs for fuel pump, is located on lower shaft. See that locking ears on fuel pump coupling engage slots in gear hub.

If ½" timing gear retainer bolts are used, install special lock washer and pierced retaining washer on bolt for upper gear so that retaining washer pierced lugs engage slots in gear hub, and lock washer ear engages slot in retaining washer.

For lower gear lock, install special lock washer and fuel pump coupling disc on retainer bolt so lock tangs of disc engage slots in gear hub and lock washer ear engages slot in coupling disc. Draw retainer bolts reasonably tight but not enough to bend fuel pump coupling disc.

BLOWER ROTOR TIMING

1938-46: The three lobes on each blower rotor are located spirally (helical), relative to the center line of the rotor shaft. The teeth on the timing gears are also helical, and, as previously stated, the rotor with the right-hand helical lobe is driven with a gear having right-hand helical teeth.

The blower rotors, when properly positioned in the housing, run with a slight clearance between the lobes. This clearance may be varied by moving one of the helical gears in or out on the shaft relative to the other gear.

If the upper gear is moved out, the upper rotor will turn counter-clockwise when viewed from the gear end. If the lower gear is moved out, the lower rotor will turn clockwise when viewed from the gear end. This positioning of the gear, to obtain the proper clearance between the rotor lobes, is known as Blower Timing.

Moving the gears out or in on the rotors is accomplished by adding or removing shims between the gear hub and the bearing back of the gears.

The clearance should be the same between the leading and trailing sides of individual rotor lobes with their mating lobes.

The clearance between rotor lobes may be checked with various thickness feeler ribbons ½" wide. When measuring clearances more than .005", laminated feelers made up of .002", .003" or .005" are more practical and suitable than one single thick feeler.

The clearance between rotor lobes must be taken between two of the lobes at one end of the blower while revolving the rotors to the right, and also between the same two lobes at the same end while revolving the rotors to the left. This double check must be made between each pair of mating lobes at each end and at the midsection for the three and four-cylinder engines, and at several intermediate points on blowers for the six-cylinder engine. Always determine point of minimum clearance and adjust for that point.

EXAMPLE: If there is .004" existing on leading side and .012" existing on trailing side, then these two added together makes .016" total both sides, ½ total = .008" desired each side. Desired minus existing = .008"—.004"=.004", or the amount one rotor must be revolved to produce proper clearance on both sides of each lobe. See illustration and table for specific data.

NEW BLOWER ASSEMBLIES

New blower assemblies incorporating rotor contour and clearance changes are now used on all engines. Except for contour and clearance revisions on the blower rotors, the old and new assemblies are identical, and interchangeability is affected only by clearance changes. Therefore, it is important to note the following remarks and charts which give all the necessary information as to part number, interchangeability and clearances.

Identification: The bore diameters of the new housings are .006" offset as compared with the .002" offset for the original housings. This increases the clearance between the rotors and housing at the inlet side .004". Refer to the sketch showing the old and new housings and the respective offset of the bore diameter in relation to the dowels in the end of housings.

The new housings may also be identified by the part number stamped on the upper face of the housing. The first of the new housing models were marked with the letter "H" in this location. Those housings used in service that had neither of these markings can be identified by the part number cast on the inside of the housing. See the "Blower Rotor Clearance" sketch for location of housing identification and consult the chart showing the part numbers of the old and new blower assemblies, the old and new housings and the old and new rotor assemblies.

Rotor Contours: The contours of the old and new rotors may be compared by referring to the "Housing and Rotor Comparison" sketch. Note that the new rotors have a raised portion on the maximum diameter of the rotor lobes, while the old rotors have no raised portion.

Using New Type Rotors with Old Type Housings: Although these parts may be used together, the clearances are different from those shown in the "Blower Rotor Clearance Chart." For these clearance variations, see the "Clearance Comparison Chart."

Using Old Type Rotors with New Type Housings: On the 6-71 engine, interchangeability is not affected, but on the 3-71 and 4-71 engines, the clearances obtained are insufficient and must be corrected by removing .004" from the diameter of the rotors. **This is the narrow area at the top of the lobes.** The smaller diameter can be obtained either by machining or using sandpaper on the maximum diameter of the rotors. Before reassembly, be sure to remove all traces of abrasive material. See the "Clearance Comparison Chart."

NOTE—All blowers rebuilt in service should be reassembled to the revised rotor-to-rotor clearance dimensions "C" and "CC" as shown in the "Blower Rotor Clearance" chart and sketch.

Checking Rotor Clearances: (1) Check dimension "CC" from the outlet side of blower, and check the dimension for the full length of the lobe. (2) Check dimension "C" from the inlet side of the blower, and check for the full length of the lobe. (3) Rotate the rotors 60 degrees from the location for step No. 1 and check "CC" from the inlet side of the blower. (4) Check dimension "C" from outlet side of blower.

NOTE—These checks should be performed on all three lobes of the blower.

Using Old Rotor with New Rotor: If an old type rotor is used with a new type, the clearances should be maintained as given in the following. See the "Blower Rotor Clearance" sketch for "C" and "CC" checking points.

The "CC" clearance on all engines should be .004" minimum and .006" maximum. The "C" clearance should be .010" minimum on 3-71; .011" on 4-71, and .012" minimum on 6-71 engines.

A .001" shim back of the blower gear will revolve the rotor .001". Having determined the amount one rotor must be revolved to produce the proper clearance (same as the thickness of shims required) observe engine series on which the blower is to be used and add shims back of either the upper or lower gears to produce the desired result.

NOTE—Adding shims back of the upper gear will increase the clearance between the leading and trailing sides of the lower and upper rotor lobes, respectively. When additional shims are required, both gears must be pulled from the rotors.

Install the required thickness of shims back of the proper gear and next to the bearing inner race, and again press the gears tight in place. Re-check clearances between rotor lobes.

If checks were carefully made, shims correctly installed, and gears tight in place, the clearances should be correct. If work was done carelessly, the operation may have to be repeated.

After correct clearances are obtained, lock gears in place.

Using cap screws and lock washers, attach blower drive shaft flange to outer face of upper rotor timing gear. Insert splined end of water pump intermediate shaft and coupling into front end of lower rotor shaft and hold coupling tight against end of shaft while tightening Allen screw securely with 3/16" wrench. Some water pump couplings are not provided with expander screw, in which case, simply insert coupling into engagement with rotor shaft inner serrations. If gasket is unsatisfactory in any way, shellac a new gasket to each blower end plate cover, supply a lock washer and plain washer, in turn, on the ten cap screws and attach both end plate covers.

NOTE—Foreign matter inside the blower is apt to ruin the unit. After blower has been assembled, attach the gasket and cover over the air inlet on the outer face of the blower housing to prevent foreign matter entering housing.

NOTE—Time may be saved and operations simplified if the various accessories are assembled to the blower before the latter is attached to the engine.

EMERGENCY ENGINE SHUT-DOWN

1938-46: Occasions may arise when an emergency engine shut-down device is desirable. Such a condition would be brought about if combustible liquids were introduced accidentally into the engine combustion chamber by way of the air box. Under such conditions, of course, the governor has no control over engine speeds, but such an emergency is provided for by a manually controlled, Emergency Engine Shut-down Device. This device should be used to stop the engine in cases of emergency only.

The emergency engine shut-down consists of one flap valve for the three and four-cylinder engines, and two valves for the six-cylinder, which are attached to a shaft and incorporated within the air inlet housing. A valve shaft lever outside the air inlet housing, is operated by a Bowden wire.

The lower end of the Bowden wire control is fastened to the valve shaft lever and the upper end terminates at the instrument panel where it is readily accessible to the engine operator. The button on the Bowden wire at the instrument panel should be all the way **in** when the engine is operating. The button must be pulled **all** the way **out** to stop the engine.

Should it become necessary to disassemble the shut-down device, note the relative position of each part so parts may be reassembled correctly.

In order to stop the engine with the shut-down device, the flap valve must close tight. To provide a perfectly flat surface for the valve to close against, a striker plate is mounted between the blower and air inlet housing with a gasket on the valve side of the plate. The valve closes against the gasket. When the shut-down is assembled, therefore, the striker plate must be perfectly flat and the gasket in place.

If occasion requires, the emergency shut-down may be disassembled after the air inlet housing assembly is removed from the blower:

Using a small punch, remove locking pin for valve shaft lever and valve, or valves (two valves used on six-cylinder engine). Remove lever and withdraw shaft from housing and valve. Remove two cap screws, lock plate, and felt seal washer in counter-bore at shaft, beneath plate. Also, remove felt seal washer in counter-bore of housing at opposite end of shaft.

The shut-down device may be assembled into the blower air inlet housing, as outlined below. Bear in mind that both ends of the air inlet housing are machined for the lock plate at the valve shaft. The valve shaft lever for the shut-down will be located at the rear end of the air inlet housing in all cases.

AIR CLEANER

1938-46: One oil bath cleaner and silencer is used as standard equipment on the 3 and 4-cylinder engines, and two of the same type units are used on the 6-cylinder engine.

Air drawn into the cleaner by the blower passes over the top of the oil bath, where a major portion of the dirt is trapped, then up through the metal wool, where the finer particles are removed, thence down the central duct to the blower.

Oil of a viscosity which compares with No. 50 SAE should be used in the reservoir. The oil level should not be above that indicated, which is just flush with the top of the reservoir itself. If too much oil is used, it will be pulled up into the metal wool, down into the blower, thence forced into the air box, and may cause excessive engine speeds.

The air cleaner should be reconditioned as directed on the cleaner housing; that is, every 100 hours (more frequently under severe working conditions), wash the metallic wool elements in fuel oil to remove the dirt. Drain dirty oil from oil reservoir and clean sludge from bottom of reservoir. Refill with engine oil up to proper oil level. Reassemble after filter element has thoroughly drained.

FUEL SYSTEM

NOTE—For detailed information on Diesel Fuel Injection Systems, see the Table of Contents on page 1.

ELECTRIC SYSTEM

NOTE—For service information on Generators, Generator Regulators, Starting Motors and Starter Switches, see the Table of Contents on page 1.

Year	Engine Model	Number Cylinders and Valve Arrangement	Bore and Stroke	Displacement Cubic Inches	Compression Ratio	Taxable H. P.	Brake H. P. at R. P. M. ①	Maximum Torque at R. P. M. Pounds Feet	Oil Capacity Quarts ②
1938–46	DOOB	4-I	3¾x4½	198.8	14.50	22.50	62@2600	143@1500	12
1938–46	DOOC	4-I	4x4½	226.2	14.50	25.60	70@2600	162@1400	12
1938–46	DOOD	4-I	4¼x4½	255	14.50	28.90	79@2600	180@1400	12
1936–46	DJXB	6-I	3½x4½	260	14.50	29.40	77@2600	178@1400	9
1936–46	DJXC	6-I	3¾x4½	298	14.50	33.75	83@2600	208@1500	9
1941–46	DJXD	6-I	4x4½	339	14.50	38.40	103@2600	232@1600	9
1936–46	DRXB	6-I	4⅜x5¼	474	14.50	45.94	120@2000	350@1300	23
1936–46	DRXC	6-I	4⅝x5¼	529	14.50	51.34	133@2000	380@1400	13
1936–44	DHXB	6-I	5x6	707	14.50	60.00	176@1800	530@1400	20
1938–44	DHXC	6-I	5½x6	855	14.50	72.60	146@1200	675@875	20
1940–46	DFXB	6-I	5x6	707	14.50	60.00	177@1800	530@1400	28–35
1940–46	DFXC	6-I	5¼x6	779	14.50	66.15	191@1800	585@1300	28–35
1940–46	DFXD	6-I	5½x6	855	14.50	72.60	193@1600	645@1350	28–35
1940–46	DFXE	6-I	5⅝x6	895	14.50	75.94	200@1600	635@1200	20

① Maximum speed—full load.

② Capacity shown for each model is to be considered in a general nature due to special oil pan installations. Always be guided by the oil level dipstick markings rather than the above quantity.

TUNEUP CHART

Year	Engine Model	Firing Order ④	Injection Timing, Degrees	Nozzle Discharge Pressure, Lb. Sq. In.	High Idle Speed, R. P. M. ①	Low Idle Speed, R. P. M.	Valve Timing	
							Intake Opens, Deg.	Exhaust Closes, Deg.
1938–46	DOOB	1243	②	1650	2750	450	12 BTDC	12 ATDC
1938–46	DOOC	1243	②	1650	2750	450	12 BTDC	12 ATDC
1938–46	DOOD	1243	③	1650	1440	450	12 BTDC	12 ATDC
1936–46	DJXB	153624	22 BTDC	1650	2750	450	12 BTDC	12 ATDC
1936–46	DJXC	153624	24 BTDC	1650	2750	450	12 BTDC	12 ATDC
1941–46	DJXD	153624	24 BTDC	1650	2750	450	12 BTDC	12 ATDC
1936–46	DRXB	153624	39 BTDC	1650	1650	450	5 BTDC	10 ATDC
1936–46	DRXC	153624	39 BTDC	1650	1440	450	5 BTDC	10 ATDC
1936–44	DHXB	153624	30 BTDC	1650	1440	450	5 BTDC	10 ATDC
1938–44	DHXC	153624	30 BTDC	1650	1440	450	5 BTDC	10 ATDC
1940–46	DFXB	153624	29 BTDC	2000	1600	450	5 BTDC	10 ATDC
1940–46	DFXC	153624	29 BTDC	2000	1600	450	5 BTDC	10 ATDC
1940–46	DFXD	153624	29 BTDC	2000	1600	450	5 BTDC	10 ATDC
1940–46	DFXE	153624	29 BTDC	2000	1600	450	5 BTDC	10 ATDC

① Maximum governed speed—no load.

② With American Bosch pump, 22 deg. BTDC for speeds below 1500 R.P.M., and 25 deg. BTDC for speeds above 1500 R.P.M. With the Timken pump, 14 deg. BTDC for speeds below 1500 R.P.M., and 16 deg. BTDC for speeds above 1500 R.P.M.

③ With American Bosch pump, 24 deg. BTDC for speeds below 1600 R.P.M., and 26 deg. BTDC for speeds above 1600 R.P.M. With Timken pump, 15 deg. BTDC for speeds below 1600 R.P.M.

④ Right-hand rotation engines.

VALVE SYSTEM

Year	Engine Model	Stem Clearance		Tappet Guide Clearance	Tappet Clearance				Valve Spring Pressure Test		Valve Seat Angle Degrees
					Running Hot①		Timing④				
		Intake	Exhaust		In-take	Ex-haust	In-take	Ex-haust	Free Length, Inches	Pounds at Inches, Length	
1938–46	DOOB	.0025–.003	.0025–.003	.001–.0015	.010	.010	.010	.010	②$2\frac{3}{64}$ ③$2\frac{17}{64}$	②37@$1\frac{9}{32}$ ③55@$1\frac{13}{32}$	45
1938–46	DOOC	.0025–.003	.0025–.003	.001–.0015	.010	.010	.010	.010	②$2\frac{3}{64}$ ③$2\frac{17}{64}$	②37@$1\frac{9}{32}$ ③55@$1\frac{13}{32}$	45
1938–46	DOOD	.0025–.003	.0025–.003	.001–.0015	.010	.010	.010	.010	②$2\frac{3}{64}$ ③$2\frac{17}{64}$	②37@$1\frac{9}{32}$ ③55@$1\frac{13}{32}$	45
1936–46	DJXB	.002–.003	.002–.003	.001–.0015	.010	.010	.010	.010	②$2\frac{3}{64}$ ③$2\frac{17}{64}$	②37@$1\frac{9}{32}$ ③55@$1\frac{13}{32}$	45
1936–46	DJXC	.002–.003	.002–.003	.001–.0015	.010	.010	.010	.010	②$2\frac{3}{64}$ ③$2\frac{17}{64}$	②37@$1\frac{9}{32}$ ③55@$1\frac{13}{32}$	45
1941–46	DJXD	.002–.003	.002–.003	.001–.0015	.010	.010	.010	.010	②$2\frac{3}{64}$ ③$2\frac{17}{64}$	②37@$1\frac{9}{32}$ ③55@$1\frac{13}{32}$	45 45
1936–46	DRXB	.0025–.003	.0025–.003	.001–.0015	.016	.016	.016	.016	②$2\frac{17}{64}$ ③$2\frac{25}{64}$	②30@1.355 ③48@1.449	45
1936–46	DRXC	.0025–.003	.0025–.003	.001–.0015	.016	.016	.016	.016	②$2\frac{17}{64}$ ③$2\frac{25}{64}$	②30@1.355 ③48@1.449	45
1936–44	DHXB	.0025–.003	.0025–.003	.001–.0015	.016	.016	.016	.016	---	②57@$2\frac{21}{32}$ ③94@$2\frac{31}{32}$	45
1938–44	DHXC	.0025–.003	.0025–.003	.001–.0015	.016	.016	.016	.016	---	②57@$2\frac{21}{32}$ ③94@$2\frac{31}{32}$	45
1940–46	DFXB	.0025–.003	.0025–.003	.001–.0015	.010	.016	.010	.016	---	②57@$2\frac{21}{32}$ ③94@$2\frac{31}{32}$	45
1940–46	DFXC	.0025–.003	.0025–.003	.001–.0015	.010	.016	.010	.016	---	②57@$2\frac{21}{32}$ ③94@$2\frac{31}{32}$	45
1940–46	DFXD	.0025–.003	.0025–.003	.001–.0015	.010	.016	.010	.016	---	②57@$2\frac{21}{32}$ ③94@$2\frac{31}{32}$	45
1940–46	DFXE	.0025–.003	.0025–.003	.001–.0015	.010	.016	.010	.016	---	②57@$2\frac{21}{32}$ ③94@$2\frac{31}{32}$	45

① Clearances may vary with special applications.
② Inner spring.
③ Outer spring.
④ Set hot and allow to cool before checking.

PISTON AND RING CLEARANCES

Year	Engine Model	Piston Skirt, Inches		Fitting Pistons with Shim and Spring Scale		Ring End Gap, Inch①		Ring and Groove, Inch	
		Top	Bottom	Shim Thickness	Pounds Pull on Scale	Com-pression	Oil	Com-pression	Oil
1938–46	DOOB	.0055–.006	.0055–.006	.005	4 to 5	.018–.022	.018–.022	.0035–.004②	.002–.0025③
1938–46	DOOC	.0055–.006	.0055–.006	.005	4 to 5	.018–.022	.018–.022	.0035–.004②	.002–.0025③
1938–46	DOOD	.006 –.0065	.006 –.0065	.006	4 to 5	.018–.022	.018–.022	.0035–.004②	.002–.0025③
1936–46	DJXB	.005 –.0055	.005 –.0055	.005	4 to 5	.018–.022	.018–.022	.003–.0045②	.0015– .003③
1936–46	DJXC	.006 –.0065	.006 –.0065	.006	4 to 5	.018–.022	.018–.022	.003–.0045②	.0015– .003③
1936–46	DJXD	.006–.0065	.006–.0065	.006	4 to 5	.018–.022	.018–.022	.003–.0045②	.0015– .003③
1941–46	DRXB	.007–.008	.007–.008	.007	4 to 5	.018–.022	.018–.022	.0035–.004②	.002–.0025③
1936–46	DRXC	.007–.008	.007–.008	.007	4 to 5	.018–.022	.018–.022	.0035–.004②	.002–.0025③
1936–44	DHXB	.008	.008	.007	4 to 5	.018–.022	.018–.022	.0035–.004②	.002–.0025③
1938–44	DHXC	.008	.008	.007	4 to 5	.018–.022	.018–.022	.0035–.004②	.002–.0025③

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Continued from previous page

PISTON AND RING CLEARANCES

Year	Engine Model	Piston Skirt, Inches		Fitting Pistons with Shim and Spring Scale		Ring End Gap, Inch①		Ring and Groove, Inch	
		Top	Bottom	Shim Thickness	Pounds Pull on Scale	Com-pression	Oil	Com-pression	Oil
1940–46	DFXB	.008–.0085	.008–.0085	.008	4 to 5	.018–.022	.018–.022	.0015–.003	.0015–.003
1940–46	DFXC	.0085–.0095	.0085–.0095	.009	4 to 5	.018–.022	.018–.022	.0015–.003	.0015–.003
1940–46	DFXD	.0085–.0095	.0085–.0095	.009	4 to 5	.018–.022	.018–.022	.0015–.003	.0015–.003
1940–46	DFXE	.0085–.0095	.0085–.0095	.009	4 to 5	.018–.022	.018–.022	.0015–.003	.0015–.003

① End gaps are for cylinder bores without taper. Fit rings in tapered bores with not less than the maximum dimensions given.

② For top or fire ring only.

③ For all rings except top compression ring.

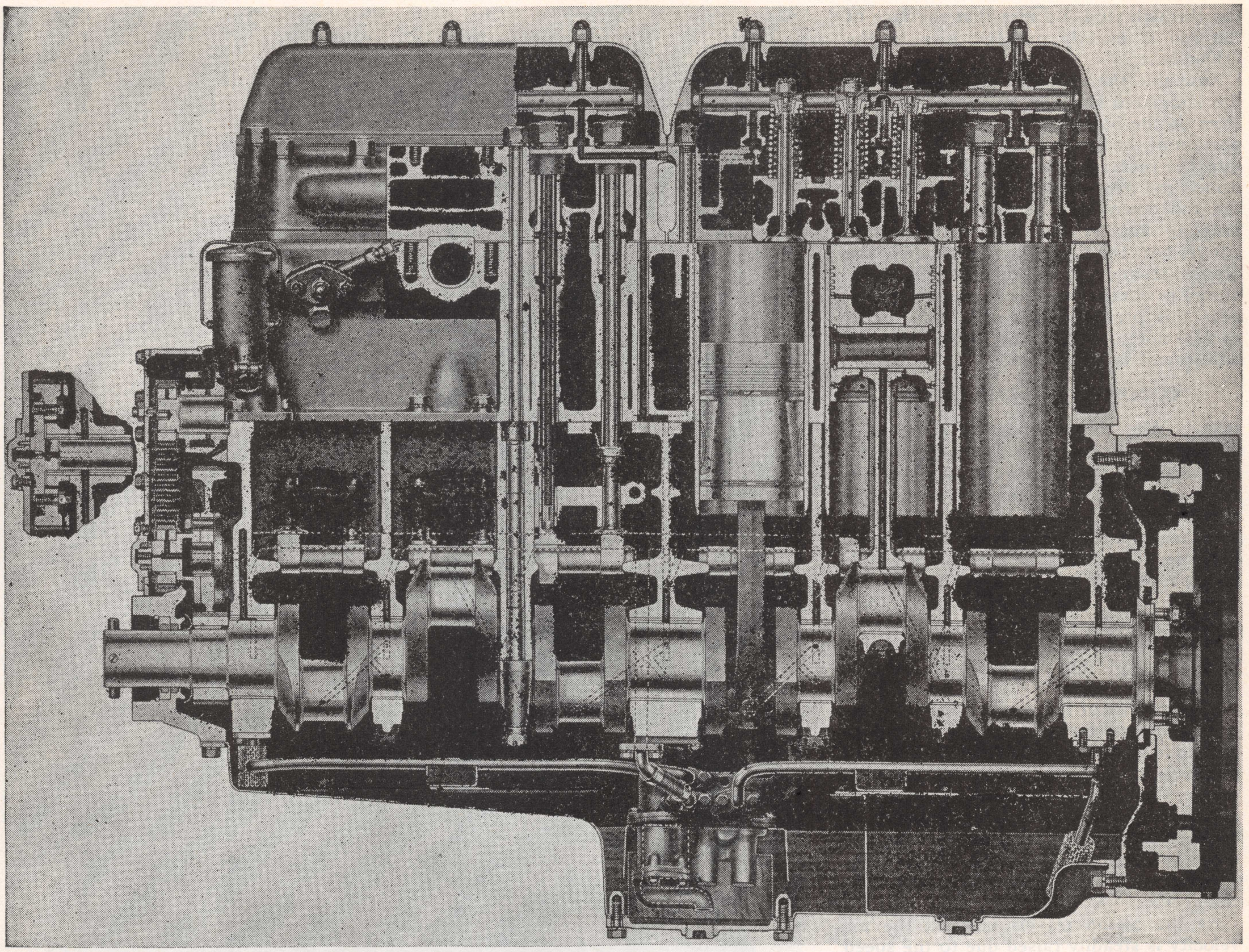
ENGINE BEARING SPECIFICATIONS

Year	Engine Model	Camshaft		Connecting Rod			Mains				
		Jour-nal Diam-eter	Clear-ance	Journal Diameter	Clear-ance	Bear-ing Bolt Ten-sion Lb. Ft.	Journal Diameter	Clear-ance	Bear-ing Bolt Ten-sion Lb. Ft.	Thrust on No.	End-play
1938–46	DOOB	2 1/16	.0015–.0025	2.497–2.498	.003–.004	140	2.997–2.998	.003–.004	77① 94½②	5	.002–.004
1938–46	DOOC	2 1/16	.0015–.0025	2.497–2.498	.003–.004	140	2.997–2.998	.003–.004	77① 94½②	5	.002–.004
1938–46	DOOD	2 1/16	.0015–.0025	2.497–2.498	.003–.004	140	2.997–2.998	.003–.004	77① 94½②	5	.002–.004
1936–46	DJXB	2 1/16	.0015–.0025	2.497–2.498	.003–.004	140	2.997–2.998	.003–.004	77① 94½②	7	.002–.004
1936–46	DJXC	2 1/16	.0015–.0025	2.497–2.498	.003–.004	140	2.997–2.998	.003–.004	77① 94½②	7	.002–.004
1941–46	DJXD	2 1/16	.0015–.0025	2.497–2.498	.003–.004	140	2.997–2.998	.003–.004	77① 94½②	7	.002–.004
1936–46	DRXB	2⅛	.0015–.0025	2.997–2.998	.003–.004	157½	3.497–3.498	.003–.004	175	7	.002–.004
1936–46	DRXC	2⅛	.0015–.0025	2.997–2.998	.003–.004	157½	3.497–3.498	.003–.004	175	7	.002–.004
1936–44	DHXB	2⅜	.003–.0035	3.309–3.310	.003–.004	262½	3.747–3.748	③	192½① 210②	7	.003–.004
1938–44	DHXC	2⅜	.003–.0035	3.309–3.310	.003–.004	262½	3.747–3.748	③	192½① 210②	7	.003–.004
1940–46	DFXB	2⅜	.003–.0035	3.309–3.310	.0035–.0045	263	4.497–4.498	.005–.006	260	7	.004–.005
1940–46	DFXC	2⅜	.003–.0035	3.309–3.310	.0035–.0045	263	4.497–4.498	.005–.006	260	7	.004–.005
1940–46	DFXD	2⅜	.003–.0035	3.309–3.310	.0035–.0045	263	4.497–4.498	.005–.006	260	7	.004–.005
1940–46	DFXE	2⅜	.003–.0035	3.309–3.310	.0035–.0045	263	4.497–4.498	.005–.006	260	7	.004–.005

① Center and rear.

② Front and intermediate.

③ Aluminum crankcase .004–.0045; iron crankcase .0035–.004.



DHX SERIES. Side sectional view.

ENGINE

NOTE—For detailed information on Diesel Fuel Injection Systems, see the Table of Contents on page 1.

CYLINDER HEAD

1936-46 All: Cylinder head nuts should be tightened down starting from the center, working outward in a criss-cross fashion to the ends. Draw down the nuts evenly and repeat the operation until all are normally tight. After the engine has been run sufficiently long to bring all parts to normal operating temperature, a final tightening should be made, preferably with a torque indicating wrench.

If a torque indicating wrench is not available, use a socket wrench with an 18" handle. When using a torque wrench, be sure the nuts and studs are free from rust and dirt, otherwise a false reading will be obtained due to the increased friction. For Series DFX, tighten nuts to 210 pounds feet; for Series DJX, DHX, DOO and DRX, tightens head nuts to at least 157½ **pounds feet.** Be sure to check and adjust the valve clearance every time the nuts are tightened.

CAUTION—Every precaution should be taken to prevent the mating surfaces of the cylinder head and block from being marred, nicked or scratched.

CYLINDER HEAD GASKET

1936-46 All: These gaskets are made of solid sheet copper and need not be changed unless they become deeply scratched or marred. When the gasket is placed in position, use care to see that no dirt or other foreign matter is lodged between the gasket and the cylinder head or block.

If the same gasket is being re-used, it should be cleaned thoroughly, removing all carbon and sealing compound. To insure a leakproof installation, use a plastic sealing compound.

THROUGH BOLT CONSTRUCTION

DHX: As shown in the illustration, long alloy studs of special design compress all the castings, which result in the main bearing caps, crankcase, cylinder block and cylinder heads being bolted into one structure.

The alloy studs have an eccentric head or center portion which seats in a recess in the top of the crankcase. This eccentric portion is for the purpose of preventing the studs from turning, thus permitting main bearing adjustment without requiring an adjustment on the top part of the engine.

These studs are provided with shims which are located between the eccentric heads in the crankcase and the machined bottom face of the cylinder block; the purpose being to prevent any upward motion of the studs when the cylinder heads are tightened, thereby preventing the main bearing adjustment from being disturbed.

Whenever the cylinder block is removed from the crankcase, it is important that the shim clearance be checked. On engines with aluminum crankcase, these shims must be .032" above the top machined face of the crankcase. With cast iron crankcase, .027" thickness of these shims must be above this face.

To check the clearance, a suitable tool can be made by using a steel rod, 3 to 4 inches long and 1½ inches in diameter. Drill a hole through the center of this rod, large enough to permit it to be slipped over the through stud. Be sure that the face of the rod is exactly perpendicular to the drilled hole.

Assemble the shims in position, placing the laminated shim on top with the solid shim on the bottom. The solid shim and a portion of the laminated shim will fit down into the recess in the case. Then slip the drilled rod over the through stud and jam the rod down hard on the shims. While pressing against the tool, insert feeler gauges between the tool and the face of the crankcase, and add or remove shims as required to obtain the desired clearance. Repeat this procedure on each stud, being careful not to disturb the shims after the adjustment is completed.

COMBUSTION CHAMBER

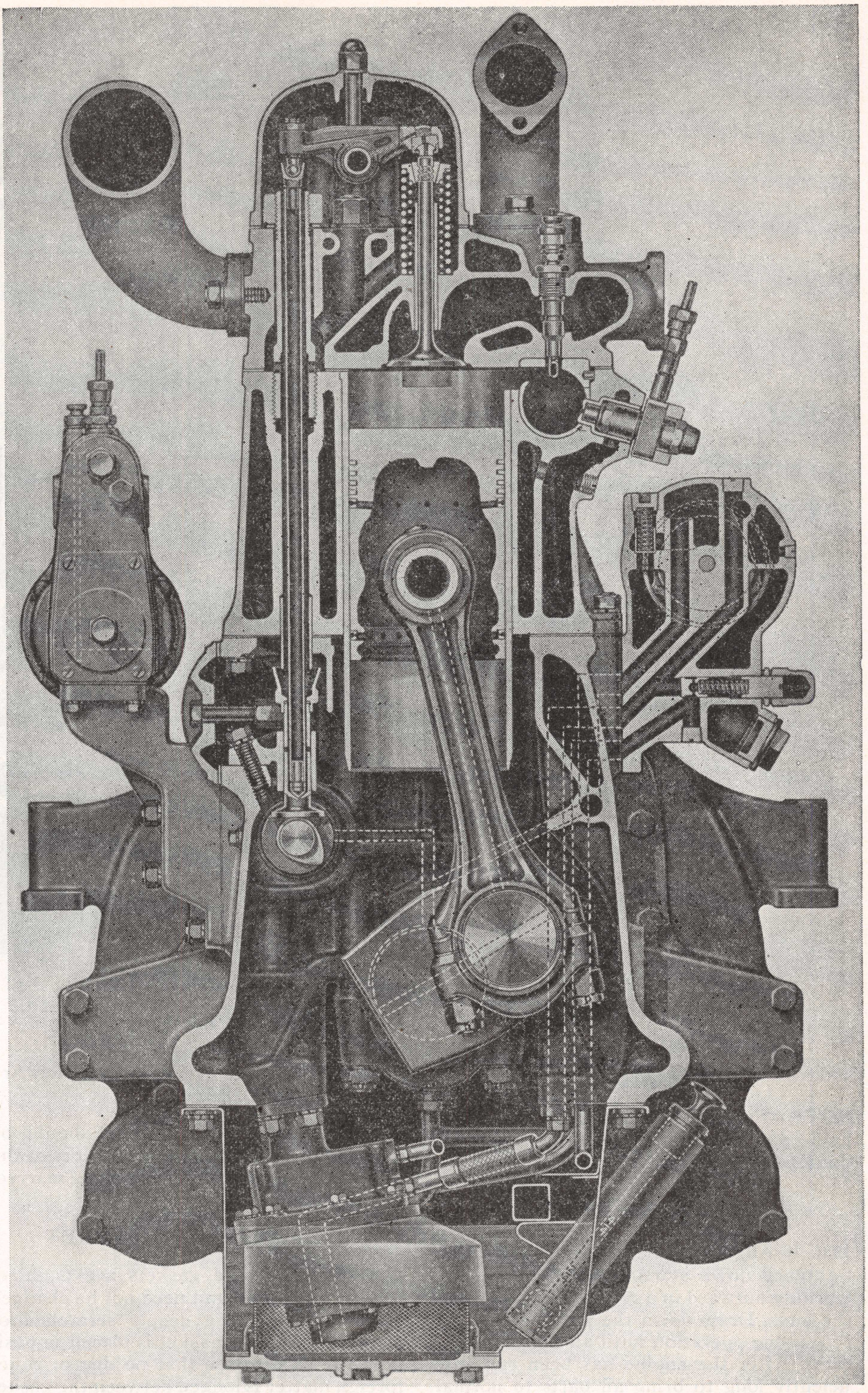
1936-46 All: The combustion chamber is located at one side of the cylinder bore and is lined with two removable sections (in some early DHX engines, the liners consisted of three sections, the middle section now being part of the lower liner). The lower section consists of one half of a hollow sphere with suitable holes for the injection nozzle. This section seats into a machined, similarly-shaped portion of the cylinder block, while the upper, or cover section extends into a recess in the cylinder head.

The purpose of this combustion chamber is to increase turbulence, and is accomplished in the following manner: When the piston is coming up on its compression stroke, the air which entered the cylinder on the intake stroke is being compressed between the top of the piston and the cylinder head. However, as the air is being compressed, it is forced into the combustion chamber.

As the piston travels upward, the air velocity is steadily raised due to the speed of the piston, and the air passing into the chamber is set whirling in motion due to the spherical shape of the chamber. At a point when this air velocity would tend to slow up due to the reducing piston speed, the piston begins to cover the chamber opening so that the velocity is steadily increased until the piston is nearing the top of its stroke.

By this time, the air inside the chamber is rapidly revolving and then, at a predetermined time, the injection of a finely atomized fuel mist into this rapidly moving air, produces a complete mixing of the air and fuel, resulting in a more complete combustion with smooth, even power.

When any of these parts are replaced, care must be used when replacing the cylinder head to make sure that the head does not rest on top of the combustion chamber liner, preventing the head from being drawn down tight against the gasket. If this condition exists, file off a portion of the top of the upper section of the liner. The hole in the center of the upper liner permits the glow plug (when used) to extend into the upper part of the combustion chamber. The spherical section of the liner has a lip which is directly opposite to the hole in the liner through which the injection nozzle is located.



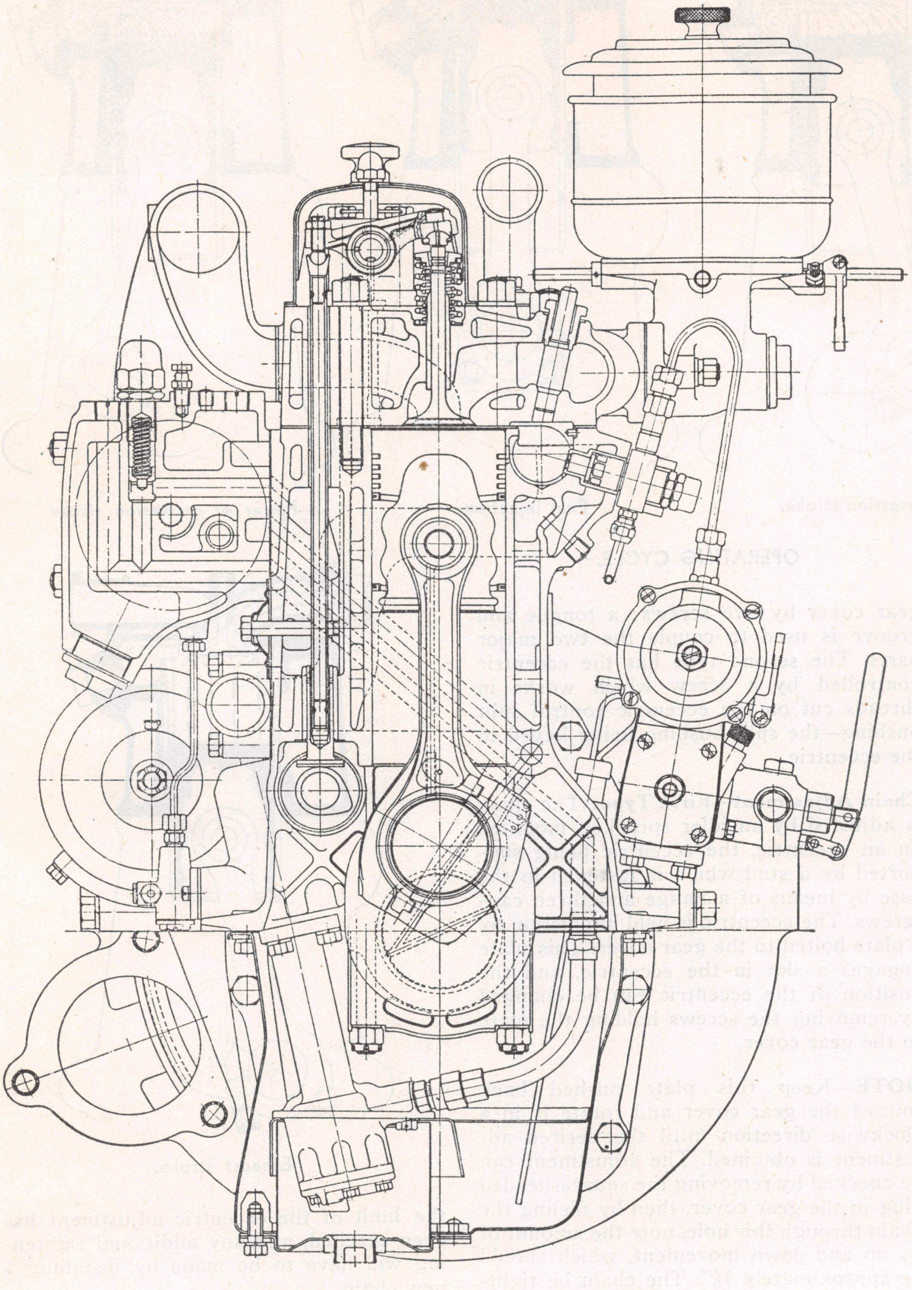
DHX SERIES. End sectional view.

ROCKER ARMS & PUSH RODS

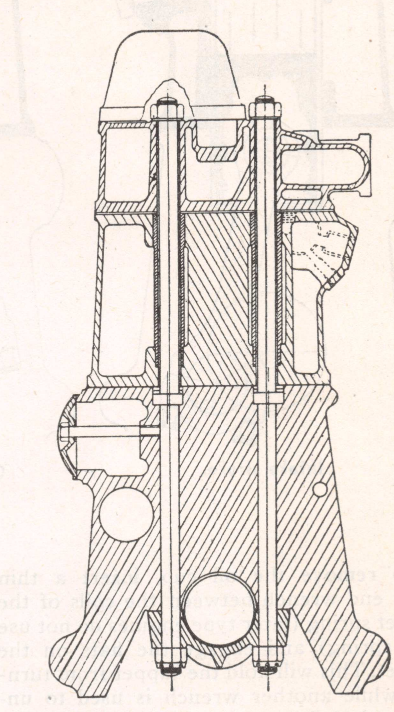
1936-46 All: When disassembling rocker arm assemblies, place all parts on the bench in their proper relationship to assure correct assembly. This is particularly important in the DHX engines as three different types of arms are used, that is, they stand at different angles with respect to their supporting shaft.

To prevent the possibility of bending or twisting push rods, they should be removed before taking off the cylinder head and replaced after the heads are installed.

NOTE—Since it requires some little time to fill the hollow rocker arm shafts with oil after the engine is started, and since the push rod ends are lubricated by a relatively low oil flow rate, initial distress of



DJX SERIES. End sectional view. Typical of DOO series.



DHX SERIES. Showing through bolt construction whereby the cylinder head, cylinder block, crankcase and main bearing caps are bolted into one structure.

parts will be prevented if—when assembling—the rocker shafts are thoroughly lubricated. As an added precaution, each end of the rocker arms should also be lubricated.

VALVE STEM GUIDES

1936-46 All: A special tool is available to remove and install stem guides. After new guides are installed, ream them to provide the valve stem clearance given in the VALVE SYSTEM table. When installing guides, see that each new guide is pressed in so that the top of the guide is the correct distance from the top of the cylinder block.

NOTE—On all engines, it is good practice to remove and install one guide at a time. When installing an intake guide, measure the depth of an intake guide not yet removed to determine the correct depth of the guide being installed. Similarly, when installing an exhaust guide, measure the depth of an exhaust guide not yet removed.

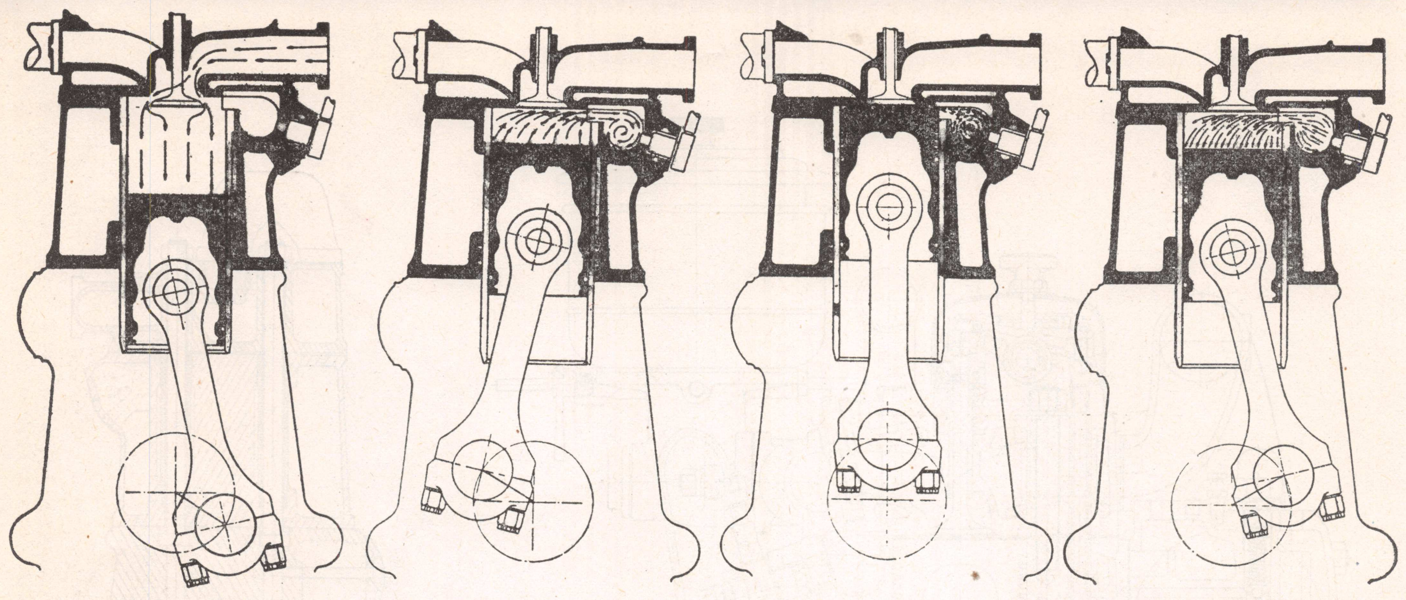
VALVE TAPPETS & GUIDES

DJX and DOO: Tappet guides in these engines are removable bushings pressed in the block. When necessary to replace, the camshaft will have to be removed and the old bushings pressed out and new ones installed. Then ream the bushings to provide a clearance within the limits given in the VALVE SYSTEM table.

DFX and DRX: Each tappet guide has a flange which rests against the machined surface of the cylinder block casting. A retaining washer straddles the flanges of the two guides for each cylinder and holds them in place; the washer in turn being retained by a capscrew.

This flange type construction permits the tappets and guides to be removed without removing the camshaft by simply taking out the push rods and removing the capscrews and retaining washers, after which, the tappets and guides can be lifted out.

DHX: An oil cup is screwed to the top of the valve tappet and forms a seal with the end of the push rod tube to prevent crankcase fumes from reaching the valve compartment.



Intake stroke. Compression stroke. Fuel injection. Power or expansion stroke.

OPERATING CYCLE.

To remove the oil cup, insert a thin open end wrench between the coils of the tappet spring (later type engines do not use this spring) and engage the flats on the tappet. This will hold the tappet from turning while another wrench is used to unscrew the oil cup.

When reassembling, use the open end wrench to hold the spring (if used) down so as to permit the threads of the oil cup to be started on the threads of the tappet. Be sure to replace the copper gasket between the cup and the top of the tappet.

The camshaft need not be removed when necessary to replace tappets. Simply take out the push rods, unscrew the tappet guide clusters and remove the assembly from the valve tappet compartment.

VALVE TIMING

1936-46 All: Valve timing is correct when the punch marks on the camshaft and crankshaft gears are meshed.

When checking valve opening or closing in degrees of crankshaft travel, do so when the engine is at normal room temperature, and set the valve clearance for timing as given in the VALVE SYSTEM table.

FUEL PUMP DRIVE

DJX, DOO: The fuel injection pump is driven by a chain and sprockets, one sprocket being attached to the camshaft and the other to the fuel pump drive shaft. The fuel pump drive shaft is supported in a sleeve which is attached to the cylinder block. To remove the sleeve, take off the fuel injection pump, remove the chain from the sprocket, detach the sleeve from the cylinder block and remove the sleeve toward the rear of the engine.

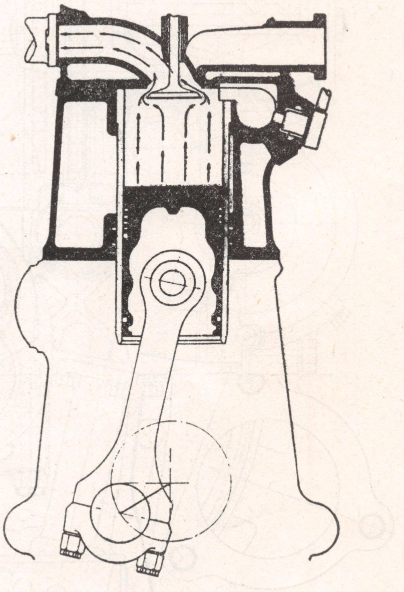
NOTE—On these engines, there are two different types of chain adjustments. The first type is an eccentric controlled by a plate having ten holes, being held to the gear cover by two screws; a tongue and groove is used to couple the two major parts. The second type has the eccentric controlled by a screw which works in threads cut on the eccentric control split bushing—the split bushing being keyed to the eccentric.

Chain Adjustment—First Type: The chain is adjusted by an idler sprocket, mounted on an eccentric, the eccentric being supported by a stud which is fastened in the case by means of a flange and three capscrews. The eccentric is held in position by a plate bolted to the gear cover. This plate engages a slot in the eccentric, and the position of the eccentric can be changed by removing the screws holding the plate to the gear cover.

NOTE—Keep this plate pushed back toward the gear cover and rotate it in a clockwise direction until the desired adjustment is obtained. The adjustment can be checked by removing the square-headed plug in the gear cover, then by feeling the chain through this hole, note the amount of its up and down movement, which should be approximately 3/8". The chain be tightened to the extent that it is perfectly taut.

NOTE—If it is not convenient to remove the square-headed plug to check the chain adjustment, adjust the chain until the backlash of the fuel pump coupling flange is approximately 1/32" as measured on the outside diameter of the coupling flange. The arrow on the gear cover indicates the direction of rotation to tighten the chain.

When a satisfactory adjustment has been obtained, move the ten-holed washer between the plate and the gear cover so that the screws can be inserted through the washer and plate, and tighten the screws to the cover. When the ear of the ten-holed washer has been rotated so that it comes near to, or strikes the pin in the gear cover, the limit of the eccentric adjustment has been reached, and any additional tightening will have to be made by installing a new chain.

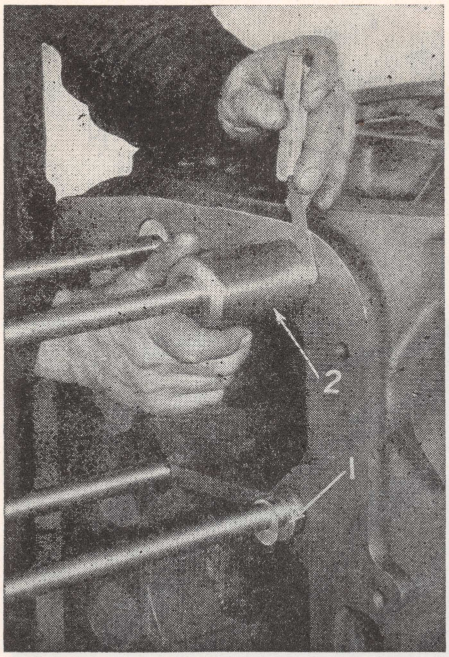


Exhaust stroke.

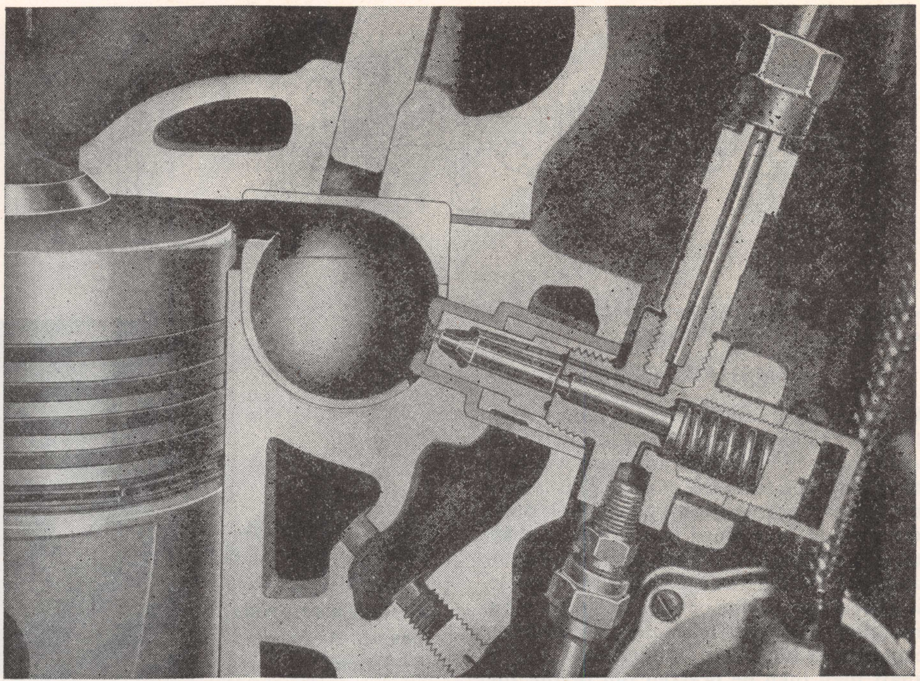
CAUTION—If the adjustment plate has been removed for any reason, be sure to install it so that the projecting ear is toward the lower part of the engine.

Chain Adjustment—Second Type: This design is similar to the first type except that the projection on the eccentric bushing is longer and protrudes through the gear cover. Whenever the gear cover is removed, it is important that this extension be properly centered before tightening the cover screws.

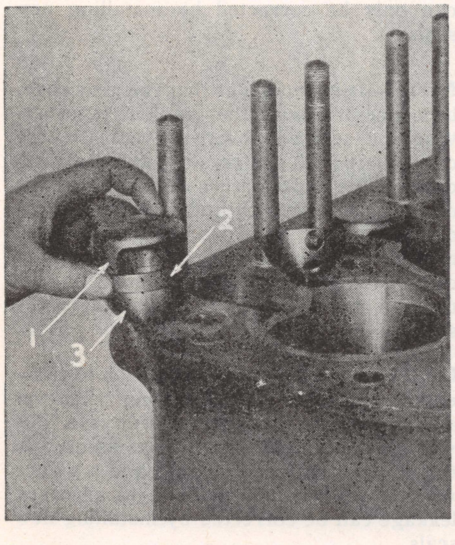
To adjust the chain, remove the square-headed plug and reach into the hole to see whether the deflection in the chain is in excess of 3/8" up and down. If it is, loosen



DHX SERIES. Method of checking shim clearance between crankcase and block. 1—Eccentric which seats in crankcase, preventing bolt from turning. 2—Gauge.



ALL SERIES. Sectional view showing turbulence chamber and injector.



COMBUSTION CHAMBER. Three-piece type. On later design, center section is integral with lower section.

the nut which holds the bushing support and use a screw driver to turn the long clamp screw in a clockwise direction. This causes the eccentric bushing to move in the same direction, thus tightening the chain.

Reach through the plug hole and feel the chain to see if the slack is approximately ⅛". If the adjustment is too tight, turn the screw in a counter-clockwise direction until the castellated nut rests against the bushing support, after which, turn the screw until the chain has sufficient slack. When the adjustment is satisfactory, reverse the action and tighten the nut.

NOTE—Always turn the screw clockwise before locking the nut to insure the elimination of all slack which otherwise may cause the chain to be loose after the engine is running.

It is never necessary to remove the screw which holds the adjustment support to the gear cover except to replace the oil seal. By keeping these parts assembled to the gear cover, the installation of the gear cover will be greatly facilitated. And before tightening the gear cover screws, always work the adjustment to see that it is correct.

NOTE—If it is not convenient to remove the square-headed plug to check the adjustment, it may be checked by rocking the fuel pump drive coupling back and forth to check the amount of backlash, which should be approximately 1/32" as measured on the outside diameter of the coupling flange. The arrow on the gear cover indicates the direction of rotation to tighten the chain.

DFX: The fuel injection pump drive chain is adjusted as described for the second type used on DJX and DOO engines.

DHX and DRX: The fuel injection pump is driven by a chain and sprocket, the drive sprocket being keyed to a flange or hub which is bolted to the camshaft gear. The driven sprocket is attached to a shaft which is supported by an eccentric sleeve mounting which is piloted on the gear cover. This design permits the chain to be adjusted externally.

To adjust the chain, remove the two lock screws which fasten the flanges together and then, while holding the flange having the large hexagon nut tightly against the sleeve flange, turn the sleeve flange in the direction indicated by the arrow until there is a slight backlash of approximately 1/64", this lash can be checked by rocking the coupling flange back and forth. When a satisfactory adjustment is obtained, install the two lock screws.

FUEL PUMP CHAIN, R & R

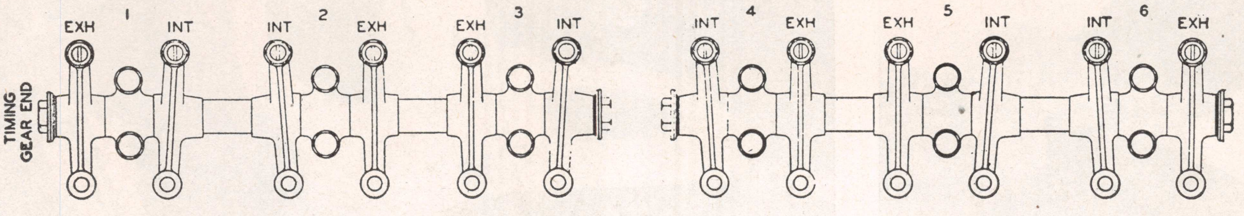
DJX, DFX, DOO: To remove the chain. spread the slotted lock which fits in the slots of two of the chain rivets. Push the rivets through the chain links and take off the chain. **When replacing the slotted lock, be sure the open end is facing opposite to the direction of engine rotation.**

To replace the chain, crank the engine until the arrow on the hub of the camshaft sprocket is pointing straight up (No. 1 piston should be on top center). Then rotate the fuel pump drive sprocket until the arrow on this hub is pointing straight up The chain should then be placed on the sprockets so as to permit these arrows to remain in the vertical position.

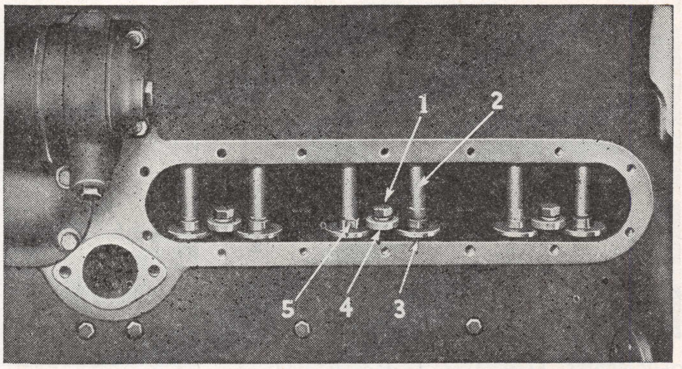
DHX and DRX: To remove the chain loosen the eccentric adjustment to permit maximum slack in the chain. Then pull out the cotter pin which holds the removable pin, push out the pin and drive the two crescent-shaped bushings out of the chain link. The chain may then be separated and removed from the case.

To replace the chain, reverse the above operations, but be sure that the arrow on the camshaft sprocket is pointing toward the crankshaft gear and that the arrow on the fuel pump sprocket is pointing toward the camshaft gear.

NOTE—When the chain is assembled, the arrow on the fuel pump sprocket should be slightly below a line drawn between the



DHX SERIES. Rocker arm arrangement.



DFX, DRX SERIES. 1—Washer lock screw. 2—Push rod. 3—Tappet guide flange. 4—Washer. 5—Tappet.

sprocket centers. Adjust the chain as described in a previous chapter.

CAMSHAFT GEAR

DJX and DOO: Since there is no provision to pull the gear from the shaft with the shaft in place, the shaft and gear will have to be removed from the engine. This is done by removing the gear cover, fuel pump drive chain (explained in a previous chapter), crankshaft oil slinger, oil pan, oil pump and push rods. Then lift up the tappets, tieing them with twine or wire in such a manner that they will not interfere with the camshaft as it is being withdrawn. The camshaft may then be pressed out of the fuel pump drive sprocket and camshaft gear.

CAUTION—Install the fuel pump drive chain, being sure that the indicating arrows on the two sprocket hubs are pointing straight up as explained under FUEL PUMP CHAIN, R & R. Be sure also, that the punch marks on the camshaft and crankshaft gears are meshed.

DFX and DRX: The procedure for removing the camshaft and gear on these engines is the same as described for the DJX and DOO engines except that the tappets can be easily removed as explained under TAPPETS AND GUIDES. Then remove the nut from the end of the camshaft (DRX) and press off the drive sprocket and camshaft gear. However, before withdrawing the camshaft on the DRX, pull the idler gear and shaft out of the case toward the front.

NOTE—When installing the camshaft and gear, be sure to mesh the punch marks on the cam and crank gears, and follow the procedure for installing and adjusting the fuel pump drive chain as explained in previous chapters.

DHX: After removing the fuel pump drive chain as explained in a previous paragraph, use a suitable puller to remove the drive sprocket and then pull off the camshaft gear by using the puller screw holes provided for that purpose.

NOTE—When installing the camshaft gear, be sure to mesh the punch marks on the cam and crank gears for correct valve timing, and follow the instructions as previously described for the installation and adjustment of the fuel pump drive chain.

CRANKSHAFT GEAR

1936-46 All: The crankshaft gear is removed by using a suitable screw type puller, using the tapped holes in the gear which are provided for that purpose.

NOTE—When installing the gear, be sure the punch mark is meshed with the punch mark on the camshaft gear for correct valve timing.

IDLER GEAR OR SPROCKET

DRX and DHX: The idler gear and shaft is easily removed by simply pulling the assembly forward out of the case.

DJX, DFX, DOO: The idler sprocket is easily removed after removing the fuel pump drive chain as explained in a previous paragraph. Then remove the cap screws which hold the sprocket to the crankcase.

NOTE—Install and adjust the fuel pump drive chain as explained in previous chapters.

ACCESSORY DRIVE GEAR

1936-46 All: The accessory drive shaft is supported in a removable sleeve casting bolted to the front of the crankcase and is used to drive the water pump. If necessary to remove this gear, simply remove the cap screws which fasten it to the crankcase and lift out the assembly.

GEAR COVER OIL SEALS

DJX and DOO: A composition seal is used in the water pump and fuel pump drive shafts to prevent oil leaks at these points. The crankshaft is sealed at the front end by half rings of felt and cork to prevent oil leaks in the gear cover and oil pan. Leakage at these points can be corrected by installing new seals.

DFX: The crankshaft is sealed at the front end by a steel enclosed spring-loaded leather or synthetic rubber type seal. The water pump and fuel pump drive shafts are provided with a composition seal which prevents leakage at these points. Leakage can only be corrected by installing new seals.

NOTE—It is important that the gear cover be concentric with the crankshaft, otherwise the seal will bear unevenly on the crankshaft with the result that a leak will develop due to premature wear. Be sure the crankshaft is smooth and free from nicks or rough spots, and, if necessary, the seal may be replaced by driving the old seal out of the cover and pressing a new one in, using a tool which will not mutilate the seal.

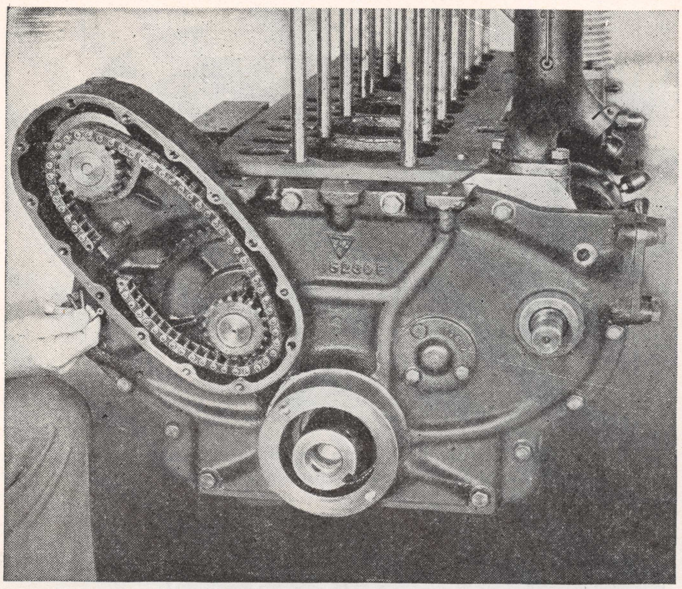
DRX and DHX: The construction of these engines provides for oil sealing whenever a shaft extends through the gear case. The seals may be of the same types as used in the above-mentioned engines and a glance will show which type is used. In all cases, leakage can be corrected by installing new seals.

GEAR COVER THRUST ADJUSTMENTS

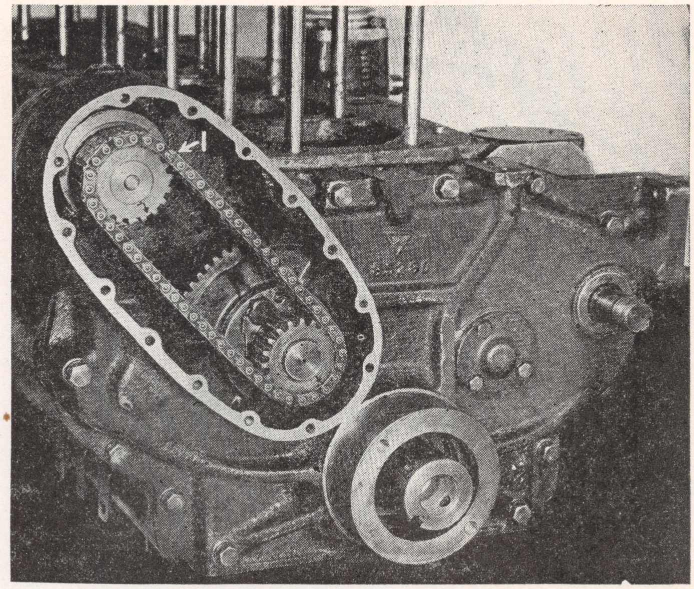
1936-46 All: On all engines, end thrust on all shafts extending through the gear case is either adjusted by a screw or by shims behind plates attached to the front of the gear case cover. At long intervals or when the engine has been disassembled for repairs, the end play should be checked.

With the adjusting screw type adjustment, loosen the lock nut and tighten the screw until its inner end contacts the shaft, then back it off about ⅛ turn before tightening the lock nut.

With the shim type adjustment, remove the thrust plate from the outside of the gear cover and, if the end play is too great,



DHX SERIES. Method of removing fuel pump drive chain.



DHX SERIES. For correct fuel pump timing, assemble chain as shown with sprockets in position indicated by arrows.

it may be reduced by removing sufficient shims from between the thrust plate and the gear cover.

NOTE—With the shim type adjustment, end play can be checked satisfactorily by coating the end of the thrust plug (inside the thrust plate) with prussion blue. Then push the shaft to the rear as far as possible and remove or install sufficient shims to permit the thrust plug to contact the shaft just enough to transfer some of the prussian blue from the plug to the end of the shaft. Remove the thrust plate and install sufficient shims (from .005" to .008") to maintain enough end play to prevent excessive pressure between the contacting surfaces, and to allow for heat expansion.

CAMSHAFT AND BEARINGS

1936-46 All: When necessary to replace bearings, they should be pressed in place and line-reamed to provide a clearance within the limits given in the ENGINE BEARING SPECIFICATIONS table.

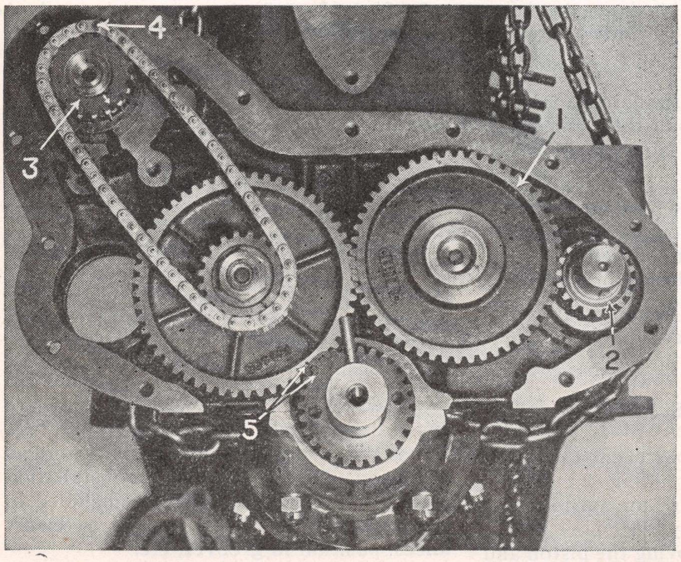
To remove the camshaft, follow the procedure as outlined under CAMSHAFT GEAR; and if end play is excessive, adjust as explained under GEAR COVER THRUST ADJUSTMENTS.

NOTE—When replacing bearings, be sure the oil holes in the bearings are in line with the oil holes in the crankcase, and that these holes have been cleaned thoroughly of all dirt, sludge or other foreign matter.

PISTONS AND RODS, R & R

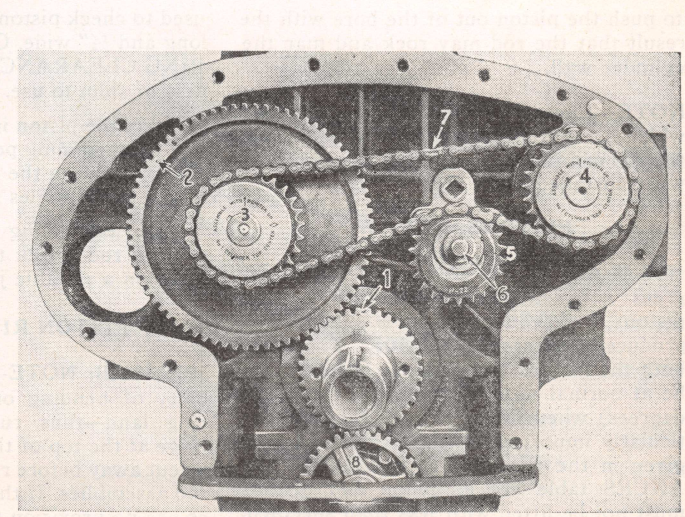
1936-46 All: The piston and connecting rod assemblies are removed from the top of the cylinder block. Although regular production rods are generally marked with the cylinder number in which they are installed, replacement rods are not; therefore, unmarked rods should be suitably identified with punch marks as they are removed.

CAUTION—When removing the piston and rod assemblies from the cylinder bores, it is good practice to wrap the big end of the rod in a cloth to prevent it from gouging or scratching the cylinder wall. As an added precaution, the carbon accumulation at the top of the bore should be carefully scraped off before taking out the piston and rod. If the carbon is not removed, it may be necessary to use considerable force

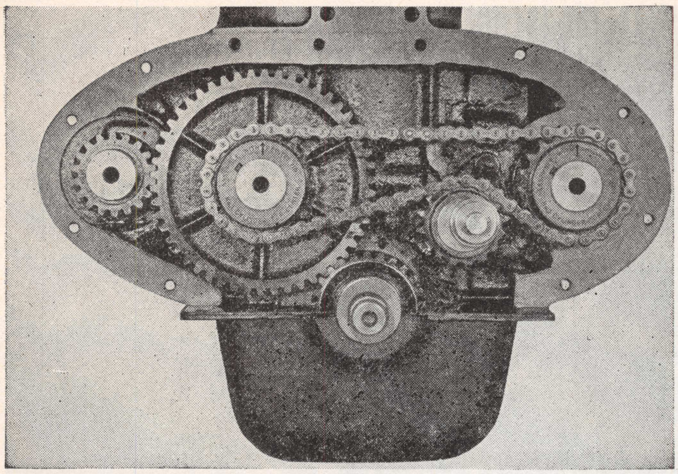


DRX SERIES. For correct fuel pump timing, assemble chain as shown with sprockets in position indicated by arrows.

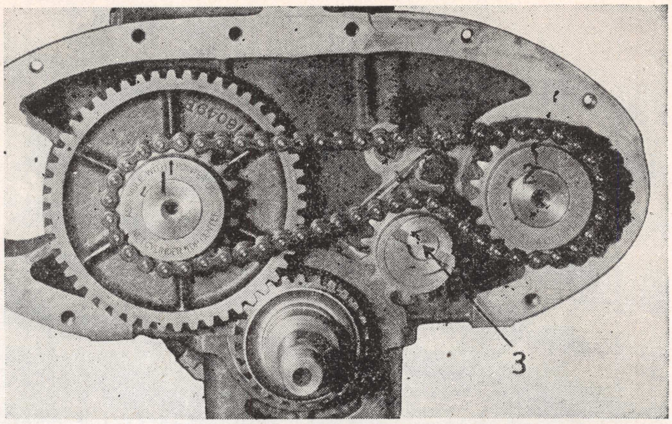
1—Idler gear. 2—Accessory drive gear. 3—Fuel pump sprocket. 4—Disconnect chain at this point for removal. 5—Match these marks for correct valve timing.



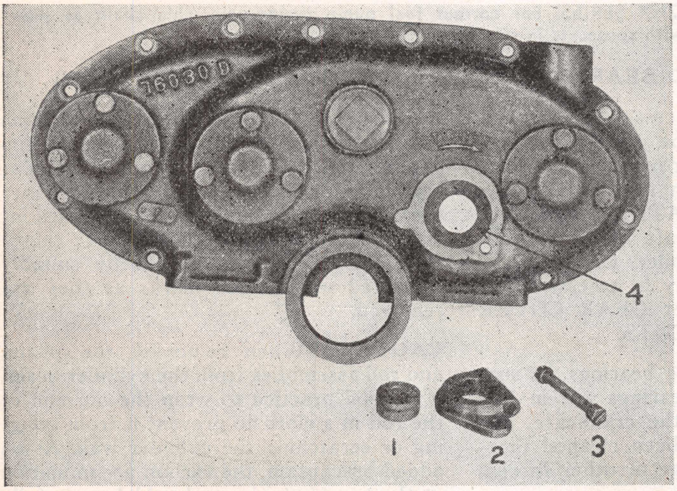
DFX SERIES. For correct fuel pump timing, assemble chain as shown with sprockets in position indicated by arrows.



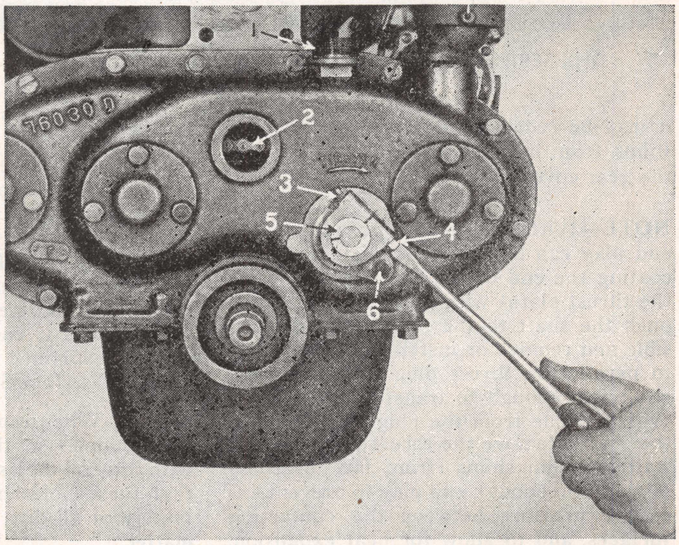
DJX, DOO SERIES. For correct fuel pump timing, assemble chain as shown with sprockets in position indicated by arrows.



DJX, DOO SERIES. Fuel pump chain adjustment—first type. 1—Camshaft gear. 2—Fuel pump drive gear pointer. 3—Idler stud



DJX, DOO SERIES.
1—Fuel pump chain adjustment eccentric bushing. 2—Adjusting screw support. 3—Adjusting screw. 4—Cork seal.



DJX, DOO SERIES. Fuel pump chain adjustment.
1—Inspection hole plug. 2—Chain. 3—Adjusting screw lock nut. 4—Adjusting screw. 5—Eccentric bushing. 6—Support attaching screw

to push the piston out of the bore with the result that the rod may rock and mar the cylinder wall.

NOTE—Engines having connecting rods which are parted at an angle should have the rod cap facing away from the camshaft when installed.

PISTONS, RENEW

1936-46 All: NOTE—A variation of 10 degrees between the temperature of the pistons and cylinder bores is sufficient to produce a difference of .0005". Therefore both the pistons and cylinder bores should be at normal room temperature (about 70 degrees) when fitting pistons. This is particularly important because the clearances given in the PISTON & RING CLEARANCES table are minimum and pistons must not be fitted with less than specified.

Before fitting pistons, wipe the cylinder walls and pistons to remove all chips, dirt or other foreign matter. The feeler ribbon used to check piston fit should be about 12" long and ½" wide. Consult the PISTON & RING CLEARANCES table for the thickness of shim to use.

Insert the piston in the bore upside down and in its running position. Place the feeler ribbon between the cylinder wall in a position at right angles to the piston pin hole.

After assembling the piston to the connecting rod, check the assembly for alignment on a suitable jig.

PISTON RINGS, RENEW

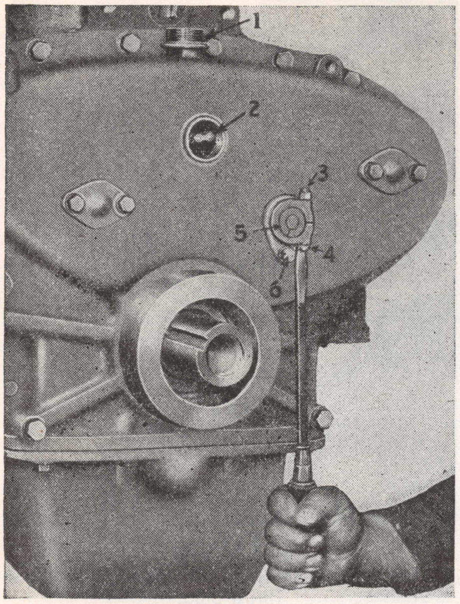
1936-46 All: NOTE—To prevent the possibility of bending or breaking the second ring land—thus ruining the piston—the ridge at the top of the cylinder bore should be cut away before removing the piston and rod assemblies. If the available ridge reamer has no provision to control the depth of the cut, it is good practice to bring the piston far enough up into the cylinder to allow the reamer to rest on top of the piston. This will serve to prevent cutting down into the ring travel area.

CAUTION—Never cut down into the ring travel area more than 1/32"—or more than half the depth of the top ring.

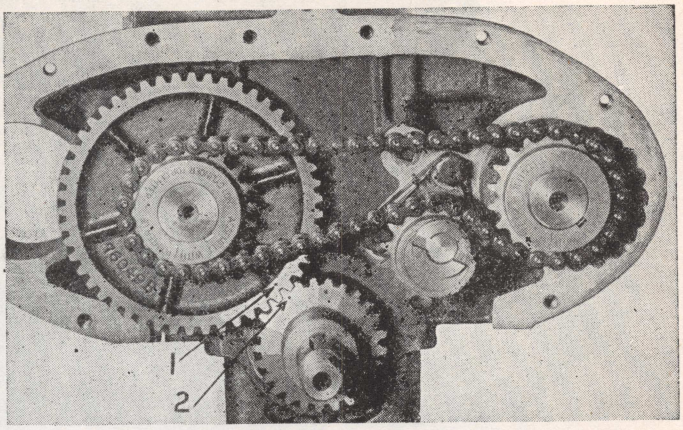
New rings should be fitted with end gaps and groove clearances as given in the PISTON & RING CLEARANCES table. Ring grooves must be clean and free from carbon, and must show no perceptible wear.

NOTE—Ring end gaps given in the PISTON & RING CLEARANCES table are for cylinder bores without taper. If rings other than standard are being installed, pay particular attention to the installation instructions which are usually included in the ring package. This applies to clearances, position in grooves, etc.

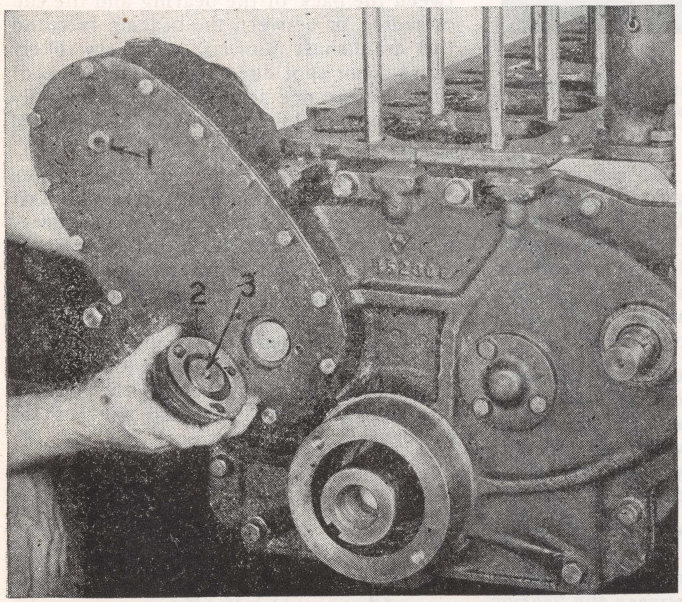
When rings are properly fitted to the pistons, be sure to stagger the ring gaps so they are spaced equal distances around the circumference of the piston. However, see that no gaps are over the piston pins.



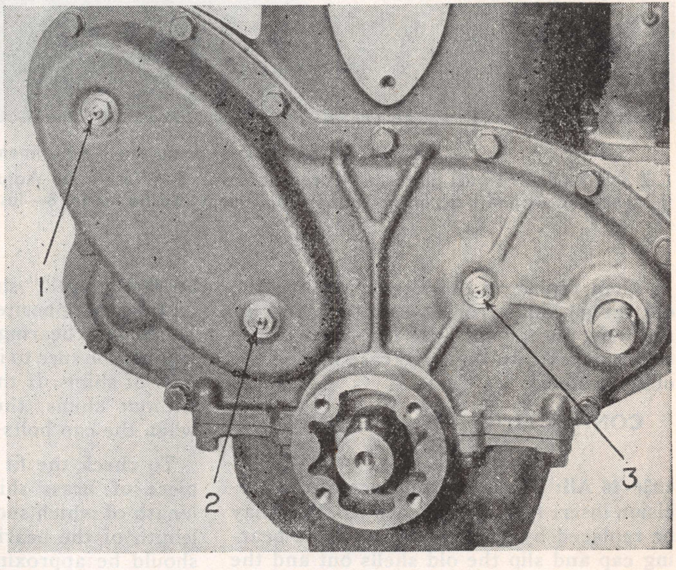
DFX SERIES. Fuel pump chain adjustment. 1 — Inspection hole plug. 2—Chain. 3—Lock nut. 4—Adjusting screw. 5—Eccentric bushing. 6—Support attaching screw.



DJX, DOO SERIES. Timing gear marks. Typical of all series engines.



DHX SERIES. 1—Fuel pump shaft thrust washer. 2—Camshaft thrust plate shims. 3—Thrust plug.



DRX SERIES. Shaft end play adjusting screws. 1—Fuel pump shaft. 2—Camshaft. 3—Idler shaft.

PISTON PINS, RENEW

1936-46 All: The correct fit of pins in aluminum pistons, at normal room temperature, should require a light tap fit with a rubber mallet to install the pin. However, to facilitate fitting pins in aluminum pistons, heat the piston in boiling water for a few minutes, after which the pin should enter the piston easily.

These pins are of the full-floating type, being held in place by snap rings in the grooves of the piston bosses. However, early DHX and DRX engines used aluminum plugs in the piston bosses to retain the pins.

PISTON PIN BUSHINGS, RENEW

1936-46 All: New bushings should be pressed in place and reamed to provide a light push fit of the pin with the parts at normal room temperature. When installed, be sure the oil hole in the bushing lines up with the hole in the connecting rod.

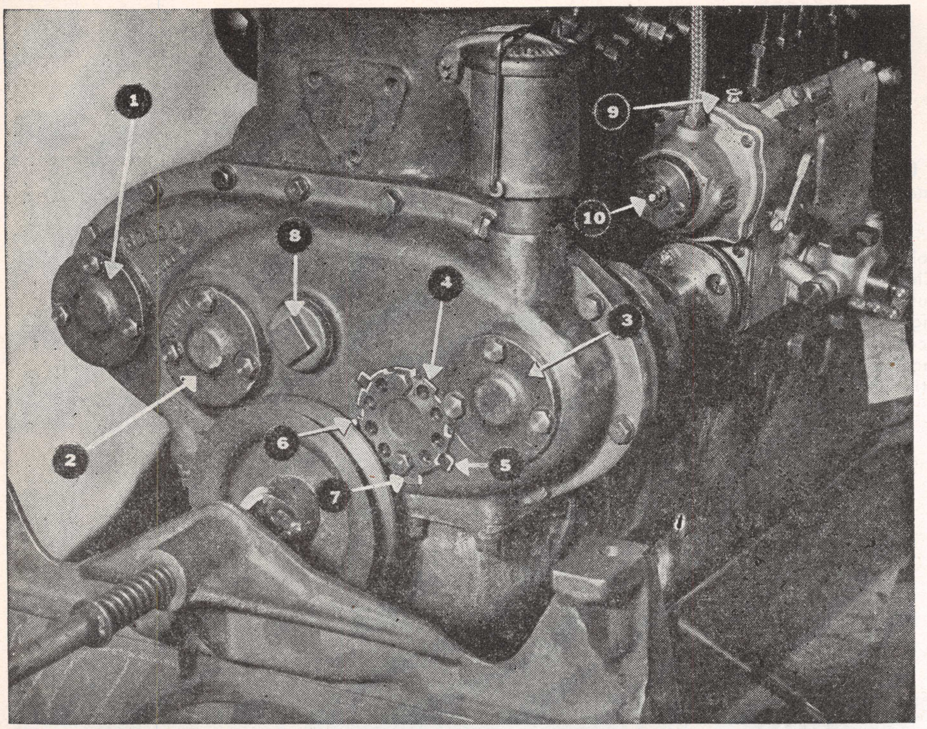
CYLINDER SLEEVES

1936-46 (All except DJXD): All engines except early DHX and DRX engines are equipped with removable cylinder sleeves of the dry type and special pullers are required to exert sufficient pressure to remove these liners.

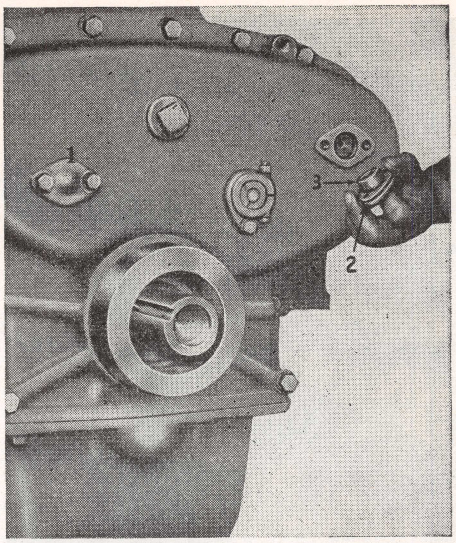
NOTE—When new sleeves are being installed, coat the outside surface with white lead so that when they are being pressed in the bore, the possibility of galling or sticking will be largely eliminated.

Wet Type Sleeve: On early DHX and DRX engines, the wet sleeve type liner is used and special equipment is not needed to remove this type. To remove the sleeve, insert a long bolt through the sleeve and attach a cross bar at the bottom and at the top, supporting the top cross bar on two blocks, being sure the blocks are long enough to be supported across the entire width of the cylinder block. By running the nut down on the long bolt, the sleeve will be released.

Each sleeve is sealed by the cylinder head gasket at the top, while rubber packing rings are fitted in the recessed grooves at the bottom of the water jacket case to keep the lower end tight.



DJX, DOO SERIES. Fuel pump chain adjustment.
1, 2 and 3—Shaft thrust plates. 4—Eccentric cover. 5—Washer. 6—Adjustment limit pin. 7—When this ear reaches limiting pin, no further adjustment can be made. 8—Inspection hole plug.



DFX SERIES.
2—Fuel pump shaft thrust plate shims. 3—Thrust plug.

When replacing the sleeve, remove the old rubber rings from the grooves and install new ones, being sure that none of the old rings fall into the crankcase to clog the oiling system.

CONNECTING ROD, BEARINGS, RENEW

1936-46 All: These bearings are of the precision insert type and when worn, they may be replaced by simply taking off the bearing cap and slip the old shells out and the new ones in. Bearings should be replaced in sets and under no circumstances should rods or caps be filed, altered or mutilated in any way in an attempt to obtain proper bearing fit.

NOTE—Before replacing bearings, make sure that the crankpins are not nicked or scored, and that all parts are thoroughly clean. This is particularly important because the presence of one small particle of metal, carbon or other foreign matter, lodged between the back of the bearing and the rod, or between the face of the bearing and the crankpin, will very likely cause a hot spot due to the elimination of the oil clearance at that point, eventually resulting in bearing failure or a scored crankpin.

CAUTION—Except for early DHX and DRX engines, these bearings are designed for use without shims and under no circumstances should shims be used in an attempt to obtain a bearing fit, because the proper "crush" fit of the bearings in the connecting rod bores will not be obtained.

NOTE—On early DHX and DRX engines, an .008" to .010" shim pack was used only on the side opposite the bearing lock notch. When new bearings are installed in these engines, be sure to install the original thickness of shims. If the bearings are installed without shims, the bearings will buckle when the cap bolts are tightened.

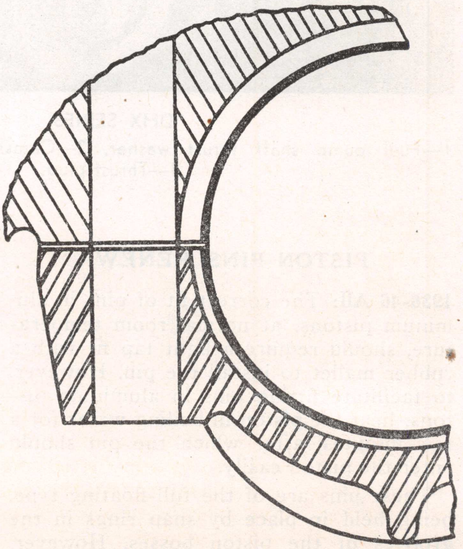
To check the fit of new bearings, use a piece of brass shim stock ¼" wide, the length of which should be ¼" less than the length of the bearing, while the thickness should be approximately the same as the minimum allowable clearance.

To avoid damaging the bearing material, smooth down the edges of the shim stock on an oil stone so that no sharp edges remain. Install the shim between the bearing and the crankpin, in the center of the bearing, then tighten the cap bolts to the recommended torque tension. When fitted properly, it should not be possible to move the rod endwise by hand, but a light tap with a hammer should cause the rod to move endwise. Then remove the checking shim and re-install the cap, tightening the cap bolts with a torque wrench, after which the rod should move endwise by hand. If the rod is too loose with the checking shim in place, the crankpin should be turned down and undersize bearings fitted.

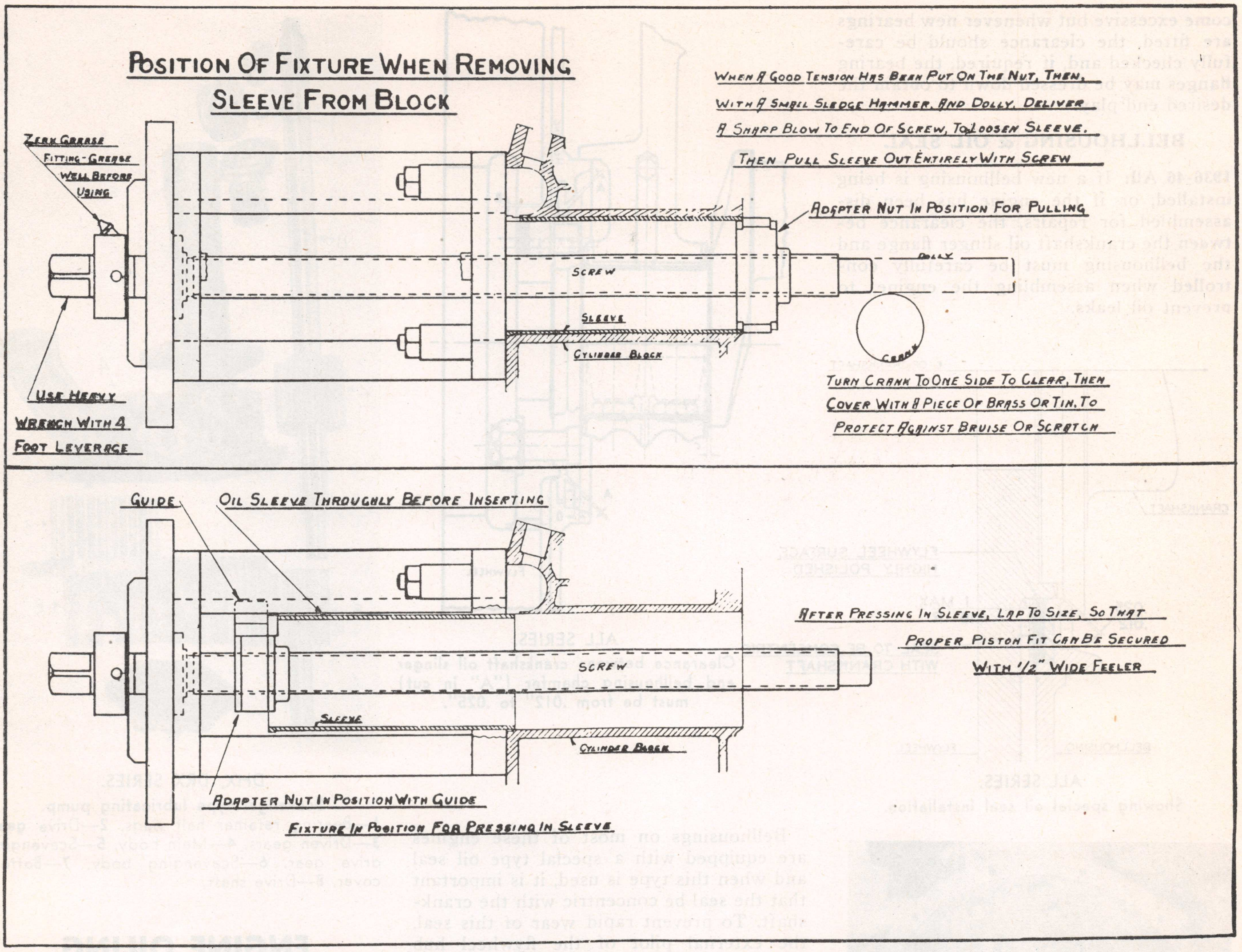
MAIN BEARINGS, RENEW

1936-46 Except DHX: Before replacing bearings, make sure that the crankshaft journals are not nicked or scored. Use care also, to see that all parts are thoroughly clean. This is particularly important because one small particle of metal, carbon, dirt or other foreign matter, lodged between the back of the bearing and the cap or saddle, or between the bearing face and the crankshaft journal, will very likely cause a hot spot due to the elimination of the oil clearance at that point, eventually resulting in a bearing failure or a scored journal.

When bearings become worn, they can be replaced without removing the crankshaft in the following manner: Remove the bearing cap and take out the worn lower shell. A suitable tool can be made to remove the upper shell by using a cotter pin with the rounded end flattened to form a T shape. Insert the long end of the pin in the oil passage hole in the crankshaft journal and, by rotating the crankshaft in the reverse direction, the T-shaped head will contact the bearing and force it out.



DHX SERIES.
Showing how main bearing shells are held in place (early design).


Position Of Fixture When Removing Sleeve From Block
Zerk Grease Fitting - Grease Well Before Using
Use Heavy Wrench With 4 Foot Leverage
When A Good Tension Has Been Put On The Nut, Then, With A Small Sledge Hammer, And Dolly, Deliver A Sharp Blow To End Of Screw, To Loosen Sleeve. Then Pull Sleeve Out Entirely With Screw
Adapter Nut In Position For Pulling
Dolly
Screw
Sleeve
Cylinder Block
Crank
Turn Crank To One Side To Clear, Then Cover With A Piece Of Brass Or Tin, To Protect Against Bruise Or Scratch
Guide
Oil Sleeve Throughly Before Inserting
Screw
Sleeve
Cylinder Block
After Pressing In Sleeve, Lap To Size, So That Proper Piston Fit Can Be Secured With 1/2" Wide Feeler
Adapter Nut In Position With Guide
Fixture In Position For Pressing In Sleeve

ALL SERIES.
Application of sleeve puller.

To install, place a new upper shell on the crankshaft journal with the locating notch in the correct position and rotate the shaft to turn the shell in place. Then install the lower shell in the cap and replace the cap, tightening the cap bolts to the recommended torque tension.

NOTE—Bearings should be replaced in sets and under no circumstances should any attempt be made to file, alter or otherwise mutilate the bearing caps to obtain proper bearing fit.

To check the fit of new bearings, use a piece of brass shim stock ¼" wide, the length of which should be ¼" less than the length of the bearing, while the thickness should be about the same as the minimum allowable clearance.

CAUTION—To avoid damaging the bearing material, smooth down the edges of the shim stock to remove sharp edges or turned over corners. And before inserting it in place, coat the shim on both sides with a light film of engine oil.

Then lay the shim lengthwise in the center of the bearing and install the bearing cap to the crankshaft, tightening the cap bolts to the recommended torque tension. Test the fit of the bearing by rocking the flywheel through an arc of 2"—not more than 1" in either direction. The bearing may be considered fitted properly if the shaft is movable with a fairly heavy drag.

NOTE—Remove the checking shim and replace the cap, but do not tighten the cap bolts, as this bearing must be loose in order to check the fit of the other bearings. It is good practice to fit bearings by starting at the center, then the rear bearing, front bearing, and finally, the intermediates.

DHX: Two types of bearings have been used in these engines. The first type is of the removable steel back shell type and is serviced in the same manner as described in the preceding chapter. However, these bearings differ from those described previously in that with this type, the upper half of the bearing is much thicker than the lower half. With this design, the steel backing in the upper shell rests on the bearing cap, thus preventing the upper shell from rotating in the case; the inner portion of the shell, in turn, holds the lower shell in place.

The later type bearing is used with the 3¾" diameter crankshaft and has a babbitt-lined shell for the upper half while the lower half is of the poured babbitt type in which the babbitt metal is bonded directly to the forged steel cap.

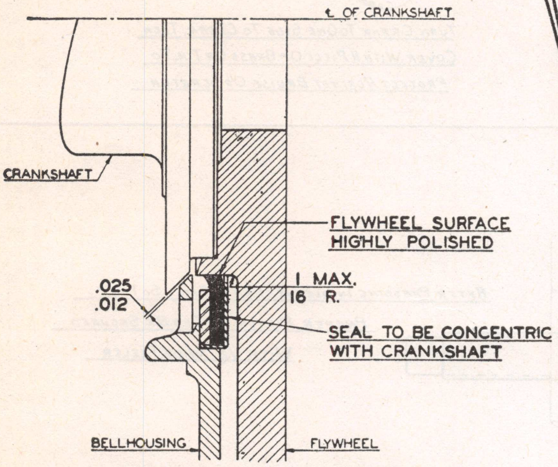
To adjust this type bearing, remove the same thickness of shims from each side until a metal-to-metal contact is established with the crankshaft journal. If the bearing material is scored, rough or shows only partial contact, the bearing may be scraped to obtain maximum contact. If the babbitt is cracked or worn excessively, new bearings should be fitted. After maximum contact is established, install the same thickness of shims on each side to provide a clearance within the limits given in the ENGINE BEARING SPECIFICATIONS table.

CRANKSHAFT END THRUST

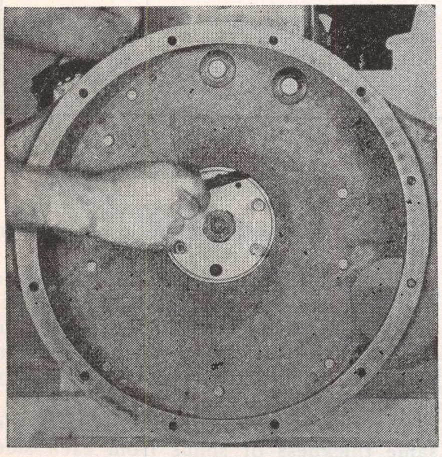
1936-46 All: End thrust is controlled by flanges on the rear main bearing. Through normal wear, the end play will seldom become excessive but whenever new bearings are fitted, the clearance should be carefully checked and, if required, the bearing flanges may be dressed down to obtain the desired end play.

BELLHOUSING & OIL SEAL

1936-46 All: If a new bellhousing is being installed, or if the engine has been disassembled for repairs, the clearance between the crankshaft oil slinger flange and the bellhousing must be carefully controlled when assembling the engine, to prevent oil leaks.


℄ OF CRANKSHAFT
CRANKSHAFT
FLYWHEEL SURFACE HIGHLY POLISHED
.025
.012
1 MAX.
16 R.
SEAL TO BE CONCENTRIC WITH CRANKSHAFT
BELLHOUSING
FLYWHEEL

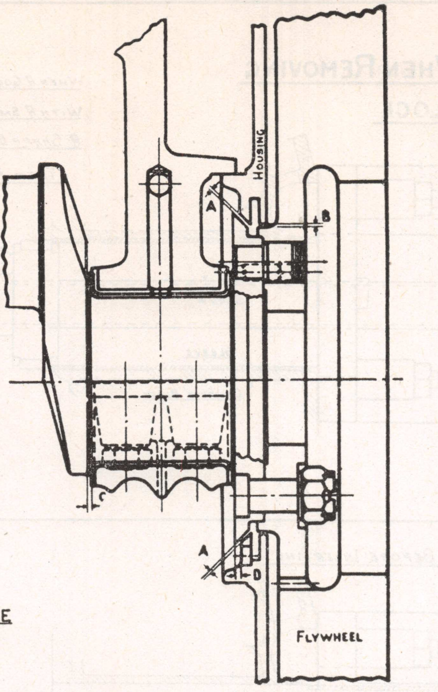
ALL SERIES.
Showing special oil seal installation.



ALL SERIES.
Method of checking clearance between crankshaft oil slinger flange and bellhousing.

To measure the clearance, force the crankshaft back to the limit of its end play and insert a feeler gauge between the oil slinger flange and the bellhousing chamfer. This clearance should not be less than .012" nor more than .025". If necessary to increase the clearance, scrape the bellhousing chamfer or install an additional gasket between the bellhousing and the case.

CAUTION—To prevent oil leaks, all possible chance of interference or rubbing should be eliminated at this point.



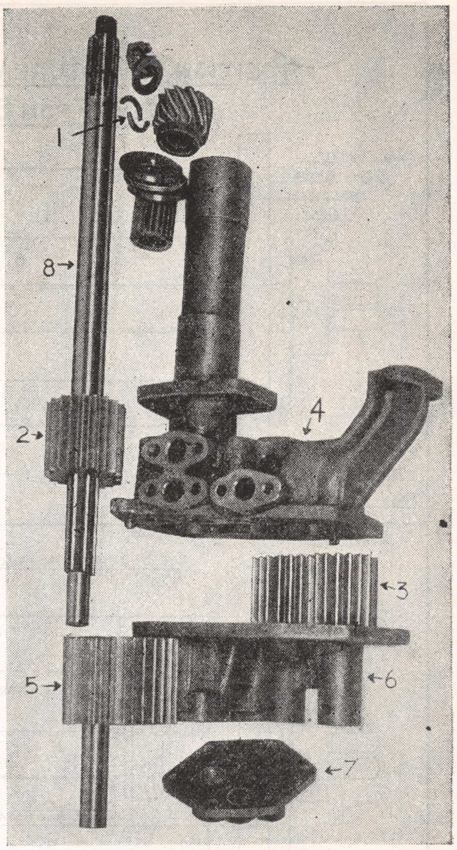
ALL SERIES.
Clearance between crankshaft oil slinger and bellhousing chamfer ("A" in cut) must be from .012" to .025".

Bellhousings on most of these engines are equipped with a special type oil seal and when this type is used, it is important that the seal be concentric with the crankshaft. To prevent rapid wear of this seal, the external pilot of the flywheel hub should be polished with a very fine emery or crocus cloth to remove all nicks or rough spots.

FLYWHEEL

1936-46 All: Whenever replacing the flywheel, it should be checked for wobble or excessive run-out. If a dial indicator is available, mount it on the bellhousing and allow its stem to contact the flywheel as the engine is being turned slowly. Make a note of the high and low sides of the flywheel through one complete revolution and if run-out exceeds .010", it should be removed and the crankshaft flange recess inspected for burrs, dirt or other foreign matter.

NOTE—On the DJX series, a change was made in the crankshaft flange. The enlarging of the bolt circle of this flange affects the interchangeability of the crankshaft, flywheel and bellhousing. The illustrations show both the old and new style crankshaft, flywheel and bellhousing, giving the important dimensions, as well as the engine serial prefix. All engines with engine numbers from 800,000 to 801,000 have the old type flywheel, crankshaft and bellhousing, while engines with serial numbers above 801,000 have the new type.



DHX, DRX SERIES.
Scavenger type lubricating pump.
1—Bearing retainer half rings. 2—Drive gea 3—Driven gears. 4—Main body. 5—Scavenging drive gear. 6—Scavenging body. 7—Botto cover. 8—Drive shaft.

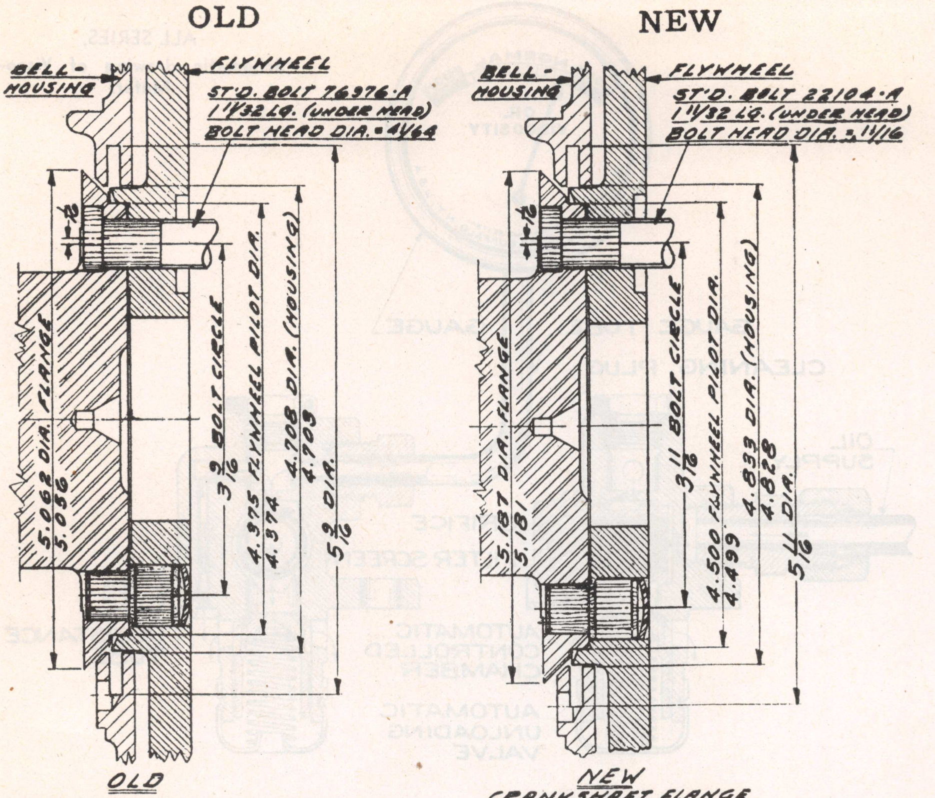
ENGINE OILING

OIL PUMP

1936-46 All: If the oil pressure drops below normal, do not remove the oil pump until the oil gauge is checked with another gauge known to be accurate. Check the oil level and examine the condition of the oil. If these items are correct and the pressure continues to drop, remove and clean the oil pan thoroughly, and disassemble, clean and inspect the pump.

CAUTION—Before replacing the oil pump and oil pan, the oil screen, tubes and lines should be thoroughly cleaned, being sure that all openings in the screen are free and clean. If the screen has been crushed, it is better to replace it rather than attempt to make a repair. When assembling, dip the gears in fresh engine oil as a means of priming the pump.

NOTE—Clearance between the gears and cover may be checked by placing a steel scale across the face of the housing, and a feeler ribbon between the steel scale and gears. If the clearance is excessive, it may be reduced by grinding the lower face of the housing, using an abrasive compound evenly distributed on a perfectly flat surface.



OLD
CRANKSHAFT FLANGE DIMENSIONS FOR ENGINES UP TO & INCLUDING PREFIX LETTER "D"

NEW
CRANKSHAFT FLANGE DIMENSIONS FOR ENGINES WITH AND AFTER PREFIX LETTER "E"

DJX SERIES.
Crankshaft flywheel flange change.

On all engines except the DFX series, the pump is easily removed for inspection or repairs after the oil pan is removed. To disassemble the pump, drive the pin out of the hub of the upper spiral drive gear and pull the gear from the shaft. Remove the key from the keyway near the top of the shaft, take off the bottom cover and withdraw the shaft.

NOTE—On some types of applications where the vehicle is operated on an extreme angle, such as tractors or trucks operating on steep grades, a scavenger type pump is employed. This type pump consists of the conventional pressure gear pump and two auxiliary pumps contained in the same housing. The pressure pump gears are located in the lower half of the housing while the auxiliary pump gears are contained in the upper half of the housing. The purpose of the auxiliary pumps is to scavenge any oil which will flow to the front or rear of the oil pan when the engine is tipped to an extreme angle.

The upper half of the pump housing is doweled and bolted to the lower half, and the assembly may easily be taken apart for repairs or inspection. To disassemble this type pump, remove the nut which fastens the upper spiral drive gear and pull off the gear. Pick out the washers and roller bearing from the top of the housing. Disconnect the upper and lower housings and lower cover, and when this is done, the shafts and gears can readily be removed.

When assembling, in order to insure the proper mesh of the gears which drive the oil pump, the camshaft should be located so that the center of the drive gear on the camshaft is exactly in the center of the pilot hole in the crankcase which guides the top end of the oil pump body.

Whenever any adjustments or replacements are necessary, and the gear on the camshaft does not line up with the pilot hole, the position of the gear can be changed by thinning down the thrust washer between the flange on the camshaft and the crankcase, or by installing suitable shims between the crankcase and the washer.

DFX: This type pump is of the gear type, mounted on the front main bearing cap and driven by a gear which meshes with the crankshaft gear. This pump consists of four gears (besides the drive gear which is driven by the crankshaft timing gear), two of which are used for scavenging, while the other two are used on the pressure side of the pump.

To disassemble this type pump, remove the pump cover and pull the drive gear (in timing case) from the shaft. Remove the Woodruff key and pull off the cover from the pressure side of the pump (front side). The gears with their respective shafts can then be removed from the pump body for inspection.

OIL PRESSURE REGULATOR

1936-46 All: Oil pressure is automatically controlled by a compression spring which controls the action of a relief or by-pass valve. Oil pressure should not be judged to be too high or too low until it is known whether the proper weight of oil is used, and the engine is warmed up to normal operating temperature.

As the engine bearings become worn, the oil pressure will be slightly lower due to more oil escaping around the bearings. It is not advisable to try to correct this slight pressure loss by an adjustment of the pressure regulator, because the extra amount of oil being thrown off by the worn bearings is already over-oiling the cylinder walls.

DJX and DOO: The pressure regulator is incorporated in the oil filter and if an adjustment is necessary, remove the acorn nut which covers the adjusting screw and turn the screw clockwise to increase the pressure and counter-clockwise to decrease the pressure.

DFX: The oil pressure regulator is located on the outside of the crankcase at the center. If an adjustment is required, remove the acorn nut and turn the adjusting screw in to increase pressure and out to decrease it.

DHX and DRX: The pressure regulator is incorporated in the oil filter and if an adjustment is required, remove the acorn nut and loosen the adjusting plug lock nut. To increase the pressure, screw the slotted plug in, and to decrease the pressure, screw the plug out.

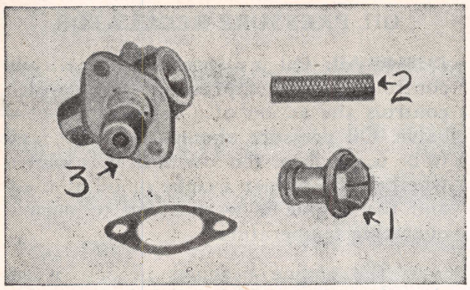
NOTE—If no change in pressure resulted after screwing the plug in either direction, stop the engine and remove the plug, spring and piston. Then clean the piston, as well as its seat in the base, with fuel oil or kerosene, and reassemble, after which make another check.

LUBRICATING OIL FILTERS

1936-46 All: Several types of filters are used in these engines and usually, complete maintenance instructions accompany each filter in the form of a sticker pasted on the filter itself. If additional information is required, see the Table of Contents on page one for the location of the OIL FILTER chapter.

At frequent intervals, the filter should be drained to get rid of any solid matter which may have settled in the filter sump. Whenever this is done, be sure to add sufficient oil to the crankcase to compensate for the oil drained.

Filters should be cleaned thoroughly every time the oil is changed and after every 1,000 miles of operation, or after every 50 hours of operation in industrial units. If the dip stick shows the oil to be thick and very dirty, it indicates that the filter requires service.



ALL SERIES.
Visco-Meter.
1—Plug. 2—Filter screen. 3—Body.

CRANKCASE VENTILATOR

1936-46 All: The crankcase ventilator breather should be inspected at least every 2,000 miles, and if a sludge formation is evident, remove the breather and clean it thoroughly in gasoline or kerosene. Allow it to soak for about 30 minutes, then blow it out with compressed air and at the same time, tap it lightly to dislodge any solid particles of sludge.

If the breather is fitted with an air cleaner, it should be removed and washed every 1,000 miles. After the element is washed, blow it dry with compressed air and, if the cleaner is of the oil-wetted type, dip the element in fresh engine oil before assembling. If it is of the oil-bath type, wipe out the oil reservoir with a clean cloth and fill it to the proper level with fresh engine oil.

NOTE—The interval at which the ventilator and air cleaner should be serviced can only be determined by the type of service to which the vehicle is subjected. Vehicles operating in dusty or sandy areas require more frequent service than vehicles operating under more favorable conditions.

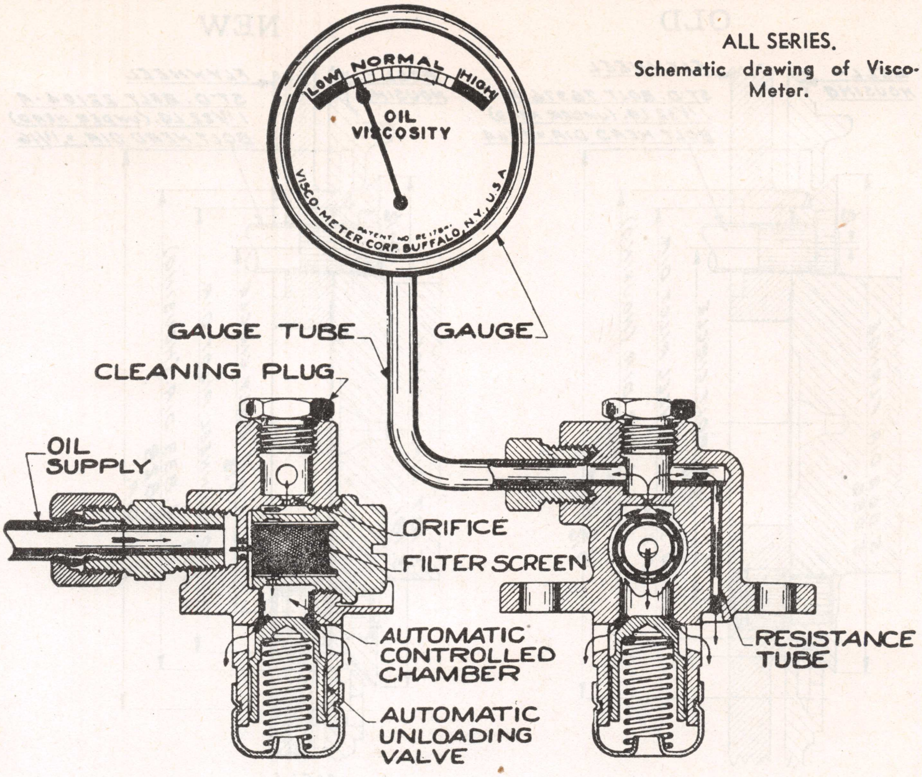
IMPORTANT—For vehicles operating in dust storm areas, the cleaner should be cleaned immediately after such storms occur.

VISCO-METER

1936-46 All: The purpose of this unit is to indicate the viscosity of the lubricating oil just before it enters the main bearings. It is located on a pad on the crankcase on the oil filter side of the engine.

Some of the lubricating oil is lead from the main oil header in the engine through a short insulated copper tube to the unit; as shown in the schematic drawing, this tube is labeled "oil supply." The oil enters the unit through an orifice into a filter screen. It then passes through the screen into an "automatic control chamber" which has an orifice on one side and a spring-loaded check valve ("automatic unloading valve" in illustration) on the other side.

Although the oil may enter the unit at any pressure, this check valve is permanently set at a pressure which is low enough to maintain a constant, even pressure in the chamber, regardless of engine pressure—unless the engine pressure is less than the setting of the unloading valve spring.



ALL SERIES.
Schematic drawing of Visco-Meter.

The excess oil flows past the check valve and spills back into the oil pan. The rest of the oil passes through the orifice on the other side of this chamber and into a chamber which connects with the resistance tube. The other end of the resistance tube is connected to the crankcase to permit some of the oil to spill into the oil pan.

Since the diameter of the resistance tube is smaller than the oil supply line, the oil which passes through the tube is restricted, thereby setting up a pressure in the gauge tube line. This pressure, as determined by the rate of oil flowing through the tube, is registered on the Visco-Meter Gauge.

NOTE—Thick oil will not flow through the resistance tube as rapidly as will thin oil under the same pressure. The thinner the oil, the less the pressure in the gauge line will be, since there is less resistance to the oil flow through the resistance tube. For this reason, thin oil will register lower on the gauge and thick oil will register higher.

Visco-Meter Service: The interval at which the unit should be cleaned can only be determined by the type of oil being used; some oils gum or plug up passages more rapidly than other oils.

To remove the unit, disconnect the oil tubes and remove the capscrews which fasten the unit to the engine, and lift off the unit.

To disassemble, remove the plug which holds the filter screen and take out the screen. Unscrew the plug from the chamber which connects with the resistance tube, then thoroughly clean the body and all parts in clean fuel oil, kerosene or gasoline, being sure to remove all carbon, sludge or other foreign matter. Blow out all chambers and the resistance tube with compressed air.

If compressed air is not available, use a piece of soft copper wire which will go through the resistance tube easily. Work the wire back and forth from the unloading valve end of the tube until it is thoroughly clean, after which, wash the body again.

Reassemble the parts and install it on the engine, but before connecting the oil lines, they should be removed and cleaned.

NOTE—Whenever the oil is changed, remove and clean the filter screen.

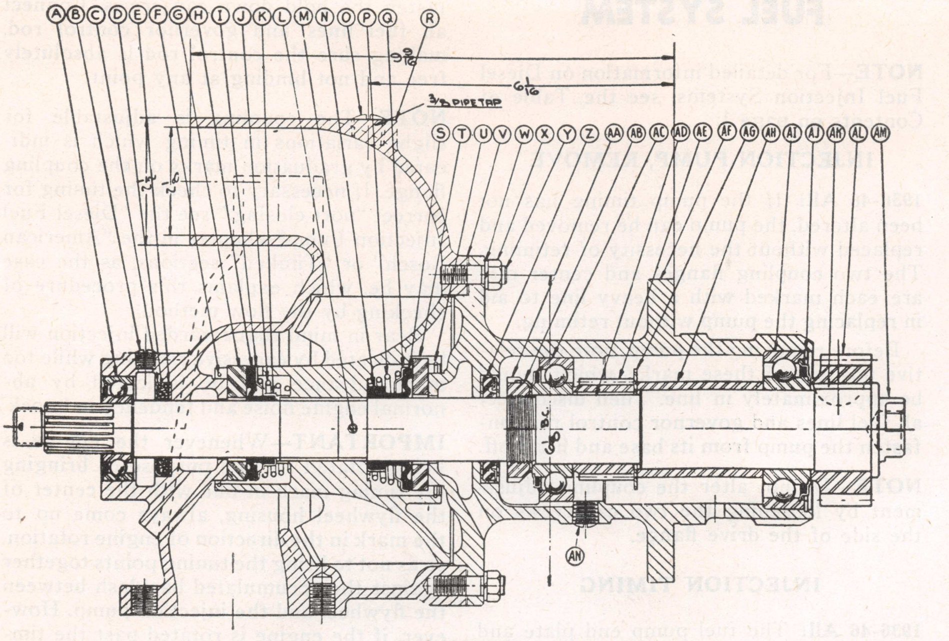
COOLING SYSTEM

WATER PUMP, OVERHAUL

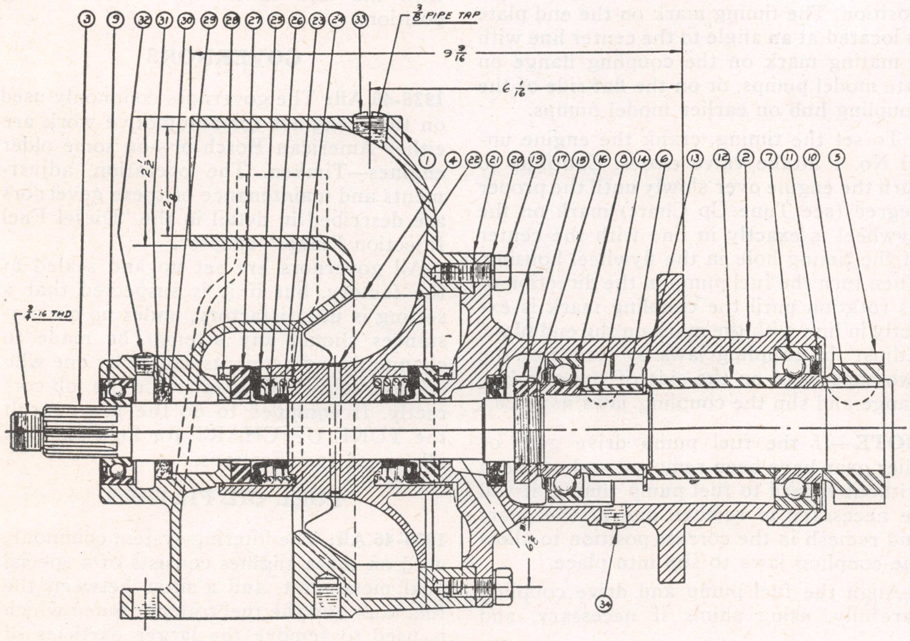
DJX and DOO: The water pump assembly is readily removed from the engine without the necessity of taking off the timing case cover. Simply remove the attaching screws and pull the pump directly toward the rear of the engine.

The pump is of the packless seal type, requiring no adjustments or lubrication. A leak can be remedied by installing new parts. When disassembling the pump, pay particular attention to the arrangement of the parts. It is good practice to lay the parts on the bench in their correct relationship so that the possibility of a wrong assembly will be largely eliminated.

NOTE—Inspect all parts and replace any that show wear. If the bearings are worn, replacing the seal parts only will not definitely correct the condition unless the


A B C D E F G H I J K L M N O P Q R
S T U V W X Y Z AA AB AC AD AE AF AG AH AI AJ AK AL AM
AN
9 9/16
6 1/16
3/8 PIPE TAP

DFX SERIES.
Water pump (first type).



DFX SERIES.
Water pump (second type).

bearings, and possibly the shaft, are also replaced.

When assembling the pump, bear in mind that the carbon seal washer is held against the face of the housing by the coil spring. The rubber seal and the two stampings are placed between the spring and the carbon washer; the larger stamping being used to prevent the spring from cutting into the rubber and gives more equal pressure on all parts of the carbon washer. The small stamping surrounds the smaller diameter of the rubber seal and helps to compress this end of the seal so that water will not leak out from between the seal and the shaft.

On the DOO series pump, the snap ring is used to keep the seal parts in their respective positions. On the DJX series, this is accomplished by a cup and pin.

NOTE—The thrust surfaces, against which the carbon washer bears, must be clean and smooth in order to prevent leakage between these two surfaces.

DFX: The pump is of the packless seal type, similar in principle to the type used on DOO and DJX engines. To remove the pump, take off the generator and coupling, after first disconnecting any hose or water pipe which would prevent the removal of the pump. Take out the pump attaching screws and pull the pump straight back toward the rear of the engine. If a tachometer is installed on the engine, it should be disconnected before sliding the pump back.

To disassemble the pump, remove the screws which fasten the two housings and separate the pump, pulling the body away from the front half of the pump, uncovering the impeller. Release the snap ring from the impeller recess and take out the rear water seal, noting the relation of these parts as they are removed so that they can be assembled correctly.

To remove the impeller, drive out the pin and release the snap ring, which is located in front of the pump just behind the drive gear. Support the pump on either flange and press or drive the shaft out of the impeller and pump cradle. Strip the shaft by removing the bearing retaining nut, after which, all the parts may then be pressed from the shaft. Remove the front seal in the same manner as the rear seal was removed.

After all parts have been inspected and renewed, as required, assemble the pump in the reverse order of disassembly.

CAUTION—Due to the close working clearances between the impeller and the housing as indicated at "A" in the illustration, and because the flow of water may be impeded at the point indicated by "B" in the illustration, the impeller must be located accurately on the shaft so as to provide the necessary clearance at "A" and have the impeller line up with the housing at "B." Therefore, when pressing the impeller on the shaft, press it on until a dimension of 1" between the front cradle and the front face of the impeller is obtained at "C" in the illustration.

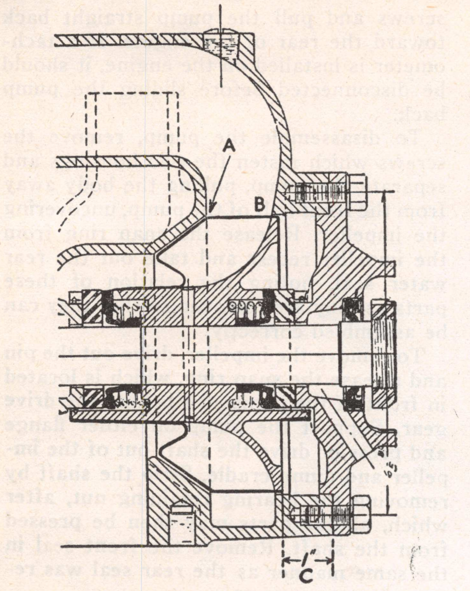
When assembled, lubricate the pump by means of the hole (enclosed by a screw plug), using the same grade of oil as is used in the engine.

NOTE—The latest type pump used on these engines differs from the one described above in the method of fastening the impeller to the shaft. In this pump, a tapered pin is used instead of serrations and a straight pin. However, disassembly and repairs to this type pump are accomplished in the same manner as described for the earlier type pump.

DHX and DRX: The pump is driven by a gear which meshes with the idler gear in the timing case. The shaft rotates in a bushing which is pressed into the sleeve. Suitable bronze thrust washers are provided at each end of this sleeve, one washer bears against the large flange which is part of the shaft and the other makes contact with the flange which is part of the spiral drive gear which is used to drive a tachometer and other similar accessories with which the engine may be equipped.

End play in the shaft can be adjusted by means of a nut near the water pump end of the shaft.

The pump is easily disassembled by separating the housing from the sleeve and when this is done, the internal parts are



DFX SERIES.
Water pump (second type). Press impeller on shaft until the 1" dimension at "C" is established.

accessible and readily removed. If the thrust washers are worn, they should be replaced, being sure that the thrust surfaces against which these washers bear, are perfectly smooth.

ENGINE WATER THERMOSTAT

1936-46 All: If the thermostat is not functioning properly, remove the assembly from the water outlet and see if the bellows and valve are in good condition. If they are, test its operation by completely submerging the assembly in water, heating the water gradually until it reaches the opening temperature of the thermostat, which is approximately 145 degrees F. When the water reaches a temperature of about 170 degrees, the thermostat should be fully open.

NOTE—When taking temperature readings, agitate the water thoroughly. And if the unit fails to function properly, it should be replaced rather than attempt to make a repair. Before installing a new unit, it is good practice to give it a test as directed above.

FUEL SYSTEM

NOTE—For detailed information on Diesel Fuel Injection Systems, see the Table of Contents on page 1.

INJECTION PUMP, REMOVE

1936-46 All: If the pump timing has not been altered, the pump can be removed and replaced without the necessity of retiming. The two coupling flanges and center disc are each marked with a heavy line to aid in replacing the pump without retiming.

Before removing the pump, note the relative position of these marks, which should be approximately in line. Then disconnect all fuel lines and governor control rod, unfasten the pump from its base and lift it off.

NOTE—Do not alter the coupling adjustment by loosening the two capscrews on the side of the drive flange.

INJECTION TIMING

1936-46 All: The fuel pump end plate and the coupling are marked for timing. The center mark on the end plate indicates the center line of the cam or the top plunger position. The timing mark on the end plate is located at an angle to the center line with a mating mark on the coupling flange on late model pumps, or on the flat side of the coupling hub on earlier model pumps.

To set the timing, crank the engine until No. 1 intake valve closes. Continue to turn the engine over slowly until the proper degree (see Tune Up Chart) mark on the flywheel is exactly in line with the center of the timing hole in the flywheel housing. Then turn the fuel pump in the direction of its rotation until the coupling mark is exactly in line with the mark on the end plate. Adjust the coupling jaws by means of the two capscrews on the side of the coupling flange and slip the coupling jaws in place.

NOTE—If the fuel pump drive gear or idler gear have been removed and replaced without regard to fuel pump timing, it will be necessary to remove one of the gears and remesh in the correct position to allow the coupling jaws to slip into place.

Align the fuel pump and drive coupling carefully, using shims if necessary, and fasten the hold down capscrews. Connect all fuel lines and governor control rod, making sure the control rod is absolutely free and not binding at any point.

NOTE—The coupling is adjustable for slight variations in timing which is indicated by graduation marks on the coupling flange. If necessary to check the timing for correct "port closing," see the "Diesel Fuel Injection Pump" chapter in the "American Bosch" or "Timken" sections, as the case may be, which explains this procedure of checking by the flow method.

Bear in mind that retarded injection will be indicated by excessive smoking while too much advance will be indicated by abnormal engine noise and tendency to knock.

IMPORTANT—Whenever the engine is being rotated for the purpose of bringing the timing mark in line with the center of the flywheel housing, always come up to the mark in the direction of engine rotation, so as not to bring the timing points together against the accumulated backlash between the flywheel and the injection pump. However, if the engine is rotated past the timing mark, it may be backed up far enough so that it can be brought forward again with the lash taken up in the running position.

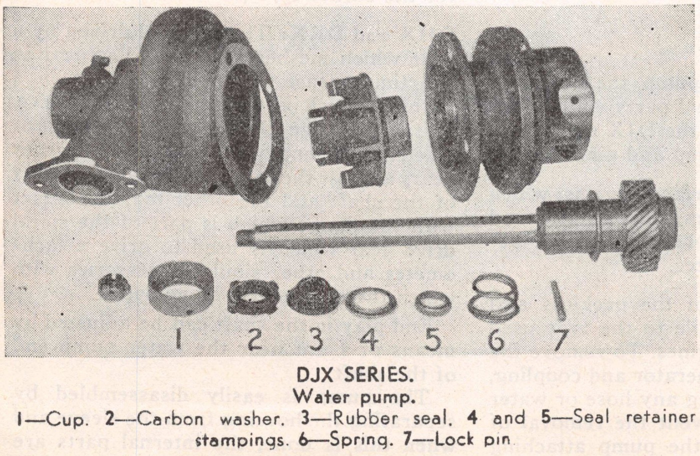
GOVERNORS

1936-46 All: The governors commonly used on these engines for automotive work are either American Bosch or—on some older engines—Timken. The operation, adjustments and maintenance of these governors are described in detail in the "Diesel Fuel Injection Pumps" chapter.

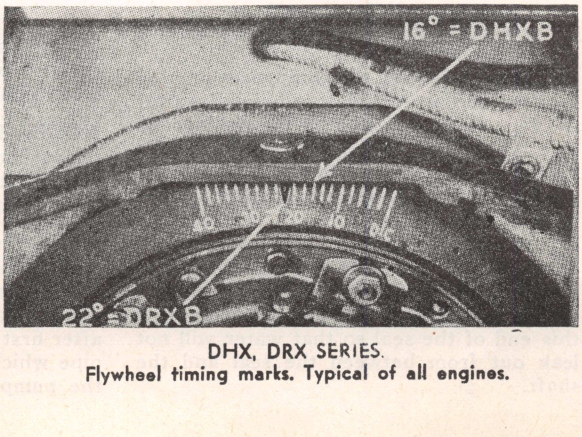
All governors are set up and sealed at the factory, but if it is suspected that a setting is unsatisfactory, under no circumstances should any attempt be made to change the adjustments except by one who is thoroughly competent to do the job correctly. If equipped to do the job, consult the TUNE UP CHART for high and low idle speed specifications.

FUEL OIL FILTERS

1936-46 All: The filtering system commonly used on these engines consists of a special dual metal unit, and a filter between the fuel tank and the fuel transfer pump which is used to remove the larger particles of



DJX SERIES.
Water pump.
1—Cup. 2—Carbon washer. 3—Rubber seal. 4 and 5—Seal retainer stampings. 6—Spring. 7—Lock pin.



DHX, DRX SERIES.
Flywheel timing marks. Typical of all engines.

dirt and water and is equipped with a knife cleaner. This latter type filter is also used on some automotive applications and is mounted in the bottom of the fuel tank. A metal and cloth final filter is installed between the fuel transfer pump and the fuel injection pump. As a final filter, some engines are equipped with a sealed type filter instead of the metal and cloth type. If the pressure gauge indicates a pressure of less than five pounds, the sealed type filter should be replaced. If not equipped with a pressure gauge, the filter should be replaced when the engine power falls off due to clogging of the filter causing insufficient fuel to reach the fuel injection pump manifold.

The dual type filter which is equipped with a cleaning knife should have the turning handles on top turned once a day. This wipes off the largest particles of dirt and drops of water which have been caught on the element. Once a week the drain plug at the bottom of each case should be removed and the cases allowed to drain.

The filter unit should be removed and washed in clean fuel oil, kerosene or gasoline every week or every 100 hours of operation. Do not use a wire brush or a hard instrument to scrape sludge but wash it with a clean cloth or a soft bristle brush.

The final filter of the metal and cloth type should be cleaned more frequently than the dual filters. To clean, remove the case, the cloth unit and the metal unit. The metal unit should be washed in the same manner as the dual filters. The cloth unit may be washed in the same cleaning fluid but be sure that all dirt and gum is washed out of the fabric.

ELECTRIC SYSTEM

NOTE—For service information on Generators, Generator Regulators, Starting Motors and Starter Switches, see the Table of Contents on page 1.

TROUBLE DIAGNOSIS

ENGINE WON'T START OR HARD STARTING

1. No fuel in tank—fill tank.
2. No fuel in fuel pump.
3. Not properly prepared for starting at the atmospheric temperature being encountered.
4. Weak batteries will not turn engine over rapidly enough—Recharge batteries.
5. Fuel too heavy to flow through pipes properly—Lighter fuel.
6. Water in fuel—Drain fuel system and tanks. Change fuel supply.
7. Rings or cylinder walls worn badly. Replace with new.
8. Exhaust or intake valve seats pitted or worn—Regrind valves.
9. Leaking head gasket—Replace gasket.
10. Air cleaner plugged not allowing sufficient air to pass through—Clean air cleaner.
11. Governor stop lever stuck in shut-off or stop position.

ENGINE STOPS SUDDENLY

1. No fuel—Fill tank, prime and start.
2. Fuel pumps or lines air or gas bound.
3. Fuel filter plugged—Clean filter and prime lines.
4. Obstruction in or broken fuel line—Check, starting with fuel tank to strainer.
5. Water in fuel—Drain entire system including tank and clean. Fill with clean fuel.
6. Transfer pump not functioning properly—Inspect valves, springs, gaskets, plunger, roller and guide.
7. Piston seizure due to lack of lubrication—Remove piston and replace with new if badly scored. Change lubricating oil after thoroughly cleaning oil pan, lines and filter.
8. Bearing seizure due to lack of lubrication—If not too badly wiped scrape enough to clean up and reinstall. If badly wiped replace with new.
9. Broken fuel pump driving chain—Replace with new chain and re-time engine.
10. Fuel pump adjustable coupling slipped due to not being properly tightened—Retime pump.

ENGINE MISSING ERRATICALLY OR INTERMITTENTLY ON ALL CYLINDERS

1. Improper fuel or fuel with poor burning qualities—Drain system including tank and refill with suitable fuel.
2. Water in fuel—Drain fuel system including tank of all water and sediment. Refill with clean fuel.
3. Sticking nozzle valve stems or pump delivery valves or both—Remove stuck parts and clean. (Caused usually from dirty fuel. Clean entire system after draining and fill with clean fuel.)
4. Worn piston rings or cylinders or both —Replace with new.
5. Leaky intake or exhaust valves or both —Regrind valves.
6. Plugged air cleaner reducing air admitted into cylinders—Clean air cleaner.

ENGINE MISSING ON 1 OR 2 CYLINDERS

To determine which cylinder or cylinders are missing loosen the nuts connecting the fuel lines to the fuel nozzles one at a time. If the engine speed remains the same and exhaust sounds the same that is the cylinder missing. If the engine speed slows down and the exhaust loses its same rhythm then the cylinder is functioning.

1. Fuel valve stuck in body—Remove and clean.
2. Air or gas binding in fuel pump or lines —Usually when testing to see what cylinder is missing this condition will be cleared up as opening the nut allows the air or gas to escape.
3. Exhaust or intake valve stuck—Remove valve cover and check which one stuck. Free with kerosene, gasoline or alcohol poured down stem. Alcohol is the quickest solvent. If it still sticks remove head and determine cause.
4. Leaky exhaust or intake valve—Regrind valve.
5. Exhaust or intake valve spring or spring retainer lock broken—Replace with new.
6. Improper exhaust or intake valve clearance between valve and rocker arm—Check clearance and reset to proper clearance.
7. Fuel pump delivery valve leaking or stuck—Remove and clean with soft cloth and clean fuel oil or gasoline. Do not use abrasive or sharp tools on this part. If cleaning does not free the valve remove both valve and seat and install new. (These valves and seats must be used as an assembly as parts are not interchangeable one seat with another valve.)
8. Fuel pump delivery valve spring broken—Replace with new.
9. Piston rings or cylinder walls badly worn—Replace with new.

CAUSES AND REMEDIES

Smoke in Exhaust

The brown or black color in exhaust is pure carbon—one of the elements of the fuel, the other being hydrogen. When combined they form liquid oil or gas which may be perfectly transparent or clear in the case of oil and absolutely invisible in the form of gas. These minute particles of carbon are solid substances and black. Their presence in the exhaust gases makes it appear as dark or black smoke. The more carbon particles, the darker color the exhaust, ranging from a very light grey haze to brown and even black smoke. The cause is incomplete combustion. Since combustion is never perfectly complete, it is not presumed that exhaust gases will be absolutely invisible. Smoke from the exhaust either brown or black, is not itself mechanically harmful to the engine but may indicate corrections that should be made, particularly if an increase of smoke appears with no change in conditions such as load, speeds, temperatures, change of fuel oil, or engine taken to higher altitude.

Increase of Brown or Black Smoke in Exhaust Gases

1. Leaky cylinder head gasket. Remove and clean or replace from spares.
2. Leaky valves. Regrind.
3. Improper fuel oil. Change fuel to brand with good ignition and burning qualities.
4. Dirty spray nozzles. Clean.
5. Fuel injection timing too early; usually accompanied with "fuel knocks" or "noisy engine." Adjust timing of injection.
6. Fuel injection timing too late; accompanied with loss of power but smooth and quiet running engine. Adjust timing of injection.
7. Leaky piston rings. Replace with new ones from spares.
8. Fuel delivery valve in fuel pump stuck. Remove and clean with soft cloth. Do not use hard or sharp tools or abrasives They will spoil these parts. If valve can

not be made to operate freely have replacement of new valve and seat assembly made at a Bosch Diesel Service Station or Timken Factory Branch.

9. Fuel delivery valve spring in fuel pump broken. Replace with new one from spares.
10. Fuel pump drive chain too loose. Tighten and retime engine.

Knocking in Engine or "Fuel Knocks"

Fuel Knocks may come from one or more cylinders. If knocking is from one cylinder:

1. **Spray nozzle valve sticking from dirt or corrosion. Clean valve with a cloth (not abrasives) and clean body with piece of wood. Turn valve stem in body until free, then smear with good clean engine lubricating oil or vaseline and replace.**
2. **Spray nozzle spring broken. Replace complete holder from spares. Never attempt to change nozzle springs in field as they must be accurately calibrated with instruments, at the factory.**
3. **Fuel delivery valve in pump stuck open from dirt or corrosion. Clean valve stem with cloth and valve seat with small piece of wood. Do not use abrasives or metallic tools, they will spoil these delicate parts. If necessary, replace with new valve and seat at Bosch Diesel Service Station or Timken Factory Branch.**
4. Broken delivery valve spring in fuel pump. Replace from spares.
5. Inlet or exhaust valve not seating properly from sticking or in need of grinding. Free valve with alcohol or other oil such as kerosene or clean fuel oil or gasoline. Grind valve if necessary.
6. Leaky cylinder head gasket. Clean or replace from spares.

If "fuel knocking" is in more than one cylinder and erratic and intermittent:

1. Improper fuel. Has poor ignition qualities. Add equal parts or more if needed of fuel oil with good ignition qualities or change fuel to a brand having good ignition and burning qualities. See specifications of fuel oil.
2. **Sticking nozzle valve. This comes from dirt in fuel oil or corrosion of these parts from acid in the fuel oil. Dismantle and cleanse these parts and also fuel strainers. If parts are corroded change fuel to an acid free brand and install nozzle and barrel if necessary.**
3. **Water in fuel oil. Drain fuel oil strainer sump and fuel tank of all water and sediment.**

If "fuel knocking" is in all cylinders continuous and steady and is usually accompanied with dark smoky exhaust:

1. Improper fuel oil, has poor ignition qualities. Change fuel to brand of suitable ignition qualities or add equal quantities or more if needed of fuel oil with good ignition qualities.

Knocking from Mechanical Causes may be from several sources, among which are:

1. Piston hitting inlet and exhaust valves from using improper gasket. Use only those supplied by Hercules Motors Corporation.
2. Pistons hitting exhaust and inlet valves from bearings badly worn. Replace with new bearing shells.
3. Valve tappet clearance too great. Adjust clearances.
4. Badly worn bearings, either main or rod or both. Adjust and replace with new bearing shells.
5. Badly worn piston pins or bushings or both. Replace with new.
6. Badly worn pistons or liners or both. Replace with new.
7. Loose flywheel. Tighten.

There are many other mechanical causes of knocks which must be found and remedied. If impossible to determine what the trouble is after a thorough investigation it is best to have a factory trained expert investigate and remedy the trouble.

Year	Engine Model	Number Cylinders and Valve Arrangement	Bore and Stroke	Displacement Cubic Inches	Compression Ratio	Taxable H. P.	Brake H. P. at R. P. M. ②	Maximum Torque at R. P. M. Pounds Feet	Oil Capacity Quarts ①
1940–41	END-405	6-I	4x5⅜	405	14.6	38.4	107@2200	308@1200	12–16
1941–46	END-457	6-I	4¼x5⅜	457	14.6	43.3	122@2200	353@1200	12–16
1940–46	ED	6-I	4⅜x5¾	519	14.6	45.9	131@2000	381@1300	15–19
1940–46	END-605	6-I	4⅝x6	605	14.6	51.3	144@2000	455@1100	16–24

① High number includes filter; low number, without filter.

② Governed speed—full load.

TUNE UP CHART

Year	Engine Model	Firing Order	Injection Timing, Degrees	Nozzle Discharge Pressure, Lb. Sq. In.	High Idle Speed R. P. M.	Low Idle Speed R. P. M.	Valve Timing Intake Opens, Degrees	Valve Timing Exhaust Closes, Degrees
1940–46	ED	153624	①	1700	2100	500	16BTDC	5½ATDC
1941–46	END-457	153624	③	1700	2350	500	18BTDC	5½ATDC
1940–41	END-405	153624	②	1700	2350	450	18BTDC	5½ATDC
1940–46	END-605	153624	④	1700	2100	500	16BTDC	5½ATDC

① With Synchrovance 19 deg. BTDC; without Synchrovance 31 deg. BTDC.

② With Synchrovance 19 deg. BTDC; without Synchrovance 28 deg. BTDC.

③ With Synchrovance 17 deg. BTDC; without Synchrovance 29 deg. BTDC.

④ With Synchrovance 22 deg. BTDC; without Synchrovance 31 deg. BTDC.

VALVE SYSTEM

Year	Engine Model	Stem Clearance		Tappet Guide Clearance	Tappet Clearance				Valve Spring Pressure Test		Valve Seat Angle Degrees
					Running, Cold		Timing				
		Intake	Exhaust		In-take	Ex-haust	In-take	Ex-haust	Free Length, Inches	Pounds at Inches, Length	
1940–41	END-405	.0015–.003	.005–.007	.0005–.0015	.008–.010	.018–.020	.008–.010	.018–.020	I 2 15/16	35@2 17/32①	30
									O 3½	57@2 21/32②	
1941–46	END-457	.0015–.003	.005–.007	.0005–.0015	.008–.010	.018–.020	.008–.010	.014–.016	I 2 15/16	35@2 17/32①	30
									O 3½	57@2 21/32②	
1940–46	ED	.0015–.003	.0035–.005	.0005–.0015	.012–.014	.017–.019	.012–.014	.017–.019	I 2 15/16	35@2 17/32①	30
									O 3½	57@2 21/32②	
1940–46	END-605	.0015–.003	.005–.007	.0005–.0015	.010–.012	.020–.022	.010–.012	.020–.022	I 2 15/16	35@2 17/32①	30
									O 3½	57@2 21/32②	

① If less than 31, install a new spring.

② If less than 52, install a new spring.

I—Inner spring. O—Outer spring.

ENGINE

NOTE—For detailed information on Diesel Fuel Injection Systems, see the Table of Contents on page 1.

NOTE—See Trouble Diagnosis data at the end of this chapter.

CYLINDER HEADS

ED, END-405, 457, 605: Cylinder heads are cast in two **interchangeable** blocks of three, each head being held down by studs which are installed in the cylinder block **finger tight** so that when the heads are removed, the studs may readily be taken out to facilitate further service on the engine.

Heads on the 405, 457 and 605 should be tightened down as shown in the diagrams. On the ED engine, start with the middle nut in the center row, working outward in a criss-cross fashion to the ends.

On all engines, draw down the nuts evenly and repeat the operation until all are normally tight. After the engine has been run sufficiently long to bring all the parts to normal operating temperature, a final tightening should be made with a torque indicating wrench, and the nuts tightened to a tension of from 135 to 140 pounds feet. After the first day's operation, re-check the nuts, repeating after every 500 hours of operation.

NOTE—Whenever one head is removed for any reason, the nuts on the other head should be loosened to prevent the possibility of distortion. When using a torque

PISTON AND RING CLEARANCES

Year	Engine Model	Piston Skirt, Inches		Fitting Pistons with Shim and Spring Scale		Ring End Gap, Inch ①		Ring and Groove, Inch	
		Top	Bottom	Shim Thickness	Pounds Pull on Scale	Compression	Oil	Compression	Oil
1940–41	END-405	②	.004–.0043	.004③	.0045④	.015–.019	.015–.019	⑤	⑤
1941–46	END-457	②	.004	.0045	.005④	.015–.019	.015–.019	⑤	⑤
1940–46	ED	②	.0045–.0048	.0045③	.005④	.015–.019	.015–.019	⑤	⑤
1940–46	END-605	.007	.005	.005③	.0055④	.016–.020⑦	.016–.020⑦	⑥	⑥

① End gaps are for cylinder bores without taper. Fit rings in tapered bores with not less than the maximum dimension given.

② Measure clearance at bottom edge only.

③ Piston should pass on shim thickness shown.

④ Piston should lock on shim thickness shown.

⑤ Top—.0025″–.004″. 2 and 3—.001″–.003″. 4—.002″ .0045″. 5—.002″–.004″.

⑥ Top—.0025″–.0035″. 2 and 3—.0015″–.0035″. 4—.002″–.0045″. 5—.002″–.004″.

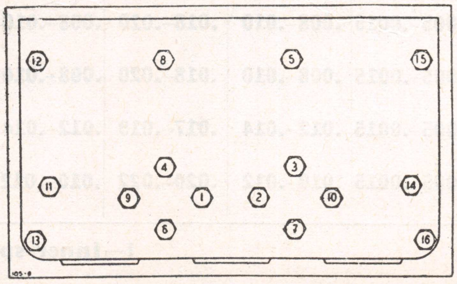
⑦ For top ring, .010″–.020″.

ENGINE BEARING SPECIFICATIONS

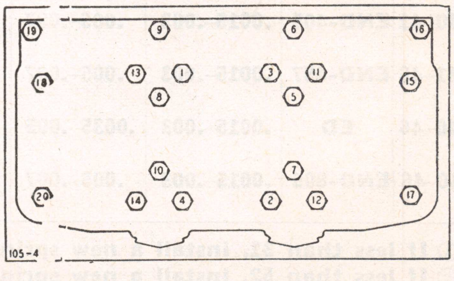
Year	Engine Model	Camshaft		Connecting Rod			Mains				
		Journal Diameter	Clearance	Journal Diameter	Clearance	Bearing Bolt Tension Lb. Ft.	Journal Diameter	Clearance	Bearing Bolt Tension Lb. Ft.	Thrust on No.	End-play
1940–41	END-405	2.251–2.252	.0015–.003	2.7475	.0015–.003	100–106	②	①	100–106	4	.004–.011
1941–46	END-457	2.251–2.252	.0015–.003	2.7475	.0015–.003	100–106	②	①	100–106	4	.004–.011
1940–46	ED	2.251–2.252	.0015–.003	2.9975	.0015–.003	137–150	②	①	100–106	4	.004–.011
1940–46	END-605	2.251–2.252	.0015–.003	2.9975	.0015–.003	145–150	②	①	100–105	4	.004–.011

① For Nos. 1, 2, 3, 5 and 6 .0015″–.003″; for Nos. 4 and 7—.0025″–.004″.

② For Nos. 1, 2, 3, 5 and 6—3.4975″; for Nos. 4 and 7—3.4970″.



END-405, 457. Cylinder head tightening sequence.



END-605. Cylinder head tightening sequence.

wrench, be sure the nuts and studs are free from rust and dirt, otherwise a false reading will be obtained due to the increased friction. For clean and oily threads, tighten the nuts to the low limit, and for clean and dry threads, use the high limit. Every time the nuts are tightened, it is important that the tappet clearances be checked and adjusted.

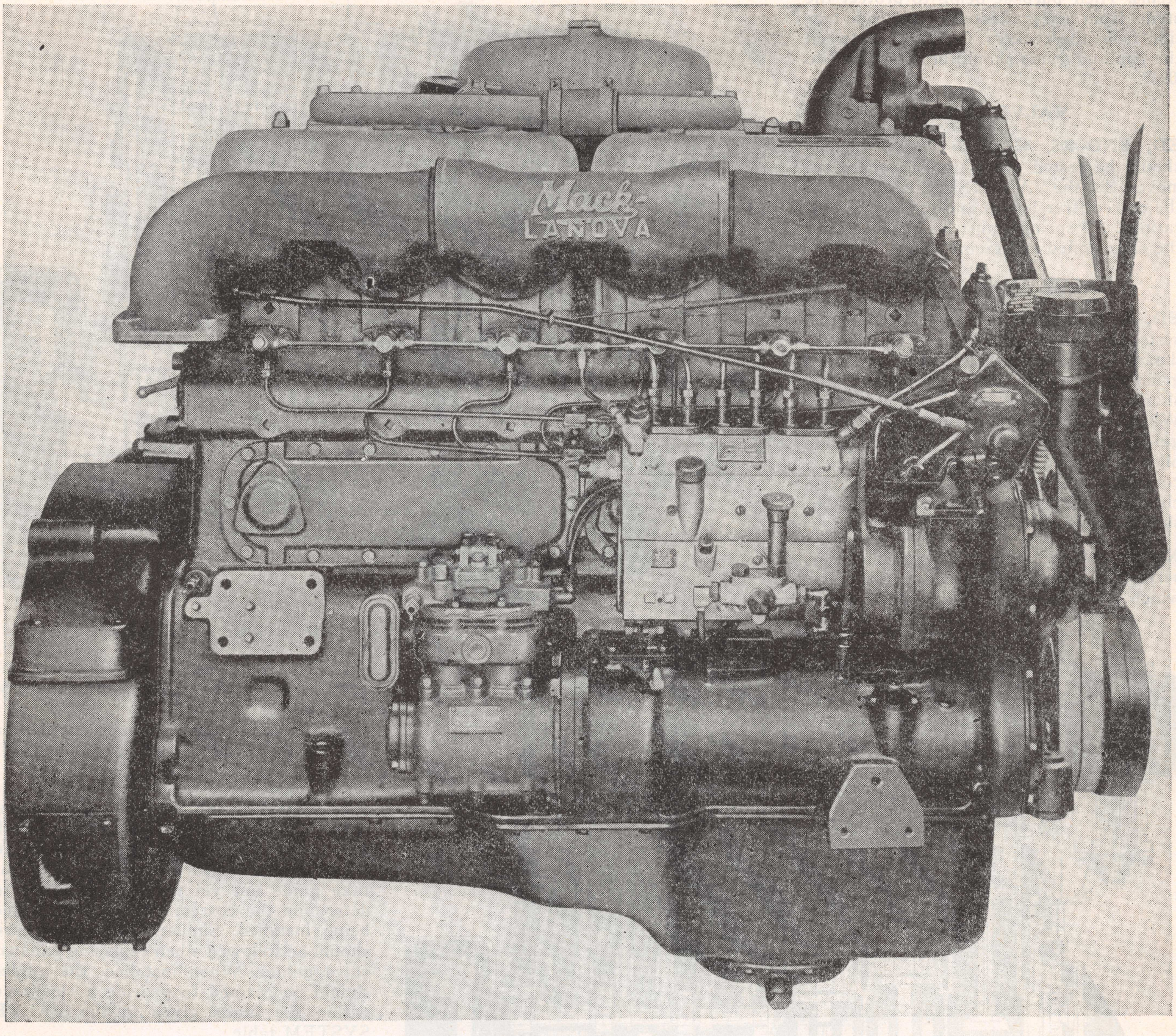
IMPORTANT—Whenever it is necessary to remove heads while the engine remains in the chassis, always unscrew the studs, as this practice will greatly facilitate the removal operation. Every precaution should be taken to prevent the mating surfaces of the heads and cylinder block from being marred, nicked or scratched.

CYLINDER HEAD ENERGY CELLS

ED, END-405, 457, 605: The energy cells are located in the cylinder heads directly opposite the fuel injection nozzles. The primary purpose of the cells is to increase turbulence and control combustion. When the energy cell is charged with fuel from the injection nozzle, the initial combustion takes place in the main combustion chamber. The fuel in the inner chamber of the energy cell is partially burned, developing high pressures, which causes the remainder of the fuel to return to the main chamber. This action creates intense turbulence, insuring complete burning of the entire fuel charge. At the same time, the rate of burning is controlled so that high pressures on the piston are avoided.

NOTE—For detailed information on fuel injection nozzles, refer to the "Diesel Fuel Injection Pump" chapter elsewhere in this book.

Energy cells should be removed and cleaned every time the fuel injection nozzles are removed for cleaning, or after every 18,000 miles of operation. Each cell is stamped with a number as to their location and should be installed in the original position. When the cells are removed for cleaning, or for any other purpose, all parts of the cell, as well as the cavity in the cylinder head, must be thoroughly



ED ENGINE. Exterior view.

cleaned of carbon. As there is no gasket used for sealing the joint between the cell and the cylinder head, the cell should be reseated in the head by lightly lapping with a medium valve grinding compound, using the same motion as when grinding poppet valves.

To remove a cell, a suitable puller should be used, and when using this tool, first remove the cover, then the cell cap and unscrew the cell from the cell cavity.

When cleaning the cell, a suitable scraper should be used, but by immersing the cell in a carbon solvent such as carbon tetrachloride, the same result will be obtained.

NOTE—When cleaning the small orifice, a tool of soft material and correct diameter is available. A drill or reamer should never be used for this operation. To provide a gas tight fit between the cell and cell cap, the mating surfaces of these two parts should be lapped, using a medium grade of valve grinding compound, evenly distributed on a perfectly flat lapping plate (cast iron preferably).

CYLINDER HEAD GASKETS

ED, END-405, 457, 605: Head gaskets used in the ED and 605 engines are of solid copper, while copper-steel asbestos gaskets are used in the 405 and 457. If handled carefully, these gaskets may be used several times but when installing, do not use sealing compound of any kind.

NOTE—Before installing gaskets, be sure that the mating surfaces of the heads and cylinder block are perfectly clean and free from oil or any particles of foreign matter which would prevent a tight joint.

ROCKER ARMS

ED, END-405, 457, 605: When disassembling rocker arm assemblies, place all parts on the bench in their proper relationship to assure correct assembly. **To prevent the possibility of bending or twisting push rods, they should be removed before taking off the cylinder heads, and replaced after the heads are installed.**

Clearance between the rocker arm and shaft should be from .001" to .002".

IMPORTANT—Since it requires some little time to fill the hollow rocker arm shafts with oil after the engine is started, and since the push rod ends and valve caps are lubricated by a relatively low oil flow rate, initial distress of parts will be prevented if—when assembling—the rocker shafts are filled with oil. As an added precaution, each end of the rocker arms should also be lubricated.

VALVE THRUST CAPS

ED Only: These cups operate in the valve spring guides and bear upon the valve stems. Their purpose being to protect the stems from being affected by any side motion from the rockers. Clearance between the cup and guide should be from .001" to .003".

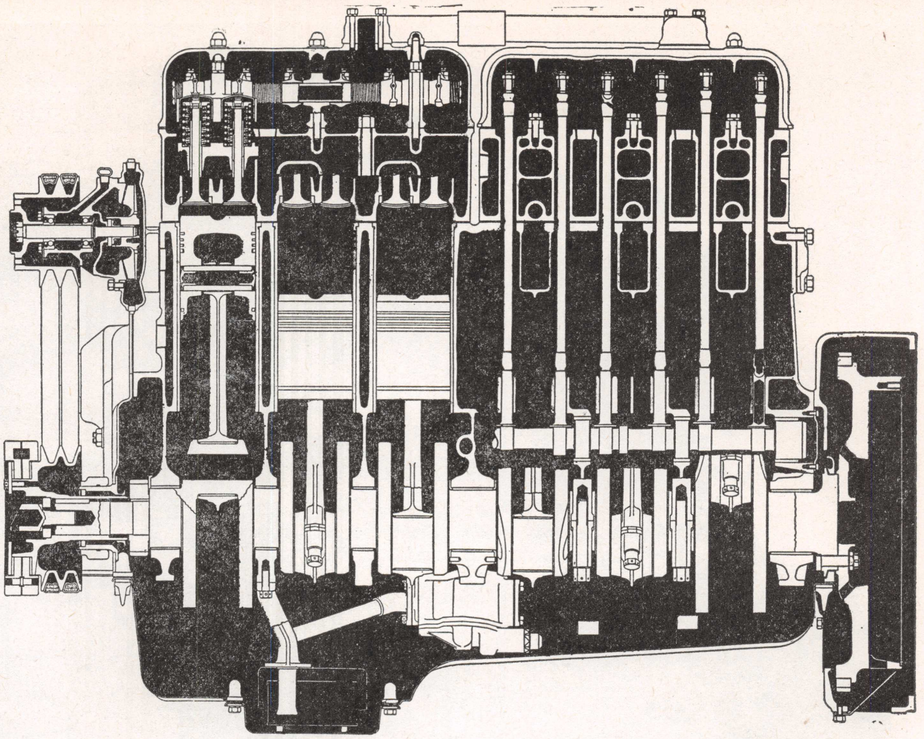
VALVE SPRINGS

ED, END-405, 457, 605: Valve springs should be tested every time they are removed. See the VALVE SYSTEM table for the correct free length and for test specifications. All springs must be installed with the close coiled end facing down.

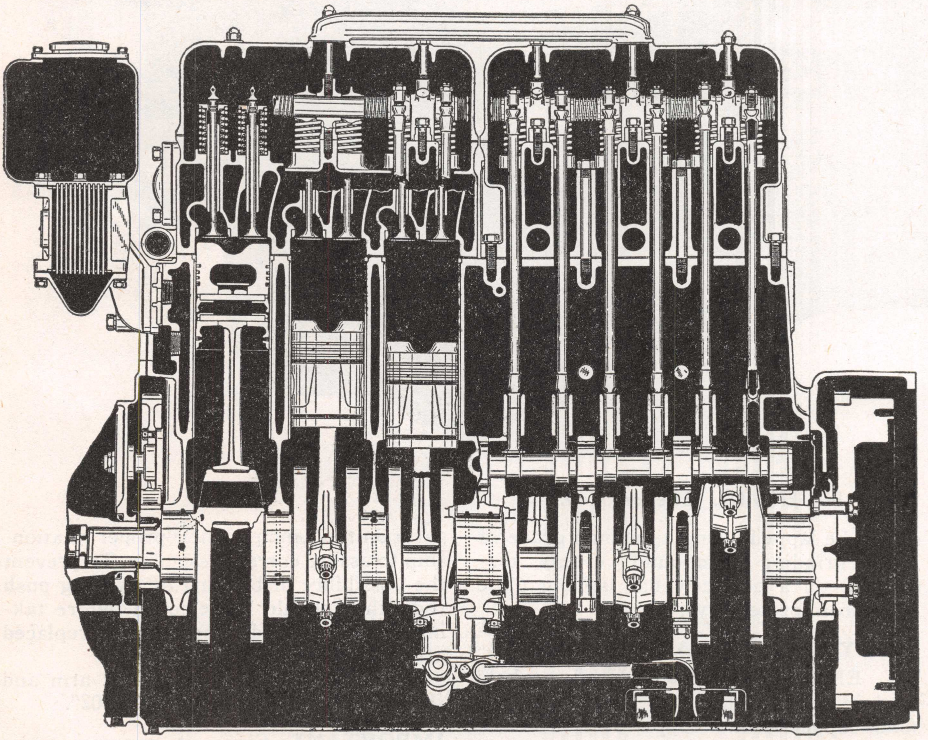
VALVE SEAT INSERTS

ED, END-405, 457, 605: Since these inserts are too hard to reface by the ordinary grinding methods, a high-speed grinding stone or a special lapping tool should be used to perform this operation. When using this equipment, be sure valve guides are clean and that the valve guide pilot is a snug fit in order to assure a concentric finish. Finished seats should be checked with a dial indicator and run-out should not exceed .0005".

NOTE—When necessary to replace inserts, it is advisable to use a special puller which is available for the purpose. However, if this equipment is not procurable, the inserts may be removed and replaced in the following manner:



ED ENGINE. Side sectional view.



END-405 ENGINE. Side sectional view. Typical of END-457.

To remove an insert, use a drill which is smaller in diameter than the insert width and drill two holes at opposite sides, but not all the way through. Cut through the undrilled portion of the insert with a sharp chisel and remove the two pieces.

To install an insert, pack in "dry ice" for at least fifteen minutes to allow the metal to contract, and heat the exhaust valve port area gradually, to permit this material to expand. Then press the insert into the cylinder head, using extreme care to see that it is not cocked or misaligned. When installed, finish the seats with the grinding or lapping equipment already mentioned.

Should an insert become loose, a 1/64" oversize insert is available. Suitable counterboring cutting tools should be used to cut the insert bore to accommodate the oversize insert. The counterbore should be 7/16" deep.

If a second replacement is needed, a 1/32" oversize insert can be supplied.

VALVE STEM GUIDES

ED, END-405, 457, 605: On all engines, it is good practice to remove and install one guide at a time. When installing an intake guide, measure the depth of an intake guide not yet removed in order to determine the correct depth of the guide being installed. Similarly, this procedure should be followed when replacing exhaust valve guides. When installed, the guides should be reamed to provide a clearance within the limits given in the VALVE SYSTEM table.

On ED engines, the dimension from the lower end of the guide to the insert face which contacts the valve should be 1 33/64". Since the valves are at an angle, be sure to measure at the right angle to the valve seat.

VALVE TAPPETS

ED, END-405, 457, 605: Tappets must be a free fit in their guides without excessive side play. Since the tappets are of the hollow mushroom type, and the guide holes are bored directly in the cylinder block, the camshaft will have to be removed when necessary to replace tappets.

IMPORTANT—Whenever a new camshaft is installed, the tappets must also be renewed as the Ferrox treatment of the new tappets is required to lap the noses of the cams to a high polish for long wear.

VALVE TIMING

ED, END-405, 457, 605: On ED and 605 engines, intake opens 16 degrees before

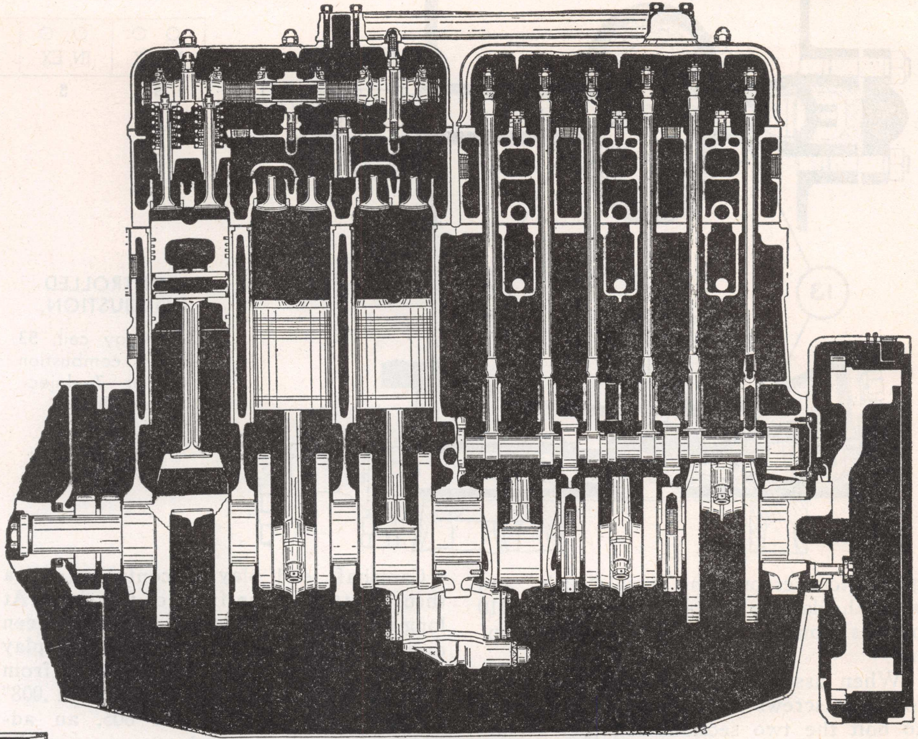
TDC and exhaust closes 5½ degrees after TDC. On 405 and 457, intake opens 18 degrees before TDC and exhaust closes 5 degrees, 32 minutes after TDC.

Valve timing is correct when the tooth of the gear having the single punch-mark is located between the two marked teeth of the meshing gears, provided the flywheel is installed to the crankshaft flange so that the "O" mark on these parts are lined up.

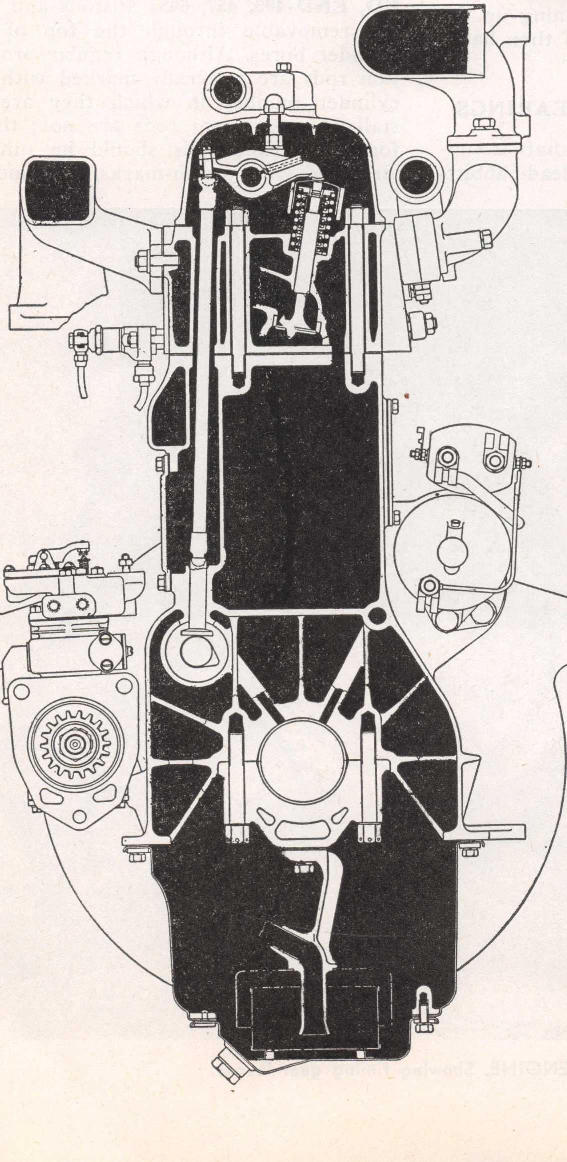
VIBRATION DAMPER

ED, END-405, 457, 605: At major overhaul periods, the vibration damper (if equipped) should be inspected for wear in the hub diameter and the friction discs. Excessive wear would not only prevent the proper functioning of the damper, but also an out-of-balance condition, causing severe vibration resulting in what might be inaccurately diagnosed as wear in the timing gears.

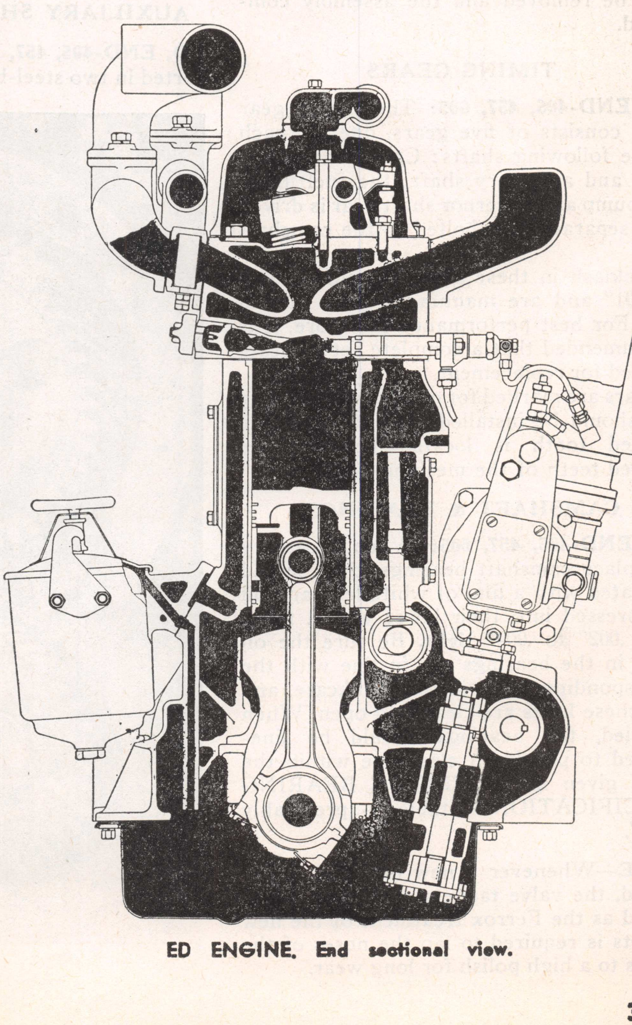
To test the friction discs, wrap a strong canvas tape around the circumference of the damper and attach a scale to the end of the tape. A pull of 200 pounds should be re-



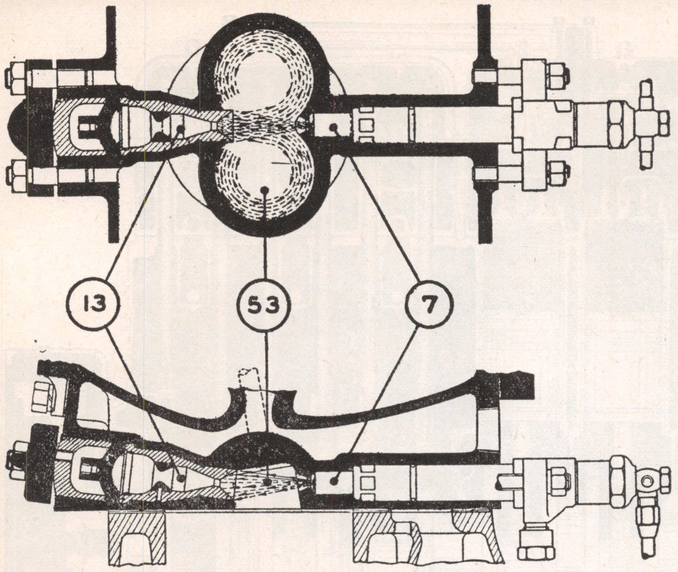
END-605 ENGINE. Side sectional view.



ED ENGINE. End sectional view showing valve mechanism.



ED ENGINE. End sectional view.



CONTROLLED COMBUSTION.

13—Energy cell. 53—Main combustion chamber. 7—Injection nozzle.

Valve Order

○ ○ IN EX	○ ○ IN EX	○ ○ IN EX	○ ○ IN EX	○ ○ IN EX	○ ○ IN EX	TIMING GEAR END OF ENGINE
6	5	4	3	2	1	

ALL ENGINES.

quired to overcome the initial "stick," and when the damper starts to turn, a pull of 110 pounds should be required to continue turning.

When assembling a damper, use three long cap screws with ample thread length to bolt the two sections together. When the two sections have been drawn together enough, three of the original damper screws may be installed. The special screws can then be removed and the assembly completed.

TIMING GEARS

ED, END-405, 457, 605: The timing gear drive consists of five gears, one for each of the following shafts: Crankshaft, camshaft and accessory shaft; the fuel injection pump and governor shaft gear is driven by a separate gear bolted to the camshaft gear.

Backlash in these gears is held to .000" to .001" and are manufactured to run in sets. For best performance therefore, it is recommended that a complete set of gears be used for replacement.

Gears are marked for correct valve timing and should be installed so that the single marked tooth is located between the marked teeth of the meshing gear.

CAMSHAFT & BEARINGS

ED, END-405, 457, 605: When necessary to replace camshaft bearings, they should be coated with a film of white lead and oil and pressed into their bores with a fit of from .002" to .004" **tight.** Be sure the oil holes in the bearings are in line with the corresponding holes in the crankcase, and that these holes are clean and open. When installed, the bearings should be line-reamed to provide a clearance within the limits given in the ENGINE BEARING SPECIFICATIONS table — preferably .0025".

NOTE—Whenever a new camshaft is installed, the valve tappets must also be replaced as the Ferrox treatment of the new tappets is required to lap the noses of the cams to a high polish for long wear.

Camshaft end play is controlled by a thrust button at the front of the shaft. At long intervals, or when the engine has been disassembled for repairs, the end play should be checked and if in excess of from .012" to .015" on ED engines, or from .008" to .014" on 405, 457 and 605, an adjustment can be made by turning up the thrust button finger tight and then backing off 1/4 turn.

AUXILIARY SHAFT & BEARINGS

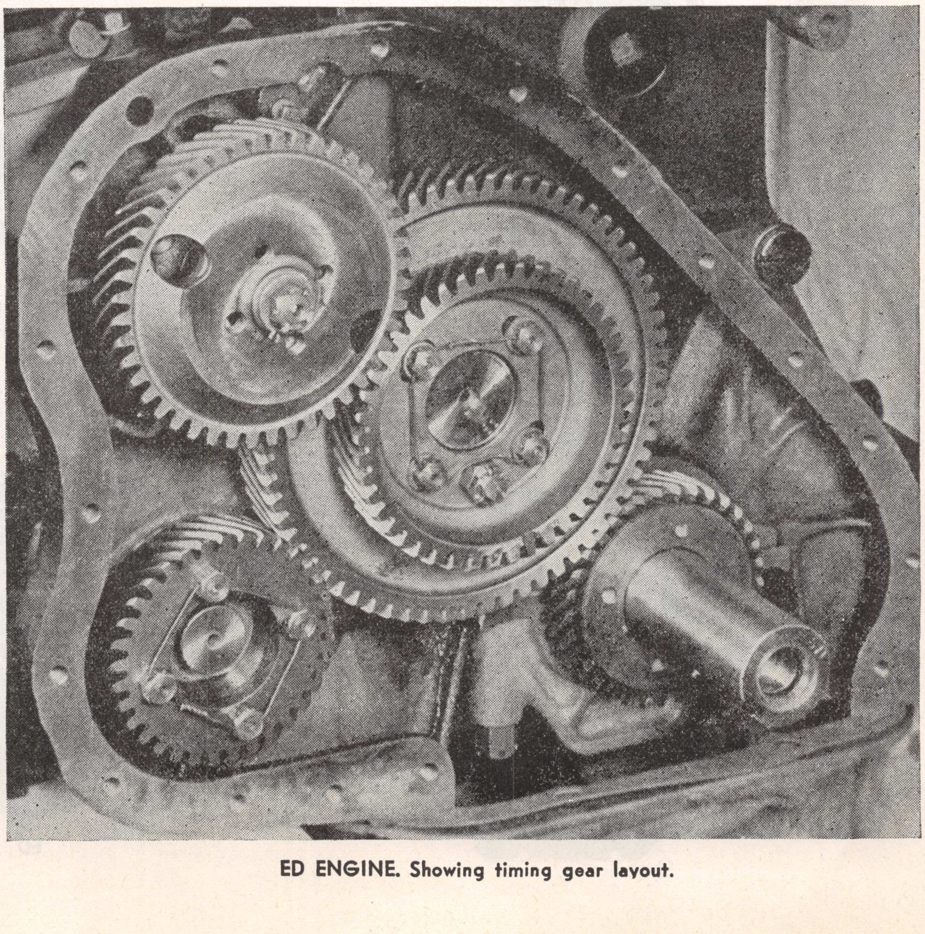
ED, END-405, 457, 605: This shaft is supported in two steel-back, high-lead babbitt-lined bearings. When necessary to replace these bearings, they should be coated with a film of white lead and oil and pressed into their bores with a fit of from .002" to .004" **tight.** Be sure the oil holes in the bearings are in line with the corresponding holes in the crankcase, and that these holes are clean and open.

These bearings are of the pre-finished type and provide a running clearance of from .0015" to .003" without the necessity of reaming. The front bearing journal diameter is 2.061"-2.062", while the rear bearing journal diameter is 1.998"-1.999".

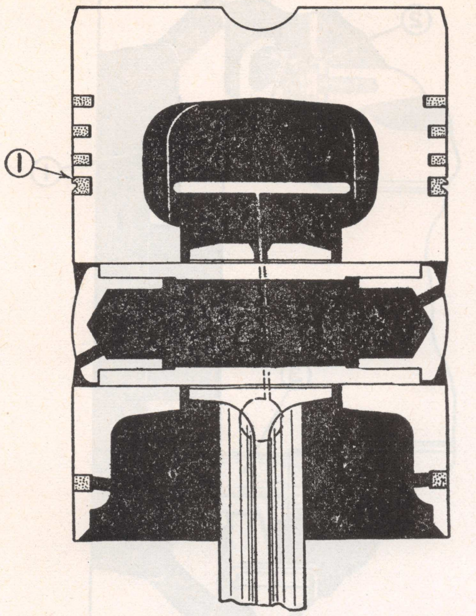
The auxiliary shaft end play is controlled by a thrust button at the front end of the shaft and should be held to within .012" to .015" on ED engines and from .008" to .014" on 405, 457 and 605. An adjustment can be made by turning up the thrust button finger tight and then backing off 1/4 turn.

PISTONS & RODS, REMOVE

ED, END-405, 457, 605: Pistons and rods are removable through the top of the cylinder bores. Although regular production rods are generally marked with the cylinder number in which they are installed, replacement rods are not; therefore, unmarked rods should be suitably identified with punch-marks, as removed



ED ENGINE. Showing timing gear layout.



PISTON ASSEMBLY. All engines. 1—Install ring as shown.

PISTON & ROD, ASSEMBLE

ED, END-405, 457, 605: The connecting rod caps are parted at an angle and when installed in the cylinder, the open side of the rod should face **away** from the camshaft on ED and 605 engines and **toward** the camshaft on 405 and 457 engines.

IMPORTANT—All Mack pistons are stamped with an arrow on the head which, when installed in the cylinder, must face toward the front of the engine. This will bring the T-slot side of the piston opposite to the camshaft side. If the pistons are not installed in this manner, the piston head will not enter the combustion chamber due to the lobes on the piston head being off-center.

PISTONS, RENEW

ED, END-405, 457, 605: A variation of 10 degrees between the temperature of the pistons and cylinder bores is sufficient to produce a difference of .0005". Therefore, both the pistons and cylinder bores should be at normal room temperature when fitting pistons. This is particularly important because the clearances given in the PISTON & RING CLEARANCES table are minimum and pistons must not be fitted with less than specified.

The exact diameter of each bore to within .0005" is stamped on the side of the block near the top. Likewise, the exact diameter of each Mack piston to within .0005" is stamped on the piston top.

NOTE—When fitting pistons to a new cylinder block, a selective fit may be obtained by subtracting the clearance given below the cylinder bore size and selecting the piston to suit, which will give the exact clearance desired.

Pistons are available in standard and oversizes of .010", .020", .030", .040", .050", and .060", and since they are cam ground, they cannot be ground down to fit an odd size bore. The cylinder must be ground to fit the specific oversize piston with an allowance made for the running clearance as given in the PISTON & RING CLEARANCES table.

To determine the exact size the cylinders should be bored, add the desired clearance to the piston size which is stamped on the top of each Mack service piston. When boring, do so in alternate cylinders due to the localized temperature build-up. After the cylinders are bored, they should be honed smooth. Verify the piston fit by the use of a feeler gauge between the cylinder and the extreme lower edge of the piston skirt with the piston inserted in the bore upside down and in its running position, that is, with the slotted side of the piston opposite the camshaft side.

After the pistons have been fitted properly and assembled to the rods, check the assemblies for alignment on a suitable jig.

PISTON RINGS, RENEW

ED, END-405, 457, 605: To prevent the possibility of bending or breaking the second ring land—thus ruining the piston—the ridge at the top of the cylinder bore should be cut away before removing the piston and rod assemblies. If the available ridge reamer has no provision to control the depth of the cut, it is good practice to bring the piston far enough up into the cylinder to allow the reamer to rest on top of the piston. This will serve to prevent cutting down into the ring travel area.

CAUTION—Never cut down into the ring travel area more than 1/32"—or more than half the depth of the top ring.

New rings should be fitted with end gaps and groove clearances as given in the PISTON & RING CLEARANCES table. Ring grooves must be clean and free from carbon, and must show no perceptible wear.

NOTE—Ring end gaps given in the PISTON & RING CLEARANCES table are for cylinder bores without taper. Fit rings in tapered bores with not less than the maximum dimension given. If rings other than standard are being installed, pay particular attention to the installation instructions which are usually included in the ring package. This applies to clearances, position in grooves, etc.

When rings are properly fitted to the pistons, be sure to stagger the ring gaps so they are spaced equal distances around the circumference of the piston. However, see that no gaps are over the piston pins.

WRISTPINS & BUSHINGS

ED, END-405, 457, 605: Wristpins are of the "floating" type being retained by aluminum plugs telescoped into the ends of the pin. Oversize pins of .003" and .005" are available, and when fitting, the pin should be free in the rod bushing and just be able to enter the piston pin bosses with the parts at normal room temperature. However, to facilitate fitting pins, heat the pistons in water of about 200 degrees F. and quickly insert the pin in the piston.

It is recommended that—in the absence of suitable equipment—connecting rods be exchanged if wristpin bushings are to be renewed.

CONNECTING ROD BEARINGS, RENEW

ED, END-405, 457, 605: When bearings become worn, they can be replaced without removing the rod by simply taking off the bearing cap and replacing the upper and lower halves. Bearings should be replaced in sets and under no circumstances should rods or caps be filed, altered or mutilated in any way in an attempt to obtain proper bearing fit.

NOTE—Before replacing bearings, make sure that the crankpins are not nicked or scored. Use care also, to see that all parts are thoroughly clean. This is particularly important because one small particle of metal, carbon or other foreign matter, lodged between the back of the bearing and the rod, or between the face of the bearing and the crankpin, will very likely cause a hot spot due to the elimination of oil clearance at that point, eventually resulting in a bearing failure or a scored crankpin.

To check the fit of new bearings, use a piece of brass shim stock ¼" wide, the length of which should be ¼" less than the length of the bearing, while the thickness should be about the same as the minimum allowable clearance.

CAUTION—To avoid damaging the bearing material, smooth down the edges of the shim stock on an oil stone so that no sharp edges remain. Install the shim between the bearing and the crankpin, in the center of the bearing, then tighten the cap bolts to the recommended torque tension. When fitted properly, it should not be possible to move the rod endwise by hand, but a light tap with a hammer should cause the rod to move endwise. Then remove the checking shim and install the cap again, tightening the cap bolts with the torque wrench, after which, the rod should move endwise by hand. If the rod is too loose with the checking shim in place, the crankpin should be turned down and undersize bearings fitted.

NOTE—It is good practice to check the connecting rod bore for roundness. A special tool with an indicator gauge is available for this operation, and before using this instrument, be sure that there are no nicks, burrs or dirt on the contracting surfaces to prevent a true reading. If the rod bore is out-of-round more than .002" or .003", the rod should be replaced.

CYLINDER SLEEVES

ED, END-405, 457, 605: These sleeves are of the "dry" type and are obtainable in the original standard sizes only. Since these sleeves are too hard to be bored, new sleeves should be installed with standard size pistons. This procedure is recommended as being more economical in a long run, as the necessity of expensive grinding equipment is eliminated. It has the further advantage of insuring parallel bores which will hold wear on the wrist-pin plugs to a minimum.

However, if grinding equipment is available, the sleeves may be ground several times until the maximum oversize piston size is reached (oversize pistons are obtainable in steps of .010" up to .060").

To assure maximum heat transfer from the sleeve to the cylinder block and water jackets, the sleeve is pressed in with a fit of from .0008" to .0013".

Sleeves should be coated with machine oil to prevent galling or sticking when being pressed in place. As the sleeve nears the bottom of the block, blow away the oil under the shoulder of the sleeve to permit the shoulder to seat firmly in the counterbore of the block.

NOTE—Always use suitable removing and replacing tools when installing sleeves as they must never be hammered or pounded into position. When properly installed, the sleeve shoulder should be approximately flush with the surface of the block but never more than .002" above or below. The depth of the counterbore in the cylinder block and the shoulder of the sleeve is from .252" to .250". It is therefore necessary to fit sleeves selectively to obtain the flush position, subject to the .002" variation mentioned above. These limits are required to permit the cylinder to be clamped evenly with the block, which otherwise would result in leakage across the cored passages. When fitted to the above specifications, the shoulder of the sleeve will be clamped, and the head gasket will be able to take care of the small amount of projection.

MAIN BEARINGS, RENEW

ED, END-405, 457, 605: These bearings are of the precision insert type and should be replaced in sets and under no circumstances should any attempt be made to file, alter or otherwise mutilate the bearing caps to obtain proper bearing fit. No shims are used.

Before replacing bearings, make sure that the crankshaft journals are not nicked or scored. Use care also, to see that all parts are thoroughly clean. This is particularly important because one small particle of metal, carbon, dirt or other foreign matter, lodged between the back of the bearing and the cap, or between the bearing face and the crankshaft journal, will very likely cause a hot spot due to the elimination of the oil clearance at that point, eventually resulting in a bearing failure or a scored journal.

When bearings become worn, they can be replaced without removing the crankshaft in the following manner: Remove the bearing cap and take out the worn lower shell. A suitable tool can be made to remove the upper shell by using a cotter pin with the rounded end flattened to form a T shape. Insert the long end of the pin in the oil passage hole in the crankshaft journal and, by rotating the crankshaft in the reverse direction, the T-shaped head will contact the bearing and force it out.

To install, place a new upper shell on the crankshaft journal with the locating notch in the correct position and rotate the shaft to turn the shell in place. Then install the lower shell in the cap and replace the cap, tightening the cap bolts to the recommended torque tension which will be found in the ENGINE BEARING SPECIFICATIONS table.

To check the fit of new bearings, use a piece of brass shim stock ¼" wide, the length of which should be ¼" less than the length of the bearing, while the thickness should be about the same as the minimum allowable clearance.

CAUTION—To avoid damaging the bearing material, smooth down the edges of the shim stock to remove sharp edges or turned over corners. And before inserting it in place, coat the shim on both sides with a light film of engine oil.

Then lay the shim lengthwise in the center of the bearing and install the bearing cap to the crankshaft, tightening the cap bolts to the recommended torque tension. Test the fit of the bearing by rocking the flywheel through an arc of 2"—not more than 1" in either direction. The bearing may be considered fitted properly if the shaft is movable with a fairly heavy drag.

NOTE—Remove the shim and replace the cap, but do not tighten the cap bolts, as this bearing must be loose in order to check the fit of the other bearings. It is good practice to fit bearings by starting at the center, then the rear bearing, front bearing, and finally, the intermediates.

CRANKSHAFT END THRUST

ED, END-405, 457, 605: End thrust is controlled by thrust washers at the center main bearing.

Through normal wear, the end play will seldom become excessive, but whenever new bearings are fitted, check the end play carefully, and if not within the limits given in the ENGINE BEARING SPECIFICATIONS table, install thrust washers of the thickness required to obtain the desired result.

REAR MAIN BEARING OIL SEAL

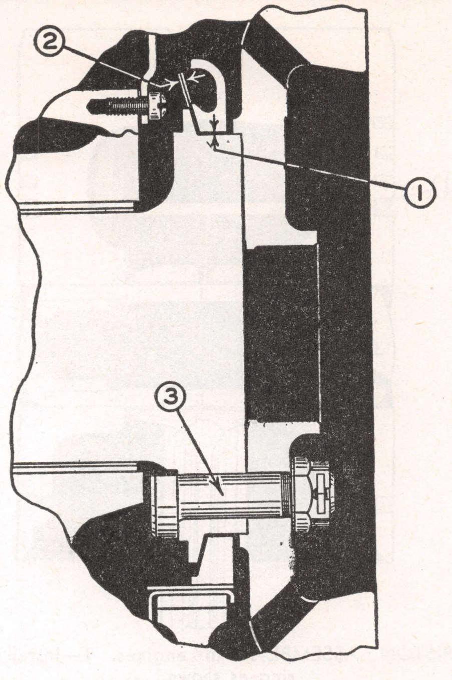
ED, END-405, 457, 605: An oil slinger, integral with the crankshaft, controls the oil sealing by returning surplus oil to the oil pan through an oil passage.

NOTE—As shown in the illustration, the clearances between the oil slinger and the crankshaft—both radial and end—must be carefully checked when reassembling an engine. The radial clearance (1) should be from .008" to .010", and the end clearance (2), from .035" to .045".

FLYWHEEL

ED, END-405, 457, 605: When installing the flywheel, the flywheel bolts must be a .002" drive fit into the crankshaft flange to prevent oil from leaking through these points.

IMPORTANT—The crankshaft flange and the flywheel are marked with an "O," and when replacing the flywheel, be sure that these marks are lined up so that the injection timing marks on the flywheel will be in the proper relationship with the engine.



ALL ENGINES. See "Rear Main Bearing Oil Seal" in text for clearance data.

ENGINE OILING

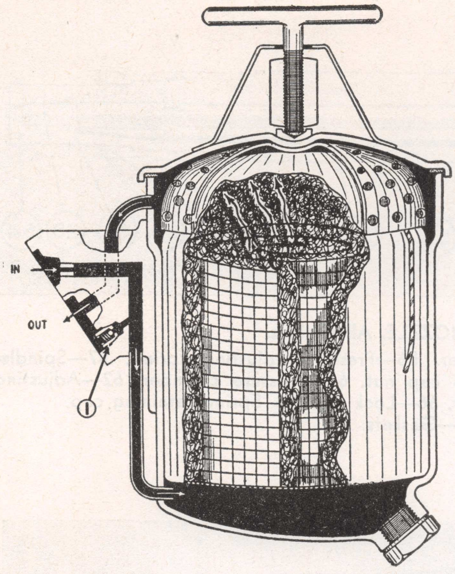
OIL PUMP

ED, END-405, 457, 605: If the oil pressure drops to zero suddenly or fluctuates violently while the engine is under load, check the oil level and examine the condition of the oil. Oil that has been used too long will be thinned by dilution, which will cause the pressure to drop. If these conditions are not the cause, before taking down the oil pan and pump, check the oil gauge with another gauge known to be accurate. If the pressure continues to drop, remove and clean the oil pan thoroughly, and disassemble, clean and inspect the pump.

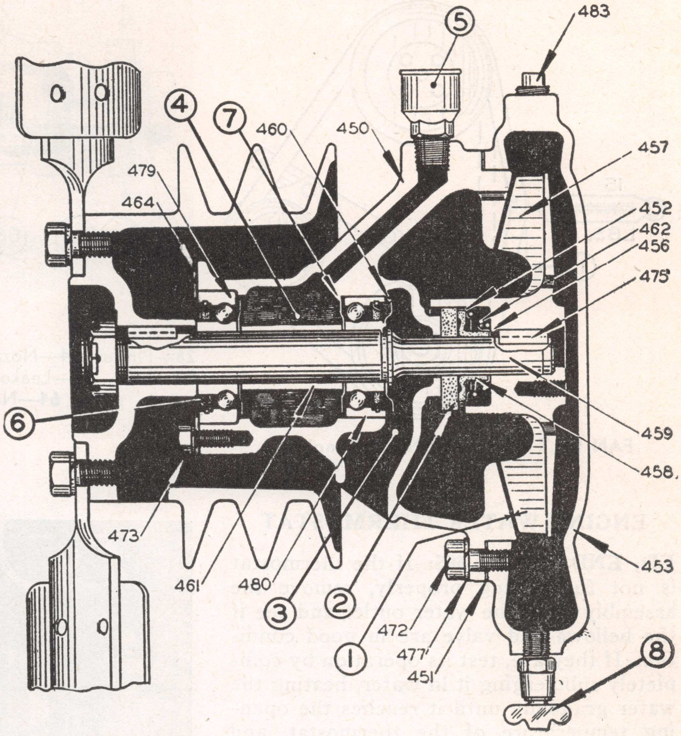
NOTE—The pump can easily be disassembled by taking off the upper drive gear and bottom cover, after which, the internal parts can readily be removed. Clearance between the gears and housing should not exceed .009". Replace any gears which have an excessive amount of backlash. When assembling, dip the gears in fresh engine oil as a means of priming the pump.

Clearance between the gears and bottom cover may be checked by placing a steel scale across the face of the housing, and a feeler ribbon between the steel scale and gears. If the clearance is in excess of .002", it may be reduced by grinding the lower face of the housing, using an abrasive compound evenly distributed on a perfectly flat surface.

Examine the oil pressure regulator ball check, spring and seat, and if these parts show wear, new parts must be installed.



OIL FILTER. All engines.



WATER PUMP. All engines.

CAUTION—Before replacing the oil pump and oil pan, the oil screen, oil tubes and oil lines should be thoroughly cleaned, being sure that all openings in the screen are free and clean. If the screen is crushed, it is better to replace it rather than attempt to make a repair.

OIL PRESSURE REGULATOR

ED, END-405, 457, 605: With the engine operating at normal temperature and at normal speeds, a gauge reading should show from 45 to 60 pounds, while at idling speeds, a minimum reading of from 10 to 20 pounds should register.

The oil pressure relief valve is built into the pump and is not adjustable. If the oil pressure is below normal, and it is known that the factors mentioned in the "Oil Pump" paragraph are not the cause, remove the relief valve and clean it thoroughly. If any of the parts show wear, they must be replaced. The free length of the spring is 3⅝" and when compressed to 2¾", a spring pressure test should read 25 pounds.

OIL FILTER

ED, END-405, 457, 605: These filters are equipped with a ball check type by-pass valve which allows oil to by-pass around the filter when the oil is cold and thick, or when the filter is clogged.

Filters should be cleaned thoroughly every time the oil is changed and approximately every thousand miles of operation. If the dip stick shows the oil to be very dirty and thick, it indicates that the filter element requires service.

To remove the element, unscrew the drain plug and draw off about one quart of oil with the engine running—which will flush the sump out under pressure. Loosen the thumb nut and take off the cover, after which, pull out the cartridge.

NOTE—If for any reason the filter cover is to be removed—other than the above—be sure to remove the drain plug first in order to "break" the vacuum. And add sufficient oil to the crankcase to compensate for the oil drained from the filter.

CRANKCASE VENTILATOR

ED, END-405, 457, 605: The crankcase ventilator breather should be inspected at least every 2,000 miles of operation, and if a sludge formation is evident, remove the breather and clean it thoroughly in gasoline. Allow the breather to soak in the gasoline for about 30 minutes, then blow it out with compressed air, and at the same time, tap it lightly to dislodge any particles of sludge.

If the breather is fitted with an air cleaner, it should be removed and washed every 1,000 miles. After the element is washed, blow it dry with compressed air and, if the cleaner is of the oil-wetted type, dip the element in fresh engine oil before assembling. If it is of the oil bath type, wipe out the oil reservoir thoroughly with a clean cloth and fill it to the proper level with fresh engine oil.

NOTE—The interval at which the ventilator and air cleaner should be cleaned can only be determined by the type of service to which the vehicle is subjected. Vehicles operating in dusty or sandy areas require more frequent service than those operating under more favorable conditions.

IMPORTANT—For vehicles operating in dust storm areas, the cleaner should be cleaned immediately after such storms occur.

COOLING SYSTEM

WATER PUMP, OVERHAUL

ED, END-405, 457, 605: This type pump is of the centrifugal design and the shaft is supported by two ball bearings. Water sealing is accomplished by a special carbon washer assembly which is held against the face of a bushing by a brass spring.

If a water leak develops, it indicates that the sealing parts are worn, which necessitates the disassembly of the pump to replace these parts.

To disassemble the pump, remove the bolts and separate the cover from the pump body. Use a suitable puller to remove the impeller from the shaft.

Insert a screwdriver through one of the slots in the impeller hub and press the snap ring out of the groove, after which, take out the seal parts.

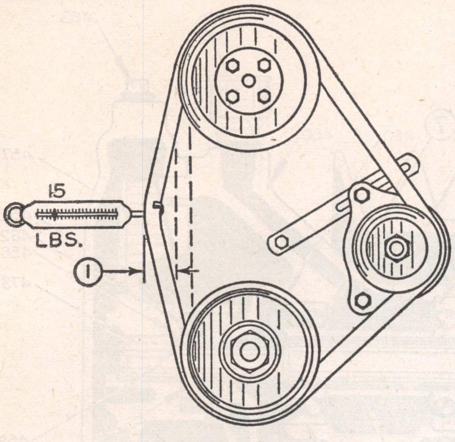
To assemble, place the ball bearings, shaft and spacer in the housing before pressing on the impeller or fan hub. After installing new seal parts, press the impeller on the shaft until it butts against the end of the shaft.

Be sure there is from .005" to .007" clearance between the slingers and the bearings to allow lubrication of the bearings.

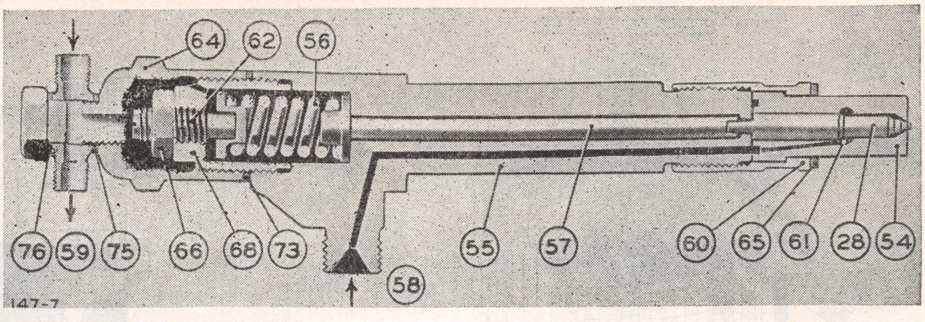
This type pump should be lubricated after every 5,000 to 6,000 miles through a fitting provided for the purpose. Turn the cap down one-half turn. The lubricant used should be Ball and Roller Bearing Grease with a melting point of about 350 degrees F. The housing should be from 1/3 to ½ full.

FAN BELT, ADJUST

ED, END-405, 457, 605: Fan belt adjustment should be checked at least every 1,500 miles. Always replace belts in pairs after first matching them for length. When properly adjusted, a pressure of 15 pounds, measured with a spring scale, should depress one belt on the long side not more than ½". New belts should be rechecked after a few hours operation.



FAN BELT ADJUSTMENT. All engines.



FUEL INJECTION NOZZLE. All engines.
28—Pintle. **54**—Nozzle body. **55**—Nozzle holder. **56**—Pressure adjusting spring. **57**—Spindle. **58**—Inlet. **59**—Leakoff or drip lines. **60**—Nozzle cap nut. **61**—Pressure chamber. **62**—Adjusting screw. **64**—Nozzle holder cap. **65**—Gasket. **66**—Lock nut. **68**—Spring retaining cap. **73, 75, 76**—Gaskets.

ENGINE WATER THERMOSTAT

ED, END-405, 457, 605: If the thermostat is not functioning properly, remove the assembly from the water outlet and see if the bellows and valve are in good condition. If they are, test its operation by completely submerging it in water, heating the water gradually until it reaches the opening temperature of the thermostat, and then in water heated to the fully closed temperature.

The standard thermostat closes at 165 degrees F., and opens at 190 degrees F.

NOTE—When taking temperature readings, agitate the water thoroughly. And if the thermostat fails to function properly, it should be replaced rather than attempt to make a repair. However, before installing a new unit, it should be tested as directed above.

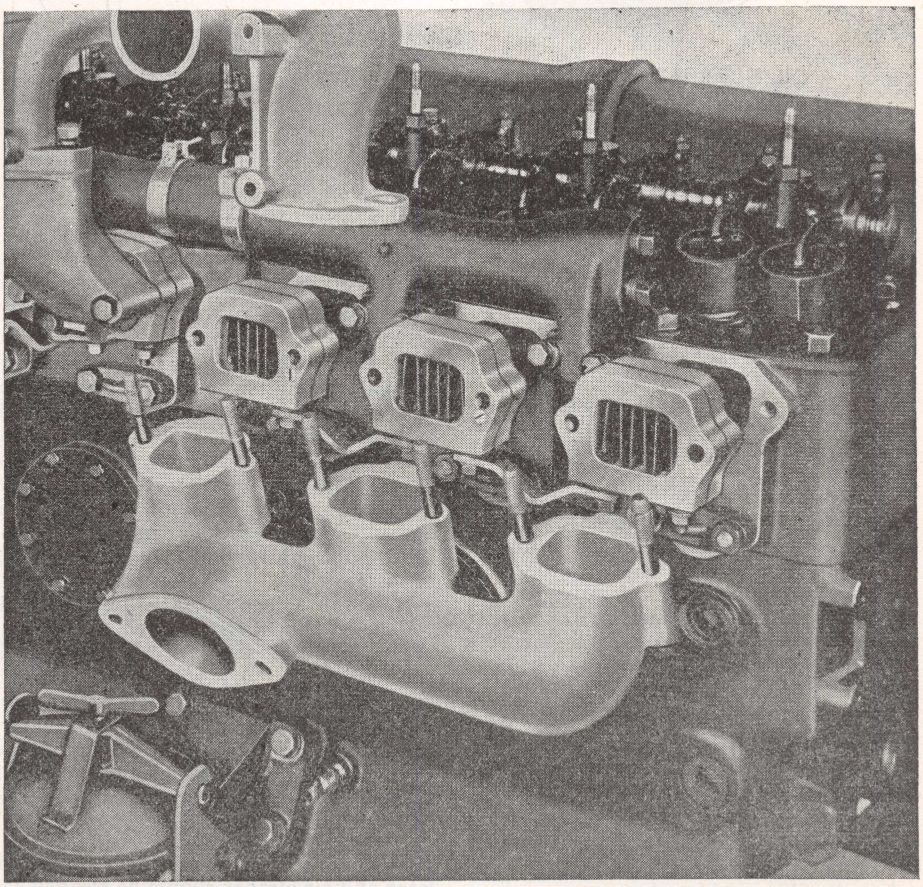
NOTE—Thermostats which close at 135 degrees and open at 160 degrees are available for operation where the engine is running too hot. If the engine is equipped with high temperature thermostats, denatured alcohol should not be used as it will boil away and leave the system unprotected. If alcohol must be used, thermostats with the above opening and closing temperatures should be installed.

FUEL SYSTEM

NOTE—For detailed information on Diesel Fuel Injection Systems, see the Table of Contents on page 1.

SYNCHROVANCE UNIT

ED, END-405, 457, 605: The fuel injection pump is connected to the timing gear drive through the Synchrovance unit (when equipped), which, when combined with a variable coupling drive, advances the injection point from the static flywheel setting during engine operation. This keeps the injection at the point best suited for maximum performance throughout the entire speed range.



Individual type manifold heaters for cold weather starting.

The Synchrovance unit is a centrifugal type of governor device which consists essentially of three parts: The driving member, sliding sleeve, and the driven member with governor weights.

Servicing the Unit: No adjustments are necessary on the Synchrovance unit during operation, but if overhauling or disassembling is required, observe the following precautions:

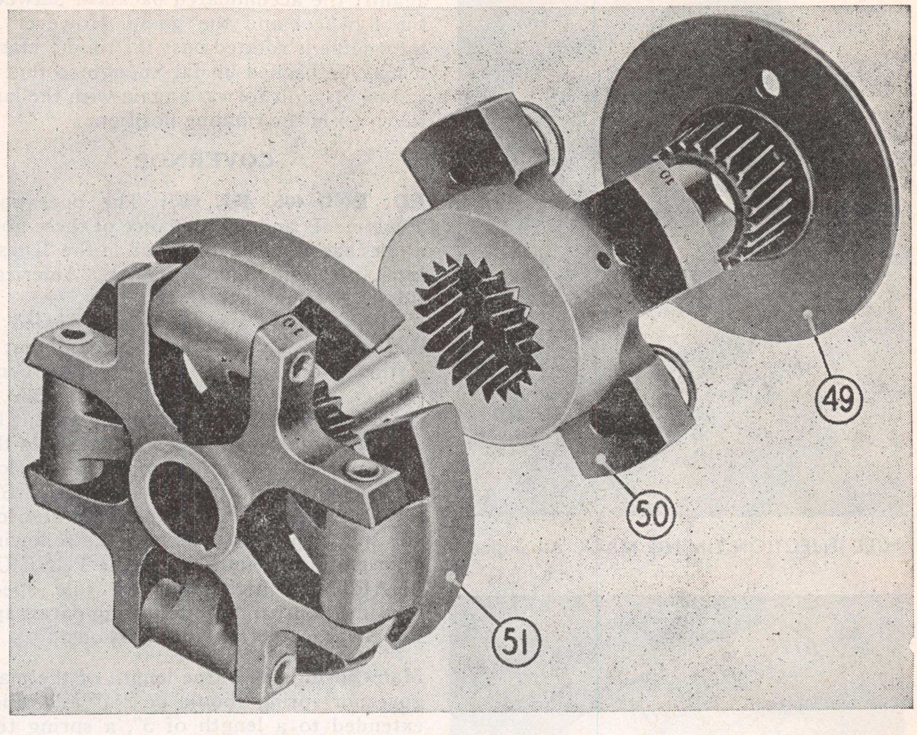
1. Before dismantling the unit, mark all parts so they may be assembled in their original position.
2. Keep the governor weight springs—both **inner and outer—in pairs, together with** their thimble spacer. These springs are accurately calibrated for the unit, and if for any reason it is suspected that any of the springs are defective, the **entire set** of four pairs of springs should be replaced, because, under ordinary circumstances, they cannot be calibrated accurately in the field.
3. When assembling the driven member on the pump shaft, be sure the key remains in position. By rotating the unit slowly, check to see that the driven member does not strike the screws which **fasten the adapter housing to the pump.**

4. When the balance of the parts are assembled, tighten the hollow hexagon-head screw, which threads on the end of the pump shaft and tightens the thrust washer against the driven member. Then tighten the countersunk head screw, which is within the hexagon-head screw. This jams the threads between the two screws by butting against the pump shaft.
5. Then check the clearance between the thrust washer and the driving member, which should be from .003" to .008", but not less than .002". If less than .002", grind off the end of the driving member, while if more than .008", install a new thrust washer.
6. Use a screwdriver to pry the governor weight out against spring force to determine whether or not all parts move freely without binding. Excessive looseness between the governor weights and their pins requires the replacement of the pins and weight bushings. When installing new pins, they must be riveted over, but be sure to check the governor weights for free movement.
7. If the Synchrovance unit is being replaced on the original injection pump, the injection timing will be correct. But if a different Synchrovance unit is being installed, it will be necessary to check the "port closing" position by the flow method as explained in the "Diesel Fuel Injection Pump" chapter in the "American Bosch" section. If the "F.P.I." mark on the driven member does not line up with the pointer on injection pump adapter housing, then the mark must be ground off and a new line stamped on the driven member. However, before changing the mark, recheck the "port closing" to make sure that no error has been made in the test.
8. When reassembling an injection pump to an engine, there should be from 1/32" to 1/16" end play between the intermediate coupling and the coupling to the pump. This end play is required, because a tight coupling will create an end pressure against the pump camshaft which will result in damage to the pump bearings. This inspection can be made by removing the governor drive, and if the end play is not within the limits given above, install gaskets of the correct thickness to obtain the desired result.

INJECTION TIMING

ED, END-405, 457, 605: Ordinarily, when an injection pump has been removed and the same pump and coupling has been replaced, it is only necessary to line up the dowel pin holes of the gear and coupling, inserting the intermediate disc so that the pin, which is pressed through this disc, engages both the hole in the gear and the hole in the pump coupling. When the pump is then bolted in place, the timing should be accurate. If the engine has been completely disassembled, or if it is suspected that the pump is out of time, see the TUNE UP CHART for timing specifications, and proceed as follows:

The flywheel is marked "TC-1 & 5" and also with a series of lines representing flywheel degrees, every fifth graduation being indicated by the number of degrees which the particular line represents.

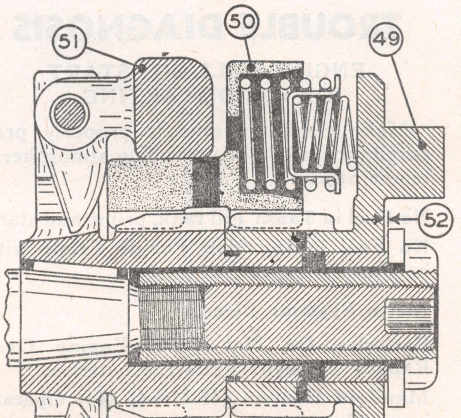


SYNCHROVANCE UNIT. All engines.
49—Driving element. 50—Sliding sleeve. 51—Driven member.

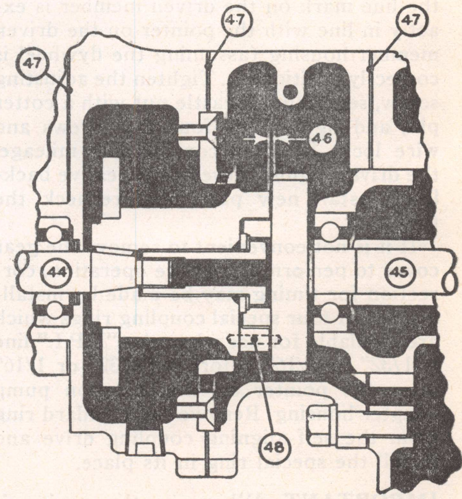
Crank the engine until No. 1 piston is **near** top center of its compression stroke, which can be determined by the opening of No. 2 exhaust valve. Continue turning the engine slowly until the desired degree mark on the flywheel is exactly in line with the pointer on the flywheel housing.

Then remove the plug from the injection pump adapter housing and note the position of the line marked "F.P.I." (fuel pump injection) on the driven member with respect to the fixed pointer on the housing. For correct timing, the pointer and the line **must match.**

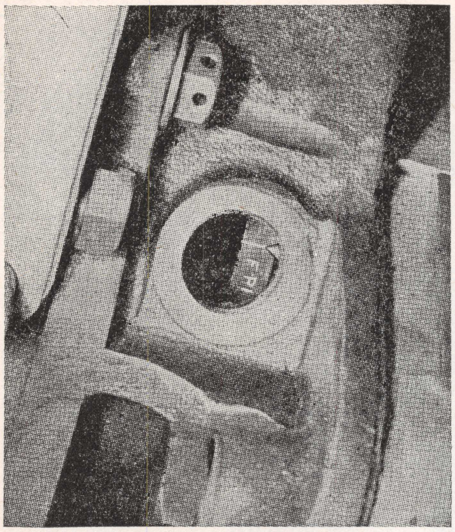
NOTE—If necessary to check the pump for correct "port closing," see the "Diesel Fuel Injection Pump" chapter in the "American Bosch" section which explains this pro-



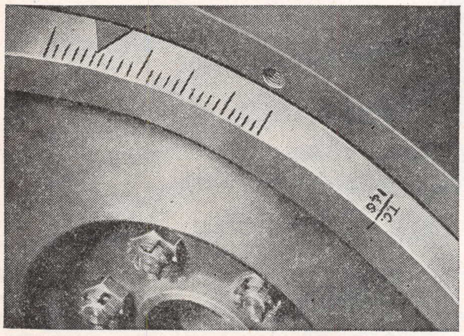
SYNCHROVANCE UNIT. Sectional view. All engines.



INJECTION PUMP COUPLING (No synchrovance unit).
44—Pump shaft. 45—Shaft to timing gear. 46—Clearance point. 47—Housing gaskets. 48—Pin engages hole in gear and in coupling.



FUEL INJECTION TIMING MARK. All engines.



FLYWHEEL MARKS. All engines.

cedure of checking by the flow method. Then, if the pump is out of time, remove the timing gear cover and loosen the four cap screws holding the injection pump driving gear, noting that the holes in this gear are slotted. Loosen the castle nut on the eccentric screw and turn the screw until the line mark on the driven member is exactly in line with the pointer on the driven member housing (assuming the flywheel is correctly positioned). Tighten the adjusting screw, securing the castle nut with a cotter pin, and tighten the four cap screws and wire lock. If, after considerable mileage, the drive coupling develops excessive backlash, install new parts and recheck the timing.

If it is not convenient to remove the gear cover to perform the above operation, correction for timing may be made by installing one of four special coupling rings which are available for use when the "F.P.I." line is 1/32" or 1/16" before, or 1/32" or 1/16" after the pointer on the injection pump adapter housing. Remove the standard ring from the self-aligning coupling drive and install the special ring in its place.

IMPORTANT—Whenever the engine is being rotated for the purpose of bringing the timing mark in line with the pointer on the flywheel housing, always come up to the mark in the direction of engine rotation, so as not to bring the timing points together against the accumulated backlash between the flywheel and the pump. However, if the engine is rotated past the timing mark, it may be backed up far enough so that it can be brought forward again with the lash taken up in the running position.

GOVERNOR

ED, END-405, 457, 605: The operation, adjustments and maintenance of these governors are described in detail in the "Diesel Fuel Injection Pump" chapter, "American Bosch" section of this book.

All governors are set up and sealed at the factory, but if it is suspected that a setting is unsatisfactory, under no circumstances should any attempt be made to change or alter the adjustments except by one who is thoroughly competent to do the job correctly. If equipped to do the job, the following information is required. See the TUNE UP CHART for high and low idle speed specifications, and the following information is required. See the TUNE UP CHART for high and low idle speed classifications, and the following paragraph for governor spring specifications.

Main Spring: The free length of the main governor spring should be 2¾" and when extended to a length of 3", a spring test should show 66 pounds, plus or minus 5 pounds; when extended to 3¼", 107 pounds, plus or minus 5 pounds.

Idle Spring: The free length of the idle governor spring should be 1⅞"—measured inside the hooks. When extended to 2 1/16", a spring test should show 5 pounds, plus or minus 1 pound; when extended to 2¼", 10 pounds, plus or minus 1 pound.

ELECTRIC SYSTEM

NOTE—For service information concerning Generators, Generator Regulators, Starting Motors and Starter Switches, see the Table of Contents on page 1.

TROUBLE DIAGNOSIS

ENGINE WILL NOT START OR HARD STARTING

Make certain engine is properly prepared for starting at prevailing atmospheric temperature.

No Fuel in Tank: Fill tank, prime and start.

No Fuel in Injection Pump: Prime with handle.

Air in System: Bleed.

Batteries Do Not Turn Engine Over Rapidly Enough: Recharge batteries.

Manifold Heaters (If Used) Not Operating: Check for loose connections and broken wires and element ribbon, and replace.

Fuel Too Heavy to Flow Thru Pipes Properly: Use lighter fuel.

Water in Fuel: Drain fuel system and tanks, clean, refill, prime, and start.

Piston Rings or Cylinder Sleeve Walls Worn Badly: Replace with new parts.

Exhaust or Inlet Valve Seats Pitted or Worn: Regrind valves and seats.

Leaking Cylinder Head Gasket: Replace with new gasket.

Ail Filter Plugged Not Allowing Sufficient Air to Pass Thru: Clean air filter.

Supercharger (If Used) Not Operating: Inspect unit, check belts and renew if broken.

ENGINE STOPS SUDDENLY

No Fuel: Fill tank, prime and start.

Injection Pump or Lines Air or Gas Bound: Check for loose fitting, tighten and prime.

Fuel Filters Plugged: Clean filters and prime system.

Obstruction In, or Broken, Main Fuel Line: Check and correct.

Water in Fuel: Drain tank and entire fuel system, clean, refill, prime, and start.

Transfer Pump Not Functioning Properly: Check valves, springs, gaskets, and plunger.

Piston Seizure Due to Lack of Lubrication: Remove piston and replace with new parts if badly scored. Also inspect cylinder sleeve for scores and replace with new part if necessary. Change engine oil after thoroughly cleaning oil pan, lines and filter.

Bearing Seizure Due to Lack of Lubrication: Replace with new bearing. Then proceed as in preceding item.

ENGINE MISSING ERRATICALLY OR INTERMITTENTLY ON ALL CYLINDERS

Improper Fuel or Fuel With Poor Burning Qualities: Drain tank and entire fuel system, clean, refill with suitable fuel, prime and start.

Water in Fuel: Drain tank and entire fuel system of all water and sediment, refill with clean fuel, prime, and start.

Sticky Injection Nozzle Valve Stems, or Injection Pump Delivery Valves, or Both: Remove stuck parts and clean. Clean entire fuel system after draining, refill with clean fuel, prime, and start.

Air in Fuel System: Bleed.

Worn Piston Rings, or Cylinder Sleeve, or Both: Replace with new parts.

Leaky Inlet, or Exhaust Valves, or Both: Regrind valves and seats.

Plugged Air Filter Reducing Air Admitted Into Cylinders: Clean air filter.

ENGINE MISSING ON ONE OR MORE CYLINDERS

To determine which cylinder or cylinders are missing, loosen the nuts connecting high pressure lines to injection nozzles one at a time. If the engine speed slows down, and the exhaust loses its rhythm, then the cylinder is functioning. If the engine speed remains the same, and exhaust sounds the same, this indicates that the cylinder is missing.

Air or Gas in Injection Pump or Lines: Usually when testing for missing cylinder, this condition will clear up as opening the nut allows the air or gas to escape, see preceding item.

Injection Pump Delivery Valve Stuck in Body: Remove and clean.

Exhaust or Inlet Valve Stuck: Remove valve cover and check. Free with kerosene or alcohol poured down stem. If it still sticks, remove head, determine and remove cause.

Leaky Exhaust or Inlet Valve: Regrind valve and seat.

Broken Exhaust or Inlet Valve Spring: Replace with new part.

Improper Tappet Clearance Between Exhaust or Inlet Valve and Rocker Arm: Check and reset to proper clearance.

Injection Pump Delivery Valve Leaking or Stuck: Remove and clean with soft rag and clean fuel oil. Do not use abrasive or sharp tools on this part. If cleaning does not free the valve, remove both valve and seat, and install new parts. These valves and seats must be used as an assembly, as parts are not interchangeable.

Injection Pump Delivery Valve Spring Broken: Replace with new parts.

Piston Rings or Cylinder Sleeve Walls Badly Worn: Replace with new parts.

Broken Injector Nozzle Lines: Replace with genuine new parts.

SMOKE FROM EXHAUST

Exhaust smoke is caused by faulty combustion of fuel oil, and by burning of excess engine oil in the combustion chamber or exhaust manifold. The color of the smoke—white, blue, or brown—does not, in itself, indicate whether the source is fuel oil or engine oil.

Engine Oil

An accumulation of oil within the combustion chambers will cause a blue smoke when the engine is started. This will continue for a time, depending on the speed and load of the engine and the amount of oil accumulation.

If such blue smoke does not disappear eventually but increases with engine speed and decreases with load, it is an indication that excessive oil is passing by the piston rings, due to carboned or stuck rings, worn rings, pistons and sleeves, or improper grade of oil.

Fuel Oil

White "smoke" is actually vaporized, but unburned, fuel oil. If it continues after the engine is running, it indicates that one or more cylinders are not firing. Missing cylinders, causing white smoke, should be located and the cause corrected. Possible causes are: engine too cold, poor compression, stuck or leaking valves, leaking cylinder head gasket, improper grade of fuel oil or contamination by water or air.

Brown and **black** smoke is the visible concentration of excess amounts of unburned carbon particles. No combustion is absolutely complete, so carbon particles are always present in the exhaust; but in the case of good combustion, their relative concentration is so slight that the exhaust is barely visible.

The following possible causes of **excessive, or continued, brown and black smoke** should be investigated and suitable correction should be made:

1. Dirty or leaking injector nozzle.
2. Insufficient air to support complete combustion of injected fuel.
   - (a) Leaking valves.
   - (b) Stuck rings.
   - (c) Worn rings, pistons, sleeves.
   - (d) Excessive fuel feed.
   - (e) Dirty and obstructed air filter.
   - (f) Rarified atmosphere at high altitudes.
3. Unsuitable fuel. Slow burning or having too high an ignition temperature.
4. Timing of injection.
   - (a) Too early—indicated by fuel knock and power loss.
   - (b) Too late—no fuel knock, but power loss.
5. Fuel injectors out of calibration or otherwise faulty.

Improper operation, resulting in overloading the engine, may cause smoke because more fuel is being injected than can be burned under the conditions.

Continued idling, or operation under light loads, may cause smoke because the lowered temperature in the combustion chambers reduces the speed of combustion which is not complete when the exhaust valves open.

Blue smoke may have the same causes that produce brown and black smoke. It is blue under certain load and speed conditions while combustion chambers have not reached normal heat.

Year	Engine Model	Number Cylinders and Valve Arrangement	Bore and Stroke	Displacement Cubic Inches	Compression Ratio	Taxable H. P.	Brake H. P. at R. P. M.	Maximum Torque at R. P. M. Pounds Feet	Oil Capacity Quarts ①
1939–46	VRZH	4-I	4⅝x5¼	353	5.60	34.2	59@1600	229@700	8
1941–46	130-HS	4-I	3¾x5	221	6.12	22.5	48@2200	142@1000	6
1941–46	130-HL	4-I	4x5	251	5.90	25.6	55@2200	155@1000	6
1941–46	140-HS	6-I	4¼x5½	468	5.80	43.3	111@2250	342@1000	10
1941–46	140-HK	6-I	4½x5½	525	5.80	48.6	124@2250	383@1000	10
1941–46	145-HS	6-I	4¾x6	638	5.60	54.1	143@2000	450@900	18
1941–46	145-HK	6-I	5¼x6	779	5.60	66.1	174@2000	550@900	18
1936–46	6-BKH	6-I	3¾x4¼	282	6.40	33.8	83@2800	174@1400	8
1938–46	6-WALH	6-I	5¾x6½	1013	5.25	79.3	172@1800	686@700	32
1938–46	6-WAKH	6-I	6¼x6½	1197	5.20	93.5	202@1800	811@700	32

① Oil capacities listed are for oil pans only. When oil coolers, oil filters or other accessories that hold and retain lubricating engine oil are installed, an extra amount equal to the capacity of these accessories should be added.

TUNE UP CHART

Year	Engine Model	Firing Order②	Timing Degrees B.T.D.C.		Nozzle Discharge Pressure, Lbs. Sq. In.	High Idle Speed, R. P. M. ①	Magneto Point Gap, Inch	Spark Plug Gap, Inch	Valve Timing	
			Ign.	Inj.					Intake Opens, Degrees	Exhaust Closes, Degrees
1939–46	VRZH	1243	16	50	750–875	1600	.012–.016	.018–.020	TDC	10 ATDC
1941–46	130-HS	1243	18	30	750–875	2000	.012–.016	.018–.020	5 ATDC	10 ATDC
1941–46	130-HL	1243	18	27	750–875	2000	.012–.016	.018–.020	5 ATDC	10 ATDC
1941–46	140-HS	153624	19	35	750–875	2250③	.012–.016	.018–.020	5 ATDC	10 ATDC
1941–46	140-HK	153624	19	35	750–875	2250③	.012–.016	.018–.020	5 ATDC	10 ATDC
1941–46	145-HS	153624	16	26	750–875	2000④	.012–.016	.018–.020	5 ATDC	10 ATDC
1941–46	145-HK	153624	16	26	750–875	2000④	.012–.016	.018–.020	5 ATDC	10 ATDC
1936–46	6-BKH	153624	14	32	750–875	2800⑤	.012–.016	.018–.020	5 ATDC	10 ATDC
1938–46	6-WALH	153624	17	42	780–925	1800⑥	.012–.016	.018–.020	TDC	10 ATDC
1938–46	6-WAKH	153624	17	42	780–925	1800⑥	.012–.016	.018–.020	TDC	10 ATDC

① Maximum speed—no load.
② Standard rotation.
③ R. P. M. shown is for engines with aluminum pistons; with cast iron, 2000 R. P. M.
④ R. P. M. shown is for engines with aluminum pistons; with cast iron, 1800 R. P. M.
⑤ R. P. M. shown is for engines with aluminum pistons; with cast iron, 2500 R. P. M.
⑥ R. P. M. shown is for engines with aluminum pistons; with cast iron, 1600 R. P. M.
Ign.—Ignition. Inj.—Injection.

VALVE SYSTEM

Year	Engine Model	Stem Clearance		Tappet Guide Clearance ②	Tappet Clearance Running, Cold①		Timing		Valve Spring Pressure Test		Valve Seat Angles Degrees
		Intake ②	Exhaust ②		Intake	Exhaust	Intake	Exhaust	Free Length, Inches	Pounds at Inches, Length ④	
1939–46	VRZH	③	③	.001–.003	.013	.021	.010	.013	2¼	I 33@1 13/64 O 72@1 5/16	②
1941–46	130-HS	③	③	.001–.003	.011	.016	.012	.015	I 2 21/64 O 2 7/16	I 100@1 11/16 O 55@1 7/16	②
1941–46	130-HL	③	③	.001–.003	.011	.016	.012	.015	I 2 21/64 O 2 7/16	I 100@1 11/16 O 55@1 7/16	②

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VALVE SYSTEM

Year	Engine Model	Stem Clearance		Tappet Guide Clearance ②	Tappet Clearance Running Cold ①		Timing		Valve Spring Pressure Test		Valve Seat Angle Degrees
		Intake ②	Exhaust ②		In-take	Ex-haust	In-take	Ex-haust	Free Length, Inches	Pounds at Inches, Length ④	
1941–46	140-HS	③	③	.001–.003	.013	.019	.010	.0135	I $2\frac{21}{64}$ O $2\frac{17}{32}$	I 55@$1\frac{1}{16}$ O 75@$1\frac{21}{32}$	②
1941–46	140-HK	③	③	.001–.003	.013	.019	.010	.0135	I $2\frac{21}{64}$ O $2\frac{17}{32}$	I 55@$1\frac{1}{16}$ O 75@$1\frac{21}{32}$	②
1941–46	145-HS	③	③	.001–.003	.013	.024	.010	.0135	I $3\frac{5}{32}$ O $3\frac{15}{32}$	I 100@$2\frac{1}{16}$ O 158@$2\frac{3}{8}$	②
1941–46	145-HK	③	③	.001–.003	.013	.025	.010	.0135	I $3\frac{5}{32}$ O $3\frac{15}{32}$	I 100@$2\frac{1}{16}$ O 158@$2\frac{3}{8}$	②
1936–46	6-BKH	③	③	.001–.003	.011	.019	.0105	.014	I $3\frac{19}{32}$ O $2\frac{17}{32}$	④	②
1938–46	6-WALH	③	③	.001–.003	.014	.023	.012	.016	I $3\frac{19}{32}$ O $3\frac{7}{8}$	I 125@$2\frac{1}{2}$ O 140@$2\frac{13}{16}$	②
1938–46	6-WAKH	③	③	.001–.003	.014	.023	.012	.016	I $3\frac{19}{32}$ O $3\frac{7}{8}$	I 125@$2\frac{1}{2}$ O 140@$2\frac{13}{16}$	②

① Plus or minus .001″.

② Intake, 30 degrees: exhaust, 45 degrees.

③ Service guides are especially machined to press in place and give proper clearance without reaming.

④ Inner, exhaust 49@$1\frac{17}{32}$; intake 53@$1\frac{1}{2}$. Outer, exhaust, 91@$1\frac{3}{4}$; intake 96@$1\frac{23}{32}$.

PISTON AND RING CLEARANCES

Year	Engine Model	Piston Skirt, Inches		Fitting Pistons with Shim and Spring Scale		Ring End Gap, Inch ①		Ring and Groove, Inch	
		Top	Bottom	Shim Thickness ⑤	Pounds Pull on Scale ⑥	Com-pression	Oil	Com-pression ⑦	Oil ⑦
1939–46	VRZH	.0055② .006③	.0055② .003③	.0055② .003③	.006② .0035③	.013–.023	.013–.023	.001–.005	.001–.005
1941–46	130-HS	.0045②	.0045②	.0045②	.005②	.015–.023	.015–.023	.001–.005	.001–.005
1941–46	130-HL	.0045②	.0045②	.0045②	.005②	.015–.023	.015–.023	.001–.005	.001–.005
1941–46	140-HS	.005② .0065③	.005④	.005④	.0055④	.010–.017	.010–.017	.001–.007	.001–.007
1941–46	140-HK	.005② .0065③	.005④	.005④	.0055④	.010–.017	.010–.017	.001–.007	.001–.007
1941–46	145-HS	.005② .008③	.005② .006③	.005② .006③	.0055② .0065③	.020–.030	.020–.030	.002–.008	.002–.008
1941–46	145-HK	.005② .008③	.005② .006③	.005② .006③	.0055② .0065③	.020–.030	.020–.030	.002–.008	.002–.008
1936–46	6-BKH	.006③	.003③	.003③	.0035③	.010–.015	.010–.015	.001–.005	.001–.005
1938–46	6-WALH	.006② .0085③	.006④	.006④	.0065④	.020–.030	.020–.030	.005–.010	.005–.010
1938–46	6-WAKH	.007② .0095③	.007④	.007④	.0075④	.020–.030	.020–.030	.005–.010	.005–.010

① End gaps are for cylinder bores without taper. Fit rings in tapered bores with not less than the maximum dimension given, measuring at the narrowest diameter of the bore.

② Cast iron pistons.

③ Aluminum pistons.

④ Cast iron or aluminum pistons.

⑤ Piston should pass on shim thickness shown.

⑥ Piston should lock in shim thickness shown.

⑦ Tapered rings. See sketch in text for method of measuring clearance. Engines equipped with straight rings, clearance should be .002″.

ENGINE BEARING SPECIFICATIONS

Year	Engine Model	Camshaft		Connecting Rod			Mains				
		Journal Diameter	Clearance	Journal Diameter	Clearance	Bearing Bolt Tension Lb. Ft.	Journal Diameter	Clearance	Bearing Bolt Tension Lb. Ft.	Thrust on No.	End-play
1939–46	VRZH	①	.0020–.0045	2.375–2.374	.001–.003	85– 88	2.375–2.374	.0015–.0035	½″ 88– 92 ⅝″100–104	3	.002–.006
1941–46	130-HS	2.125–2.124	.002–.0035	2.250–2.249	.001–.003	65– 70	2.375–3.374	.0015–.0035	108–112	3	.003–.008
1941–46	130-HL	2.125–2.124	.002–.0035	2.250–2.249	.001–.003	65– 70	2.625–2.624	.0015–.0035	108–112	3	.003–.008
1941–46	140-HS	2.125–2.124	.002–.0035	2.625–2.624	.001–.003	120–125	3.125–3.124	.002–.004	129–133	7	.003–.007
1941–46	140-HK	2.125–2.124	.002–.0035	2.625–2.624	.001–.003	120–125	3.125–3.124	.002–.004	129–133	7	.003–.007
1941–46	145-HS	2.500–2.499	.002–.0035	3.000–2.999	.001–.003	73– 75	3.500–3.499	.002–.004	242–250	7	.003–.007
1941–46	145-HK	2.500–2.499	.002–.0035	3.000–2.999	.001–.003	73– 75	3.500–3.499	.002–.004	242–250	7	.003–.007
1936–46	6-BKH	2.000–1.199	.0020–.0045	2.000–1.199	.0015–.0035	65– 70	2.625–2.624	.0015–.0035	88– 92	7	.003–.008
1938–46	6-WALH	2.743–2.742	.002–.0035	3.375–3.374	.0015–.003	85– 88	4.000–3.999	.0025–.0045	242–250	7	.004–.007
1938–46	6-WAKH	2.743–2.742	.002–.0035	3.375–3.374	.0015–.003	85– 88	4.000–3.999	.0025–.0045	242–250	7	.004–.007

① Front, 2.500–2.499. Center, 2.1855–2.1865. Rear, 1.750–1.749.

ENGINE

NOTE—For detailed information on Diesel Fuel Injection Systems, see the Table of Contents on page 1.

OPERATING PRINCIPLE

This engine is a four-stroke cycle engine based on the Hesselman fuel injection, spark ignition principle, combining the advantages of both the carburetor and Diesel type engines. Like the carburetor engine, it may be hand cranked. It also has the same easy starting characteristics, low compression and explosion pressures, invisible exhaust and smoothness of operation at all loads and speeds, as the carburetor engine.

As with the Diesel engine, it has the solid injection fuel system, enabling the use of fuel oil suitable for high-speed Diesel engines, and has the same high torque at reduced speeds. The fuel economy is somewhat midway between economies common to both the gasoline and Diesel engines.

Intake Stroke: With the intake valve open, the piston moves downward and draws in a charge of fresh air; no fuel being injected until later on. The admission of air is controlled by a butterfly throttle valve on the intake manifold, inter-linked with the fuel injection pump by manifold vacuum control. A specially designed intake directs the air into the cylinder, and imparts to it a turbulent rotary movement.

Compression Stroke: The intake valve closes, the piston moves upward, and compresses air into the cylinder to about the same pressure as in a modern gasoline engine. Near the end of this stroke, a measured quantity of fuel oil is finely atomized while it is forcibly injected into the rotating air stream where the fuel mist intimately mixes with the air.

Power Stroke: Near the moment when the piston reaches the top of its stroke, the spark plug ignites the fuel-air mixture. The features of this engine make it possible to keep the mixture ratio in the zone surrounding the spark plug, always within the limits necessary for prompt and thorough combustion, independent of engine load or speed. Combustion of the mixture delivers the power on the downward stroke. The explosion pressures during combustion are about the same as in a gasoline engine.

Exhaust Stroke: Near the end of the power stroke, the exhaust valve opens, and, with the piston moving upwards again, the burned gases are forced out. The whole series of operations is then repeated.

REMOVING CYLINDER HEADS

When valve grinding is necessary, the removal of the cylinder head of all valve-in-head engines is most easily done if the spark plugs and nozzles, as well as the top water manifold and the rocker arm assembly with its shafts and supports are first dismounted.

This will permit easy withdrawal of the long push rods and make the cylinder head nuts readily accessible. In replacing the cylinder head, be sure to follow the method described below and Figure 4, and **make certain the oil line to the rocker arm shaft is clean and free from dirt, and is secured tightly in place.**

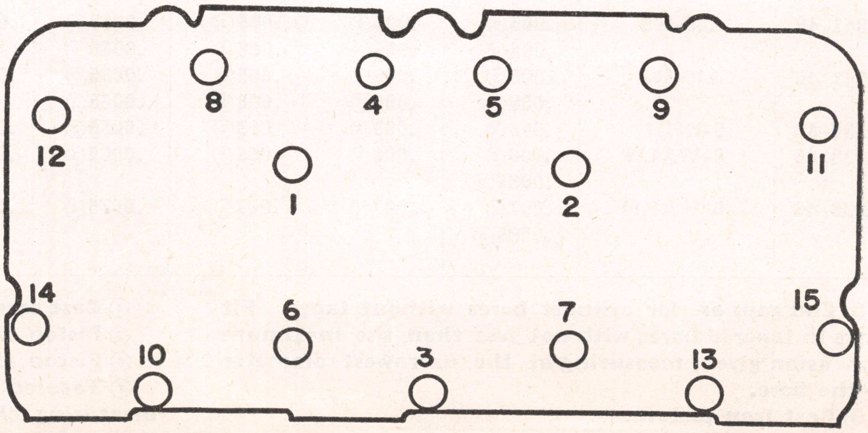


Fig. 4. Typical cylinder head layout. Tighten nuts in order shown.

REPLACING CYLINDER HEAD

Cylinder heads should be tightened down by starting from the center, working outward toward the sides and to the ends. A typical cylinder head layout is illustrated (See Fig. 4). Draw down the studs evenly and repeat the operation until all are normally tight. After the engine has been run sufficiently long to bring all the parts to normal operating temperature, a final tightening should be made.

NOTE—When using a torque indicating wrench, the final tightening should be within the torque values recommended by the wrench manufacturer. If two torque values are shown, use the lower limit for clean and oily threads; and the high limit for clean and dry threads. In any case, the threads should be free from rust or dirt, otherwise a false reading will be obtained due to the increased friction. When the final tightening is made, check the valve tappet clearance according to the recommendations given in the VALVE SYSTEM table.

NOTE—All the following service information applies to all engines unless otherwise stated.

ROCKER ARMS & PUSH RODS

On any overhead valve engine, it is good practice to remove the push rods before taking off the cylinder head to prevent the push rods from bending or twisting. Likewise, when installing the head, replace the push rods after the head is in place.

Whenever the rocker shaft is disassembled, place all parts on the bench in their relative position to assure correct assembly. And before assembling the rocker arms, be sure the faces are free from pits or rough spots, otherwise it will be difficult to maintain the proper tappet clearance.

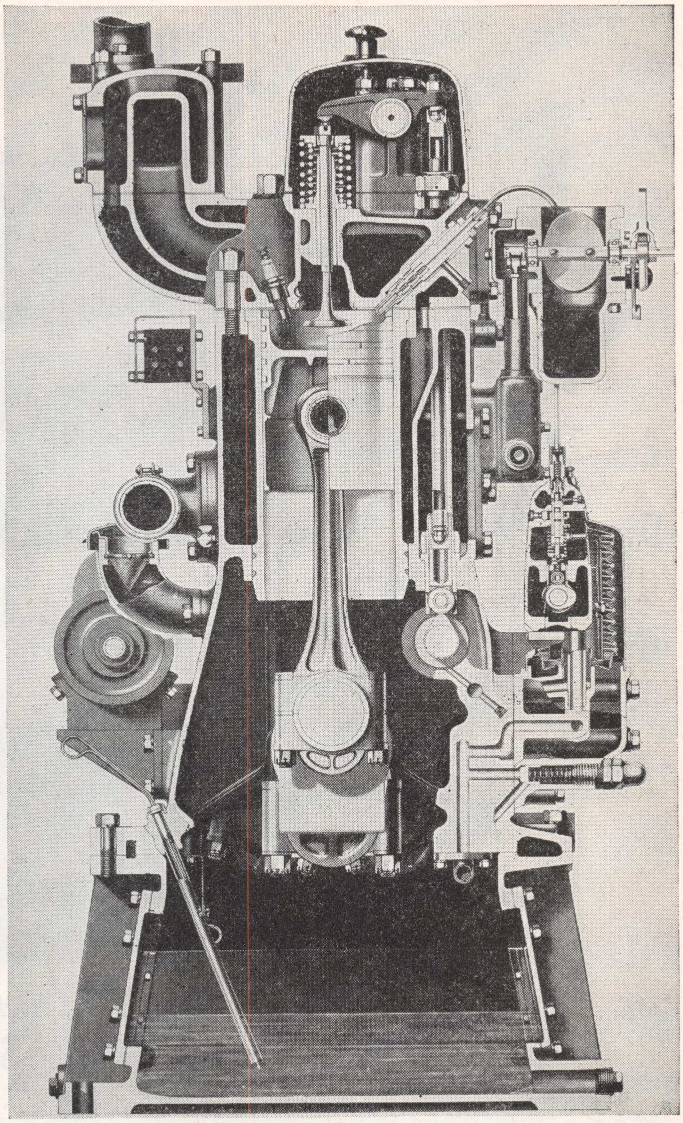


Fig. 1. End sectional view of typical engine.

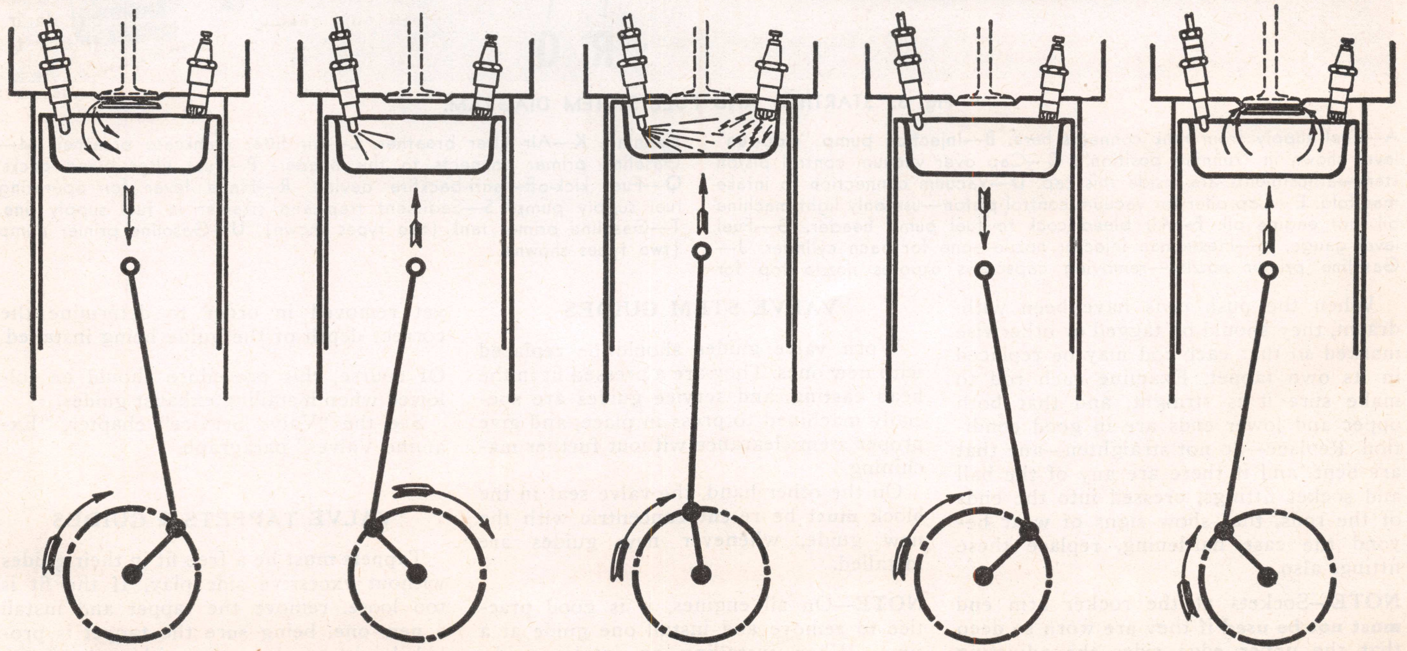


Fig. 2. Diagram showing the steps in the operation of the Hesselman working cycle. From left to right: Intake, Compression, Injection and Ignition, Power, and Exhaust.

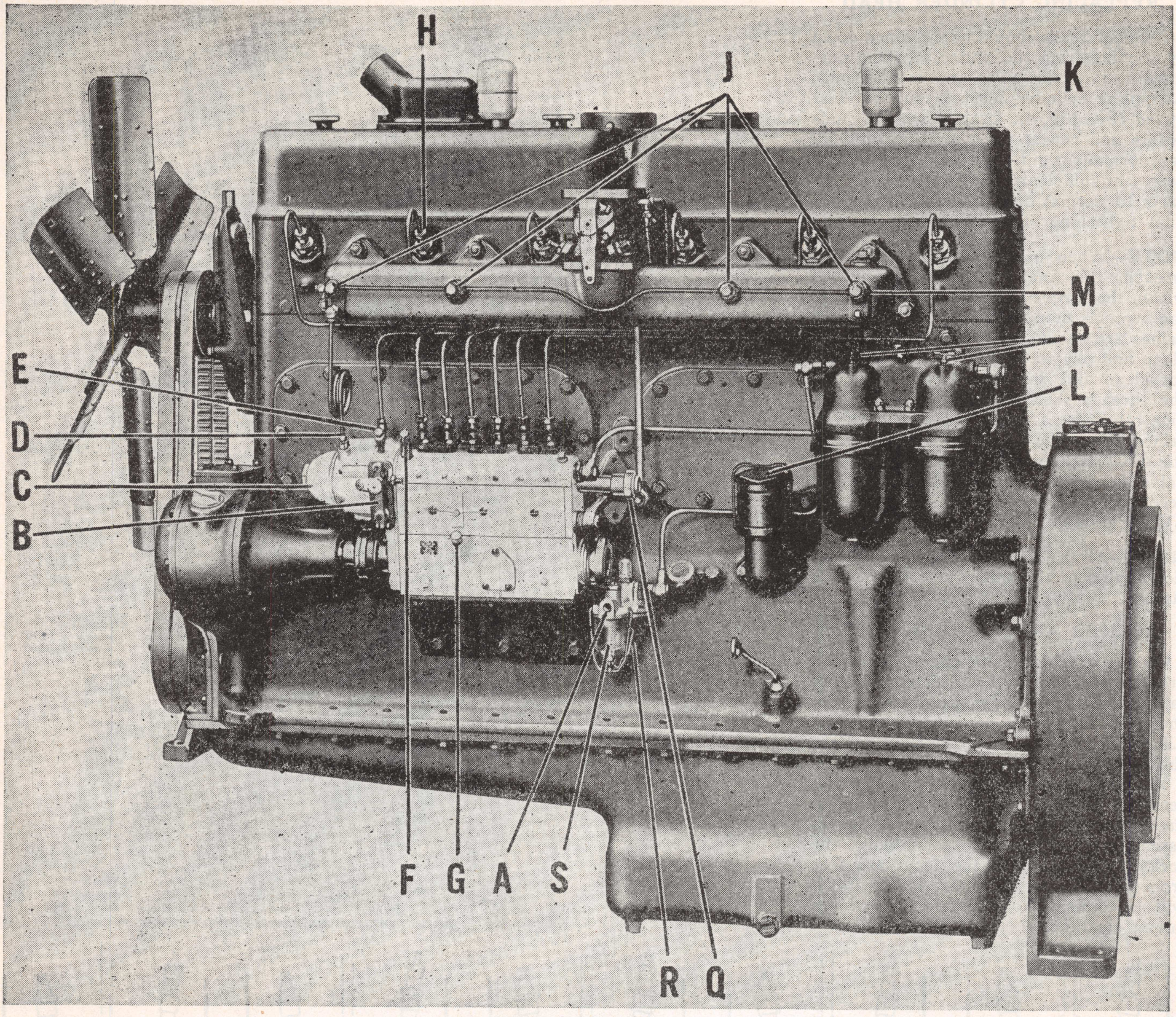


Fig. 3. STARTING AND FUEL SYSTEM DIAGRAM.

A—Fuel supply from tank connects here. **B**—Injection pump "stop-run" lever shown in "running position". **C**—Cap over vacuum control piston stem—adjustments are inside this cap. **D**—Vacuum connection to intake manifold. **E**—Cap oiler for vacuum control piston—use only light machine oil, not engine oil. **F**—Air bleed cock to fuel pump header. **G**—Fuel level gauge. **H**—Hesselman injector nozzle—one for each cylinder. **J**—Gasoline primer nozzles—removing capscrews exposes nozzle top for cleaning. **K**—Air filter breather. **L**—Air filter crankcase breather. **M**—Gasoline primer connects to this header. **P**—Fuel filter bleed cocks. **Q**—Fuel kick-off—anti-backfire device. **R**—Hand lever for operating fuel supply pump. **S**—Sediment trap and strainer in fuel supply line. **T**—Gasoline primer tank (two types shown). **U**—Gasoline primer pump (two types shown).

When the push rods have been withdrawn, they should be tagged or otherwise marked so that each rod may be replaced in its own tappet. Examine each rod to make sure it is straight, and that both upper and lower ends are in good condition. Replace—do not straighten—any that are bent, and if there are any of the ball and socket fittings, pressed into the ends of the rods, that show signs of wear beyond the case hardening, replace these fittings also.

NOTE—Sockets at the rocker arm end **must not be used** if they are worn so deep that the upper edge rides the adjusting lock nut or the rocker arm at any point.

VALVE STEM GUIDES

Worn valve guides should be replaced with new ones. They are a pressed fit in the head casting, and service guides are specially machined to press in place, and give proper stem clearance without further machining.

On the other hand, the valve seat in the block **must** be re-cut concentric with the new guide, whenever new guides are installed.

NOTE—On all engines, it is good practice to remove and install one guide at a time. When installing an intake guide, measure the depth of an intake guide not yet removed in order to determine the correct depth of the guide being installed.

Of course, this procedure should be followed when installing exhaust guides.

See the "Valve Service" chapter, "Examine Valves" paragraph.

VALVE TAPPETS & GUIDES

Tappets must be a free fit in their guides without excessive side play. If the fit is too loose, remove the tappet and install a new one, being sure the tappet is provided with a clearance within the limits given in the VALVE SYSTEM table.

VALVE SERVICE

Testing Valves: Read chapter "Starting the Engine," paragraph 11, relative to flooding the engine before making any tests that require cranking of the engine. To secure the best power and economy, and to avoid missing and overheating, the valves should always seat fully, and hold a charge so that the hand crank will bounce back or "rock" as the engine is turned over. If the engine fails to offer added resistance to the crank on the compression stroke, the leakage can generally be heard as a hiss. If it comes most distinctly through the intake, the intake valve is leaking; or if most distinctly through the exhaust, the exhaust valve is leaking; or if through the breather, the leak is past the pistons and rings. Leaks at the spark plugs and injector nozzle can be seen while the engine is running. If any of the valves leak, they should all be inspected and reground. A leaking intake valve will unbalance the vacuum control system. See "Vacuum Control Unit."

Valve Spring Retainers: The end of each valve stem is fitted with a shallow steel cup that surrounds the end of the valve spring, and is held to the stem either by a pair of wedge blocks or a thread and locking pin. The locking device must be removed before the valve can be withdrawn. To release the lock from the recess in the spring retainer, it is only necessary to push the retainer down against the spring until the blocks fall away from the valve stem.

With the screw type retainer, withdraw the pin from the valve stem, and unscrew the retainer nut. Weak or cocked springs should be discarded and new ones installed when **re-assembling.**

Examine Valves: Upon removing each valve, examine it carefully. Remove all carbon and burned oil, and check the valve stem and its fit in the guide. Excessive wear in either the stem or guide will make it impossible to secure a tight seat by grinding unless the valve or guide, and possibly both, are replaced.

IMPORTANT—Special notice of the exhaust valve guide and valve stem shoulder should be taken to make sure the guide does not project into the valve gas passage, and that the shoulder on the valve stem is sharp. This shoulder should be 1/32" to 1/16" below the top of the valve guide when the valve is seated. Thus, any accumulation of carbon around the guide and stem will be sheared off each time the valve is lifted, and in this way prevent valve sticking.

Grinding Equipment: While the usual hand grinding methods and equipment may be used, the job may be done much quicker and better, if mechanical grinding equipment is used. The accuracy of the machine method depends entirely upon the condition of the valve guide and the pilot mandrel's fit, both in the guide itself, and the hub of the grinder stone. It is vitally important, therefore, to make sure that the mandrel is a snug push fit in the valve guide, and will not wobble at the upper end. If it does have any upper-end movement, the seat will not be ground true. Guides that are worn too much to give the mandrel solid support should be replaced before grinding is attempted. The maker's instructions for dressing the grinding wheel **must** be followed to secure smooth, accurate seats.

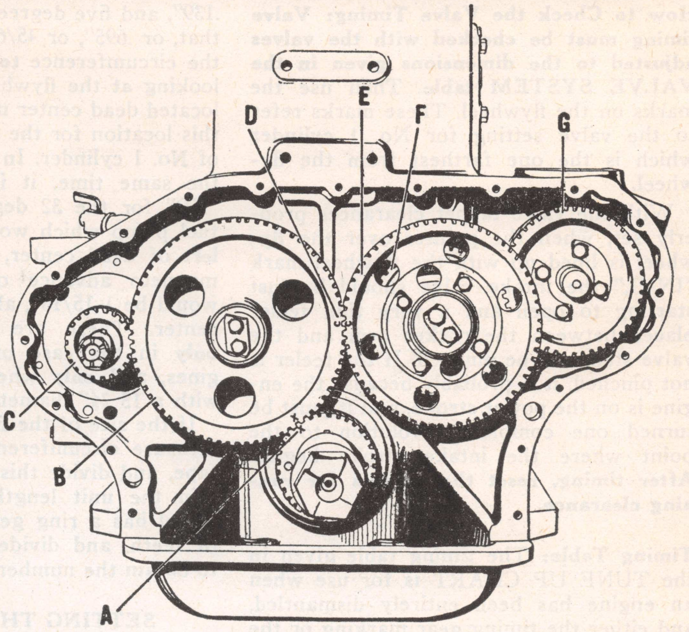


Fig. 5—TIMING GEARS.

A—Crankshaft gear with timing mark "X". B—Idler gear with timing mark "X". C—Magneto and water pump gear. D—Idler gear with timing mark "C". E — Camshaft gear meshed with idler at mark "C". F—Fuel pump drive which is bolted to rear of camshaft gear. G—Fuel pump gear.

Valve Grinding: If machine grinding equipment for both valves and seats is not immediately at hand, it will often save time, and money, as well as doing a better job if the head and valve assembly are sent to a local specialist. Even if hand grinding is employed, the **valve stems and guides must be a good fit** without wobble to insure a concentric seat, and a good tight, valve.

If the hand grinding method is used, clean the valve and its seat occasionally to see how the grinding is progressing. When all pits and grooves have disappeared, clean the valve and valve seat, and place eight or ten equally spaced marks with a soft lead pencil on the seat. Then drop the valve in place, give it a quarter turn, and remove it. A perfect seat will be indicated if every pencil mark shows where the valve has rubbed. If any pencil marks are left untouched, continue the grinding.

When the grinding is completed, check the valve seat for concentricity with a dial indicator, then oil the valve stem, clean all traces of the grinding compound from the valve chamber and ports, and **re-assemble each valve in its own opening.**

TAPPET CLEARANCE

The adjustable valve tappets are screwed into one end of the valve rocker arm. **Intake rocker arms are not interchangeable** with exhaust rockers; intake rocker arms have no oil groove leading oil to the valve stem, and **none should be made.** Refer to the VALVE SYSTEM table for the proper valve tappet clearance. Add .002" to the dimensions given for the first 10 hours of operation after a regrind job. **This must be done without fail to avoid valve burning.**

Tappet clearance dimensions are for valve setting at room temperatures, and **not** after the engine is hot. If the valves have **any** clearance at all when the engine is hot, the valves are seating. **Never attempt to adjust the tappets without first releasing the lock nut.**

IMPORTANT—Do not neglect to connect the oil lead to the rocker arm shaft. Test it to be sure it is not clogged.

VALVE TIMING

Timing in General: All engines have spiral cut timing gears which operate in a continuous bath of oil, and drive the camshaft, the magneto shaft, and the fuel pump. On both four and six-cylinder engines, the camshaft and fuel pump run at one-half engine speed. On four-cylinder engines, the magneto and water pump run at engine speed if they are driven in tandem, while six-cylinder magnetos run at 1½ times engine speed.

Figure 5 shows a typical gear train in the front with crankshaft pinion, A, idler gear, B, magneto and water pump pinion. C, and camshaft gear, E. The gears, F. and G, are the injection pump drive. These gears are all marked so that when they are removed, they may be replaced in proper timing relation without difficulty.

The crankshaft has a mark "X" on the face opposite the tooth which meshes in the **space** marked "X" on the idler gear. One other mark on the idler opposite a **space** is "C" which indicates the space into which the camshaft gear tooth with a corresponding mark is fitted.

The fuel pump and magneto drive gears are not marked, because both are fully adjustable for timing by their couplings.

How to Check the Valve Timing: Valve timing must be checked with the valves adjusted to the dimensions given in the VALVE SYSTEM table. Then use the marks on the flywheel. These marks refer to the valve setting for No. 1 cylinder which is the one farthest from the flywheel.

With the valve tappet clearances properly set, when the pointer over the flywheel is lined up with the flywheel mark "IN-O," the intake valve should be just starting to open and a very thin feeler placed between the rocker arm and the valve stem will be pinched. If the feeler is not pinched, it is probably because the engine is on the power stroke, and it must be turned one complete revolution to the point where the intake stroke begins. **After timing, reset the tappets for running clearance.**

Timing Table: The timing table given in the TUNE UP CHART is for use when an engine has been entirely dismantled, and either the timing gear marking or the flywheel marks have been obliterated. Under these conditions, first determine, from the nameplate on the engine, the model and type, and select the corresponding data, ignoring the others.

For example, if the engine is a model 6-BKH, the timing data which applies is given in the line opposite that model in the table and the camshaft should be set to open the intake valve of No. 1 cylinder five degrees on the flywheel, after top dead center.

Finding Dead Center: To determine the point of intake opening, the cylinder head must be off, and top dead center must be located first. With the cylinder head off, revolve the crankshaft until the piston has descended exactly one inch in the cylinder. In this position, make a mark on the flywheel opposite some fixed point on the crankcase. Now, rotate the engine in the opposite direction until the piston has descended again in the cylinder exactly one inch, and make another mark on the flywheel opposite the same fixed point. Halfway between these two marks, as measured by a tape line laid on the circumference of the wheel between them, is top dead center. Make a permanent mark with a prick punch or chisel to locate this point.

Locating Timing Points on the Flywheel: Continuing with consideration of the 6-BKH engine, to locate the position of the flywheel when the intake valve begins to open, a point must be found on the flywheel rim five degrees after top dead center. **Using the same fixed reference point on the cylinder block,** the simplest way to do this is to lay the tape line around the circumference on the wheel, and measure the length around it accurately. Should this dimension be 49⅞" (this is the size for one of the standard flywheels on the 6-BKH engine), one degree would be the equivalent of 1/360 of this distance or .139", and five degrees would be five times that, or .695", or 45/64". Lay off 45/64" on the circumference **to the right,** as viewed looking at the flywheel, of the previously located dead center mark, and prick punch this location for the opening of the intake of No. 1 cylinder. In the same way and at the same time, it is advisable to mark "FP" for the 32 degrees advance of the fuel pump which would be 4-7/16" to the **left** of dead center, and "MAG" for the magneto advance of 14 degrees which would be 1-15/16", also to the **left** of dead center. These are definite instructions **only** in the case of Medel 6-BKH engines, and **only** when they are equipped with a 15 ⅞" diameter flywheel.

If the size of the flywheel is not known, measure circumference accurately with a tape, and divide this length by 360 to obtain the unit length per degree. If the wheel has a ring gear, count the number of teeth, and divide 360 by this number to obtain the number of degrees per tooth.

SETTING THE CAMSHAFT

Before the camshaft setting can be checked, it is necessary to replace the cylinder head as already described and adjust the valves to the base circle clearance as given in the VALVE SYSTEM table. When this has been done, set the flywheel on the mark for the opening of the intake, and move the camshaft so that the cam gear is meshed with the idler, and with the intake cam just ready to lift the tappet.

Insert a very thin feeler between the tappet and the valve stem, and crank the engine slowly, observing if the feeler is pinched promptly. If it is not, change the position of the camshaft by one tooth, and repeat the operation.

When the proper tooth has been located, move the flywheel back again to top dead center and mark the teeth on the crankshaft pinion on either side of the meshing tooth on the idler gear, the idler gear meshing tooth itself, and similarly, the cam gear tooth, and its mesh with the idler gear. Reset tappets for running clearance as given in the VALVE SYSTEM table.

SETTING FUEL PUMP AND MAGNETO GEARS

Since the drive couplings for fuel pumps and magnetos are all fully adjustable for 360 degrees of rotation, the timing gears for these units may be installed in any position at random and the timing set at the coupling.

CAMSHAFT & BEARINGS

Camshaft end thrust is usually controlled by a steel thrust plate bolted to the cylinder block behind the camshaft gear. End play should be held within from .002" to .005" and can be checked by forcing the shaft back to the limit of its end play and inserting a feeler gauge between the thrust plate and the front end of the camshaft.

When necessary to replace bearings, they should be installed in sets and line reamed to provide a clearance within the limits given in the ENGINE BEARING SPECIFICATIONS table.

NOTE—Be sure that the oil passage holes are clean and open, and that the oil holes in the bearings are in line with the oil passage hole in the crankcase.

PISTONS & RODS, REMOVE

Piston and rod assemblies are removed from the top of the block. Although regular production rods are marked with the cylinder number in which they are installed, replacement rods are not; therefore, unmarked rods should be suitably identified with punch marks, as removed.

PISTONS, RENEW

When cylinder sleeves and pistons are ordered at the same time, they will be properly matched and no fitting is required, but when pistons alone are ordered either in the rough for local fitting or to fit reground sleeves, it will be necessary to fit the pistons on the job. From the PISTON & RING CLEARANCES table, it will be noticed that there are two kinds of material used, cast iron and aluminum, and that they may be either round or camground.

With cam-ground pistons, the sides which take the thrust from the connecting rod against the cylinder wall have the largest diameter, and are the points at which the clearance measurements should be checked. Use a ½ inch feeler strip 10 inches long of the thickness specified in the above-mentioned table for the particular model in question; lay it along the cylinder bore on one side and push the piston into the cylinder. A correct fit is obtained when the piston is a nice push fit with the feeler in place. A hard push fit is too tight, and if the weight of the piston will drop it through the cylinder it is too loose.

NOTE—A variation of 10 degrees between the temperature of the pistons and cylinder bores is sufficient to produce a difference of .0005". Therefore, both the pistons and cylinder bores should be at normal room temperature (about 70 degrees) when fitting pistons.

Before any attempt is made to fit new pistons, cylinder bores should be carefully indicated and refinished. If the bores do not require refinishing, be sure to remove the ridge at the top of each bore. If refinishing is required, it is good practice to do so in alternate cylinders due to the localized temperature build-up. When refinished, cylinder bores should not be out-of-round or tapered more than .0005".

Before fitting pistons, wipe the cylinder walls and pistons to remove all chips, dirt or other foreign matter.

After assembling the piston to the connecting rod, check the assembly for alignment on a suitable jig.

PISTON RINGS, RENEW

NOTE—To prevent the possibility of bending or breaking the second ring land—thus ruining the piston—the ridge at the top of the clyinder bore should be carefully cut away before removing the piston and rod assemblies. If the available ridge reamer has no provision to control the depth of the cut, it is good practice to bring the piston far enough up into the cylinder bore to allow the reamer to rest on top of a block of wood placed on top of the piston. This will serve to prevent cutting down into the ring travel. Never cut down into the ring travel area more than 1/32"—or more than half the depth of the top ring.

New rings should be fitted with end gaps and groove clearances as given in the PISTON & RING CLEARANCES table. Ring grooves must be clean and free from carbon, and must show no perceptible wear. Always abide by the instructions accompanying each set of rings.

When rings are property fitted to the pistons, be sure to stagger the ring gaps so they are spaced equal distances around the circumference of the piston, yet having no gaps over the piston pins.

Fitting Piston Rings to Cylinders: There are two important dimensions to be maintained in fitting piston rings: the gap between the ends when the ring is compressed to the cylinder diameter, and the fit in the groove of the piston itself. The above-mentioned table gives the desired fits for all Hesselman engines. To fit a Hesselman piston ring, first slip a piston without the rings into the cylinder so that the top is about an inch below the top of the cylinder, and then place the ring to be fitted into the cylinder and press it against the top of the piston. This insures the ring being square with the bore so that a true measurement of the gap between the ends of the ring can be made. If the ring is even slightly cocked in the bore, the apparent gap measurement will be smaller than it really is.

Measure the gap with feeler gauges, and if it is too small, use a fine file, and take off a small amount on one of the ring tips until it gauges within the limits given in the table. A gap smaller than the low limit given will cause ring seizure and cylinder scoring, while a gap larger than the high limit will cause excessive blow-by, dilution, and sometimes scuffing.

Fitting Rings to Pistons: Hesselman engines are fitted with tapered side piston rings that fit in tapered ring grooves on the piston. This is an exclusive development of the Waukesha Laboratories which reduces to a minimum the sticking, and scuffing so common with oil engines having conventional straight side rings.

After each ring has been fitted to its own cylinder, it should fit properly in its groove.

Place the rings on the pistons, and check the dimension between arrows, Figure 6, by pressing the ring into the groove at one point only—not all around—and see that it can be buried below the adjacent lands at least as deep as the minimum dimension given in the table for the model in question. Try it at four spots around the piston to make sure the ring can move freely at all points. When wear increases this dimension to such an extent that the top limit given in the table is exceeded by .002", the rings should be replaced.

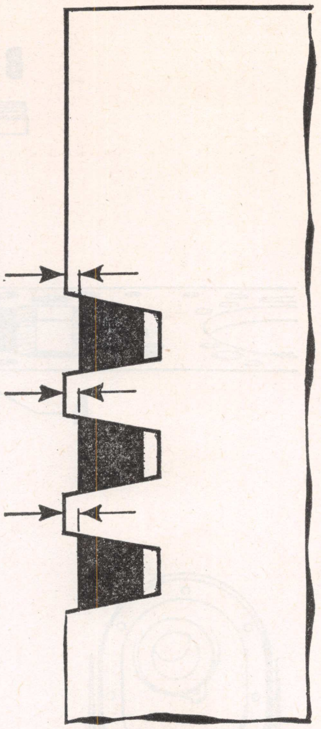


Fig. 6. Check groove clearance of tapered rings between arrows as shown.

Do not mix up rings that have been fitted to one piston and cylinder—they will not run smoothly in any but their own place.

PISTON PINS, RENEW

The correct fit of piston pins in cast iron pistons should be one which requires a light push with the palm of the hand to insert the pin. For aluminum pistons, at normal room temperature, it should require a hard push with the palm of the hand to install the pin. However, to facilitate fitting pins in aluminum pistons, heat the piston in boiling water for a few minutes, after which the pin should enter the piston easily.

To check the fit of pins after installation, hold the piston in both hands and, for aluminum pistons, the weight of the rod should not be sufficient to allow it to fall. When using the same method on cast iron pistons, the rod should drop easily by its own weight.

PISTON PIN BUSHINGS, RENEW

New bushings should be pressed in place and reamed to provide a light push fit of the pin with the parts at normal room temperature.

CYLINDER SLEEVES, RENEW

All automotive engines, except model 6-BKH, have removable wet sleeve cylinder liners. The top of the sleeve is held tightly to its seat around its entire circumference and sealed by the head and head gasket at the top, while one or more rubber packing rings fitted in recessed grooves at the bottom of the water jacket, keep the lower end tight and permit longitudinal expansion as required.

To remove the sleeve, simply insert a long bolt with a cross bar at the bottom and another at the top, supporting the latter on two blocks, as shown in Figure 9. Tightening the top nut will release the sleeve, as shown. Be sure that the two blocks supporting the top bar are long enough to be supported across the entire width of the cylinder block.

When replacing the sleeve, remove the old rubber packing rings at the bottom. and insert new ones each time, taking care that none of the old ring falls into the crankcase to clog the oiling system.

The best sealing ring lubricant for pressing the cylinder and rings into the case is ordinary liquid carriage soap. Oil will disintegrate the rubber.

Cylinder Sleeve Sealing Rings: At the base of the water jacket in the cylinder block, opposite each cylinder, there are tell-tale holes which indicate the condition of the rubber sealing rings at the bottom of each cylinder sleeve. When water drips from one of these holes, it is a sign that water is seeping past the ring. Rings can be replaced in the manner described above.

MAIN & ROD BEARINGS

Bearing Looseness: In general, any bearing that is loose will cause an abnormal knock that increases with use. The heavier the thump, the greater the need for prompt attention.

Locating Loose Bearings: A loose connecting rod bearing may be located by running the engine briskly, and then closing the throttle. If any connecting rod bearing is loose, it will rattle as the engine speed decreases. A knock in the main bearing is harder to locate, and after all other possible causes of the knock have been investigated and eliminated, remove the spark plugs to prevent the engine's rocking over on compression and injuring your hand, and remove either the oil pan or the inspection plate as shown in Figure 7, and try the adjustment of the main bearings.

Special Diesel Oils Affect Some Bearings: Special "Diesel lubricants," though not essential, may be found helpful in keeping down sludge and carbon but the **seller** should take **full responsibility** for their safe use. In some model 6-BKH and 6-WAKH engines, silver-cadmium or lead-bronze bearings are employed. These non-babbitt alloys are attacked by some of these special oils so that the user should be cautious in selecting a safe lubricant if this type is to be used. Never use **any** oil

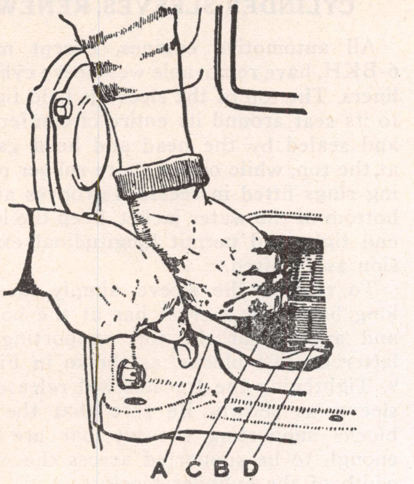


Fig. 7. Method of testing connecting rod bearings through hand hole covers on large engines. A—Pry bar. B—Fulcrum point on case. C—Fingers overlap rod end and crank cheek. D—Connecting rod lower end.

of lower viscosity than recommended by the manufacturer.

Precision Bearings: Precision bearings are used throughout most Hesselman engines. Some have light shims for take-up and some are not shimmed. Bearings without **shims** are **not** adjustable and when wear takes place, new shells **must be used.** These can be supplied to three standards for shaft sizes that are .020" undersize, .003" undersize, or standard size.

The micrometer dimensions of the shaft journal **must** be given when ordering so that the correct shells can be sent. Shimless precision bearings, correctly ordered as above will fit **without any filing, scraping or manipulation of either the cap or bushing.** To file, scrape or machine in **any** manner, the bearing, its seat, or the mating edges of either the cap or the shell **will ruin** it. No wholly inexperienced person should ever attempt so important an operation as bearing fitting. Figure 8 shows the two principal types of **bearings** used.

Replacing Bearings: Whenever non-shimmed precision bearings are to be replaced, be sure the face of the bearing seat is **absolutely** clean, and that no particles of grit or carbon are allowed to get between it and the back of the bearing shell. Many failures of new bearings within a short period of installation are due to carelessness in this respect.

Besides this precaution, whenever a bearing is opened and exposes any of the drilled oil passages or grooves, always flush them out with fuel oil or kerosene and compressed air. The tolerances in machining for precision bearings are so close that rods, caps, and shells will easily distort if they are roughly handled. For that reason, although each connecting rod **and** cap have corresponding numbers stamped on them to match them properly, these numbers are put on before the dia-

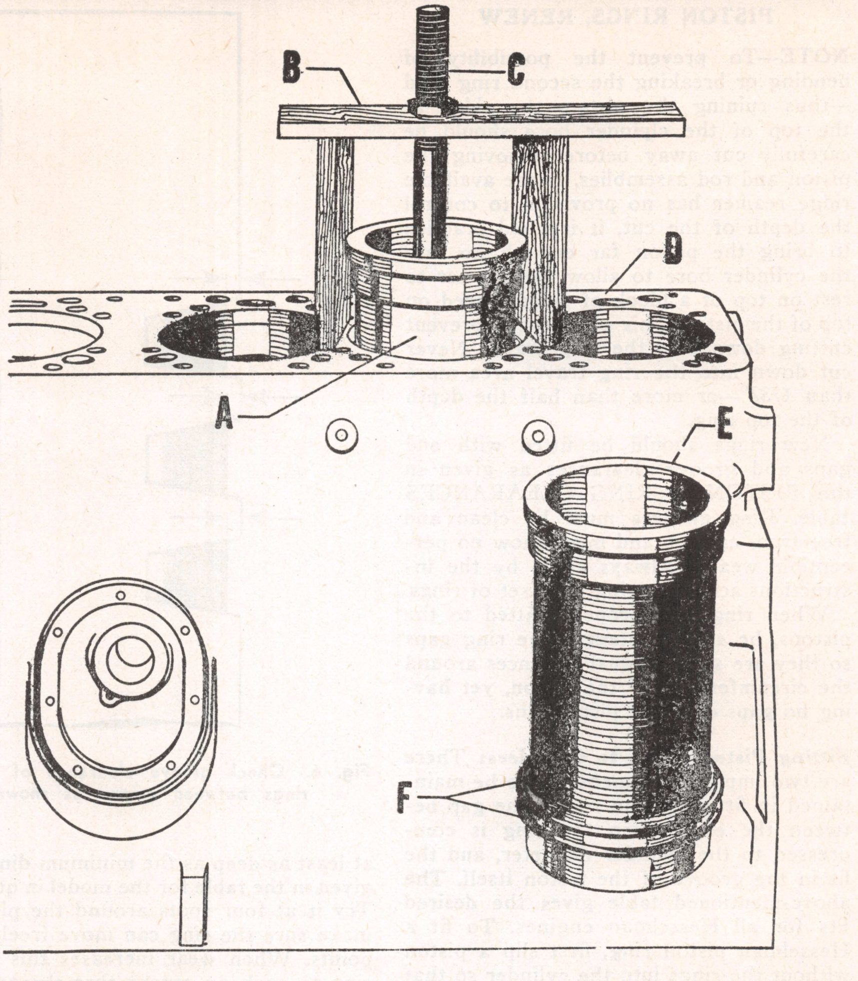


Fig. 9. REMOVING CYLINDER SLEEVES. A—Old sleeve being withdrawn. B—Blocking used as yoke for puller. C—Long stud with nut pulls sleeve when nut is screwed down. D—Water jacket and cylinder block. E—New sleeve. F—Rubber sealing rings.

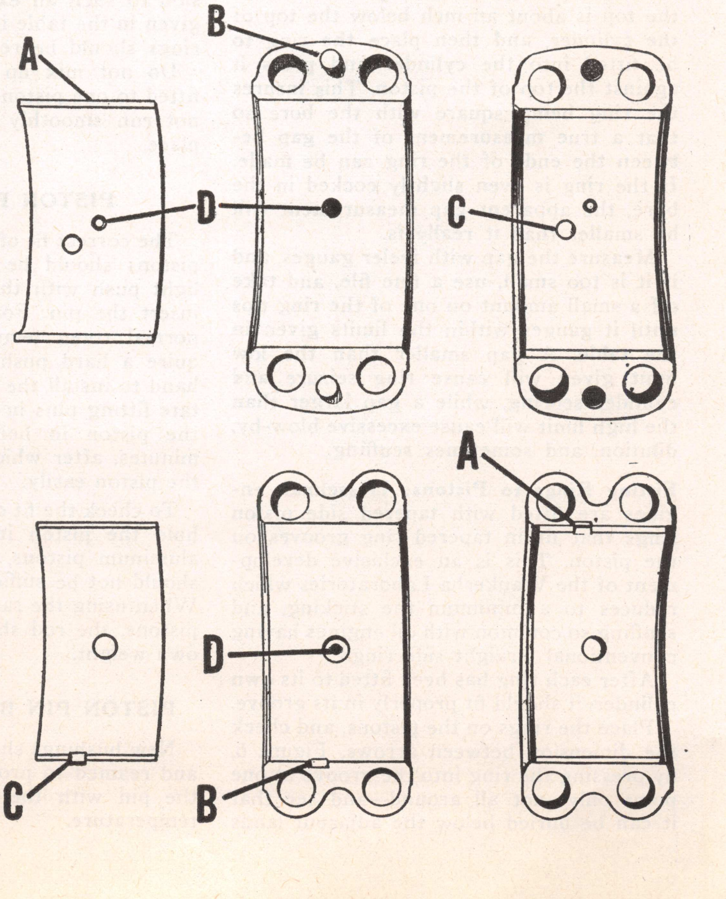


Fig. 8. SHOWING TWO TYPES OF PRECISION BEARINGS.

UPPER: Thick-walled bearing. A—Bearing shell. B—Dowel in upper half of rod. C—Dowel in cap fits dowel hole in bearing. D—Oil metering hole in bearing shell registers with rifle drilled oil passage in rod.

LOWER: Thin-walled bearing. A—Milled notch in cap with ear of bearing shell in place. B—Milled notch in upper half of connecting rod. C—Small ear in bearing shell which fits milled slot "B". D—Metering plug which fits rifle drilled oil passage in rod.

mond boring to prevent distortion or misalignment that might occur if they were stamped after machining. Rod and cap numbers do **not** correspond with the cylinder numbers in any given engine, nor are they on one side—the camshaft side for instance—only, so that the service operator must keep track of each rod as it is removed to make sure it is put back into its own cylinder, and facing the same way as originally.

In the case of main bearings, the same principles apply—clean seats and shells, clean and flush all exposed oil passages in shaft and case, handle caps and shells with respect, replace each cap properly with its mating seat. **Never use old caps with new cases or new rods.**

Shimmed Precision Bearings: Although it is not generally done, there are some special cases where precision rod bearings are fitted with shims to permit a small amount of take-up. In engines so fitted, it will be observed that the shims do **not** extend into the bearing shell itself, but are clamped **only between the cap and the rod itself.**

In the precision machining of the rod, the cap and shims are assembled with the rod, and the bearing seat is diamond-bored and ground to exact size with the shims in place so that the mating edges of the precision shells will have the exact "crush fit" required to seat perfectly.

Whenever a shim thickness is removed (remove the same amount from each side to avoid cocking the cap) it will be necessary to face the mating edges of the bearing shell by the **exact** amount of shim stock which is taken out. The shim is laminated and built up of .002" thicknesses.

Fitting Bearings: Bearings of the precision insert type should be replaced in sets and under no circumstances should any attempt be made to file, alter or otherwise mutilate the bearing caps to obtain proper bearing fit. If the bearing design does not provide for shims, under no circumstances should they be installed in an attempt to obtain a bearing fit, because the proper "crush" fit in the bearing bores will not be obtained. Similarly, if the bearing design calls for the use of shims, and if the shims are eliminated, the bearings will buckle when the cap bolts are tightened.

It is good practice to measure the thickness of shims (if used) and when replacing bearings, do not install more than this thickness. To reduce bearing clearance, however, a .001" shim may be removed. Use care to see that these shims do not project between the edges of the bearing shells because they will cause the bearings to buckle when the cap bolts are tightened.

When this type bearing becomes worn, replacement can be accomplished without removing the crankshaft in the following manner: Remove the bearing cap and take out the worn lower shell. A suitable tool can be made to remove the upper shell by using a cotter pin with the rounded end flattened to form a T shape. Insert the long end of the pin in the oil passage hole in the oil hole of the crankshaft and, by rotating the crankshaft in the reverse direction, the T-shaped head will contact the bearing and force it out.

To install, place a new upper shell on the crankshaft journal with the locating notch in the correct position, and rotate the shaft to turn the shell in place. Then install the lower shell in the cap and replace the cap, being sure the proper thickness shim pack (if used) is placed between the cap and support. Then tighten the cap bolts to the recommended torque tension which will be found in the ENGINE BEARING SPECIFICATIONS table.

To check the fit of new bearings, use a piece of brass shim stock ¼" wide, the length of which should be ¼" less than the length of the bearing, while the thickness should be about the same as the minimum allowable clearance.

CAUTION—To avoid damaging the bearing material, smooth down the edges of the shim stock to remove sharp edges or turned over corners. And before inserting this checking shim in place, it should be coated on both sides with a light film of engine oil.

Lay the checking shim lengthwise in the center of the bearing and install the bearing cap to the crankshaft, being sure the shim packs (if used) are properly placed between the cap and support. Then tighten the cap bolts to the recommended torque tension. Test the fit of the main bearing by rocking the crankshaft through an arc of 2"—not more than 1" in either direction. The bearing may be considered fitted properly if the shaft is movable with a fairly heavy drag.

When rod bearings are fitted properly, it should not be possible to move the rod endwise by hand, but a light tap with a hammer should cause the rod to move endwise. Then remove the shim and install the cap again, tightening the cap bolts with the torque wrench, after which, the rod should move endwise by hand. If the rod is too loose with the shim in place, the crankpin should be turned down and undersize bearings fitted.

NOTE—It is good practice to check the connecting rod bore for roundness. A special tool with an indicator gauge is available for this operation, and before using this instrument, be sure that there are no nicks, burrs or dirt on the contacting surfaces to prevent a true reading. If the rod bore is out-of-round more than .002" or .003", the rod should be replaced.

NOTE—Remove the checking shim (when fitting mains) and replace the cap, but do not tighten the cap bolts, as this bearing must be loose in order to check the fit of the other bearings. It is good practice to fit bearings by starting at the center—or one of the intermediates on a four-bearing job—then the rear bearing, the front, and finally, the intermediate.

Locking Precision Bearings: There are two types of locking device employed to prevent precision bearings from turning in their seats. Thick-walled bearings will have a dowel pin locating hole in the cap half which fits a dowel in the cap itself.

With thin-walled bearings, there is a milled notch in the parting edge of both the cap and the rod or case seat. The corresponding corners of the shell are slit and a small ear bent outwards which fits into the milled slot and holds each half from turning when the cap is pulled down.

Bearing Clearances and Torque Wrenches: Use a torque wrench for setting up bearing caps. Any good supply house can furnish one with a wide range of adjustments to suit all conditions. It is merely necessary to know the size of the bolts and nuts to be tightened and adjust the wrench as directed by the maker for that size. Bearing clearances are given in the ENGINE BEARING SPECIFICATIONS table for each model.

Oiling System Clean-Up: As bearing adjustment and replacement involves the removal and exposure of so much of the oiling system, it is recommended that a complete check-up of the latter be done at this time. Whenever possible, use a rifle brush, and poke through all drilled oil passages: in the crankcase, crankshaft, connecting rods, oil connecting tubing and other passages to remove the muck and carbon which forms much more rapidly in an oil engine than in a gasoline engine. These oil passages should receive particular attention:

1. Oil grooves and passages between bearing shell and bearing seat.
2. Drilled oil lead to main bearing from header—usually reached from the outside by removing a screw plug in the cross drilling.
3. Drilled oil lines in crankshaft.
4. Drilled oil lines and metering plug in connecting rods.
5. Oil return drilled in rear oil retainer plate.
6. Oil relief valve spill-over and header lead.
7. Oil line to pressure gauge—this often clogs.
8. Oil pump intake and scavenger screens.

NOTE—A good final check can be made by applying compressed air to each passage to clear it of any remaining loose carbon chips or other abrasives that may be present.

CRANKSHAFT END THRUST

Crankshaft end thrust is controlled by flanges on a bearing (see the ENGINE BEARING SPECIFICATIONS table for the bearing which takes the thrust and for the proper end play limits).

Through normal wear, the end play will seldom become excessive but, whenever new bearings are fitted, the clearance should be carefully checked and, if required, the bearing flanges may be dressed down to obtain the desired end play.

REAR MAIN BEARING OIL SEAL

Various methods of preventing oil leaks at the rear main bearing are used in these engines. On some engines, an oil slinger is used and surplus oil is returned to the oil pan through an oil passage and tube. Another installation is one which consists of a retainer in which packing is inserted, and whenever the engine is dismantled for repairs, new packing should be installed. If the rear main bearing support is provided with packing, there is usually an oil slinger, integral with the crankshaft, which deflects the major portion of oil into the groove of the bearing cap and support.

An examination of the engine being serviced will readily show which method is used to control oil leaks, and no difficulty should be met with if a reasonable amount of care is used when replacing packing.

ENGINE OILING

PROPER LUBRICATION

Some lubricating oils satisfactory for gasoline engines are not stable enough, having a tendency to form emulsion and sludge quickly, and in such quantities as to clog oil passages and filters, and stop the flow of oil in the lubricating system. The resulting damage and loss of time may be irreparable. Use oil that meets the requirements for the particular engine model to be supplied. Be sure to follow the recommended viscosities for the class of duty and temperatures.

If the "Oil Temperature Method" is used without any previous experience to guide you, start off with an oil of the average viscosity for your Engine Class, and by observing its maximum temperature after it is under load, you can make your future selections with exact knowledge.

The "Surrounding Air Temperature Method" may similarly be used for the initial trial period to obtain oil temperature data for future guidance. The chief consideration with winter oils is to use one with sufficient body to stand up after the engine warms up, and that is still light enough to permit cranking of the engine when it is dead cold.

Winter oils must have a cold test that will insure circulation at the surrounding temperatures. If the engine is only partly loaded and running intermittently, an oil one grade lighter than summer oil will usually be satisfactory.

Buy oil from only reputable oil companies who will guarantee that it has proved satisfactory in service tests for high speed Diesel or Hesselman engines. Cases are on record where engines using an inferior grade of crankcase oil had an oil consumption 5 times as large as when using a good brand of oil.

OIL COOLERS

Some engines of the larger series are supplied with oil coolers which consist of a tubular radiator core through which the oil passes from the pressure pump before it enters the distributing system. Around the outside of this oil radiator is passed the cooling water on its way to the water jackets of the engine. Whenever the oiling system is cleaned, this oil radiator should receive the same attention.

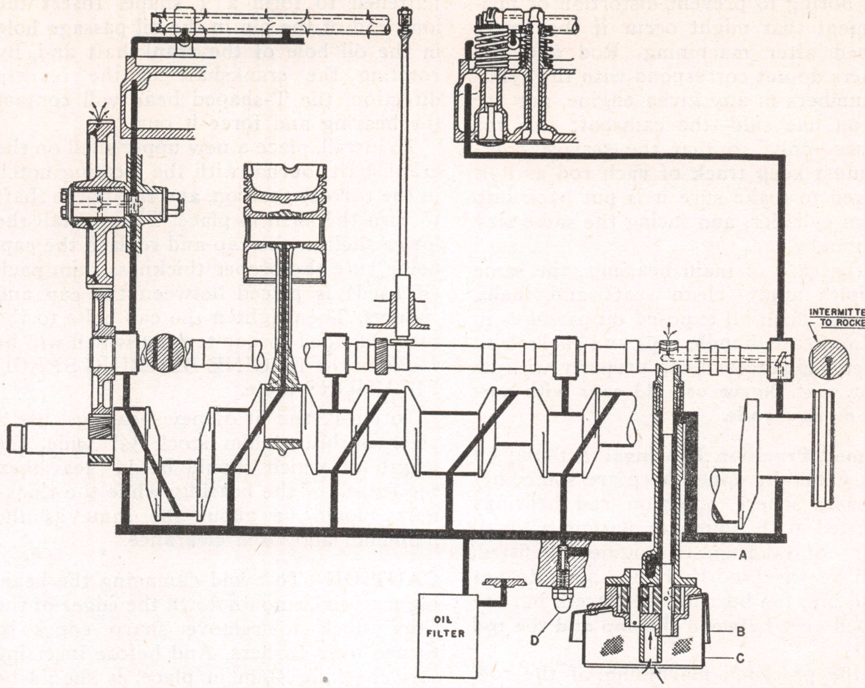


Fig. 10. Schematic diagram of full pressure oiling system. A—Oil pump. B—Oil level equalizer. C—Oil pump screen. D—Relief valve.

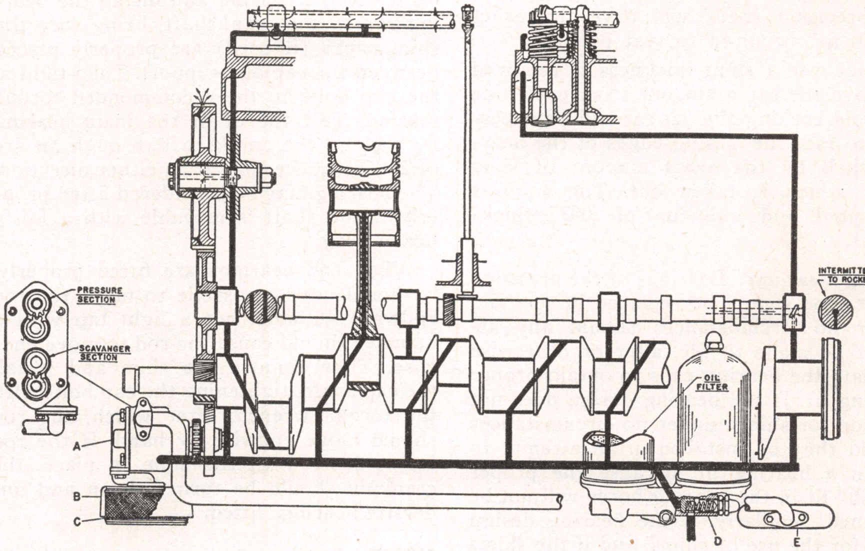


Fig. 11. Schematic diagram of full pressure oiling system with scavenger pump. A—Pump. B—Oil level equalizer. C—Oil pump screen. D—Relief valve. E—Scavenger intake screen.

Cleaning the Oil Cooler: The oil cooler should be cleaned at least every sixty hours of operation unless experience shows that it is required oftener. The sludge and gum deposit in the cooling element must be dissolved by benzol or coal tar naphtha —filling station naphthas or gasolines will not suit—by immersing the entire cooling element in a pail of the solvent. Proper cleaning fluids can be secured from paint, chemical, and drug supply houses.

Oil Cooler Cleaning Routine: Select a spot away from open flames or sparks to conduct the operation, as benzol or naphtha are highly explosive and dangerous to handle in a confined room.

Submerge the cooling element completely in the cleaning fluid for at least fifteen minutes. In doing this, be sure all the air is permitted to escape so that the fluid is in contact with every inside surface.

After the solvent has had an opportunity to work for fifteen minutes, connect a pressure gun to either the intake or the outlet of the element, and with the element still submerged in the solvent, pump it vigorously for several minutes to remove the dissolved material. The element should be submerged at this time in order to permit the solvent to flow back and forth under pressure.

Now, remove the pressure gun, drain the solvent out of the unit, blow out the oil passages with a 50-80 pound airline, but **do not put the full line pressure on the unit.**

Finally, to check the thoroughness with which the work has been done, again submerge the unit in a clean supply of benzol, connect the pressure pump, and give it a dozen vigorous strokes. If the unit is cleared, the solvent will simply have no further effect.

Reassembling the Unit: In reassembling the cooling unit, be sure that the gaskets between the unit and the case are both oil and water tight, and last, be sure the oil passages in the case casting are cleared and not obstructed by the gaskets.

OIL STRAINER SCREEN

The first strainer through which the lubricating oil passes is a 1/16 inch mesh brass screen which surrounds the intake of the lubricating oil pump. This prevents coarse particles of foreign matter from entering the pump gears. Surrounding the screen is an inverted cup, the lower edge of which extends below the screen level. This is known as the Oil Level Equalizer and prevents the pump from sucking air when the level of the oil is low, or when it is cold and stiff. It should always be in place after servicing operations, and the gasket which seals it on top must be air-tight.

OIL PUMP STRAINER SCREEN

As described above, the wire strainer screen surrounding the intake of the lubricating oil pump and scavenger intake may become stopped with carbon and sludge if it is not cleaned every time the lubricating oil is changed. In all engines, there are large hand holes or cover plates through which the strainer screens can be reached and removed. It is best to remove the screens entirely and allow them to stand in fuel oil or gasoline long enough to soften the carbon, which is usually hard and tough. A putty knife is the best tool for removing it. A blunt stick requires too much pressure and is likely to break through the screen itself while a sharp instrument might cut through. **Be sure to clean screens every time the oil is changed,** or oftener, if experience shows it to be necessary.

CRANKCASE DILUTION

Dilution of crankcase lubricating oil with fuel oil engines will invariably occur if the maximum fuel stop has been re-set to feed more fuel than the engine can consume. Otherwise it can usually be traced to thermostat failure and operating temperatures that are too cold, or to a fuel pump that is improperly timed and too early, or driven by a worn or loose coupling, and too late.

A magneto that is timed too late will also cause dilution as will fuels that have too high an end point. Change thermostats, or provide a radiator curtain if the temperature is too low. Then check fuel pump and magneto settings, as specified in the TUNE UP CHART. Check the spark plug gaps, and correct any tendency to miss, and try re-adjusting the fuel-air ratio to give a leaner mixture. Check injection pressures and renew ball checks, springs and seats if necessary. Finally, and after all other causes have been investigated, check the fuel transfer pump if it is of the diaphragm type—for if the diaphragm fails, fuel may flow directly into the crankcase.

OIL CHANGING

The lubricating oil is carried in the bottom of the crankcase. The quantity required to fill each standard engine is indicated in the first table of this chapter. Be sure to read the foot note of the table. The amount given in each case is for the oil pan only and does not include the quantity required to fill the entire system including the filters which should be cleaned and emptied every time oil is changed.

After changing oil and running the engine for half an hour, check the oil level and add the quantity needed to bring the level to the full mark on the gauge. Some of the larger engines have flat base oil pans which are baffled inside so that it may take a couple of minutes for the oil to reach its final level. Always give it time enough to fill the sump, and thus avoid a false indication on the bayonet gauge.

OIL PUMP

If the oil pressure drops to zero suddenly or fluctuates violently while the engine is under load, check the oil level and examine the condition of the oil. Oil that has been used too long will be thinned by dilution, which will cause the pressure to drop. If these conditions are not the cause, before taking down the oil pan and pump, check the oil gauge with another gauge known to be accurate. If the pressure continues to drop, remove and clean the oil pan thoroughly, and disassemble, clean and inspect the oil pump.

NOTE—Before taking down the oil pan, remove the protecting cap from the oil pressure regulator which is usually attached to the outside of the crankcase, and check to see that no dirt or foreign matter is lodged under the relief valve. If this is not the cause of the pressure drop, remove the oil pan and examine the oil lines to see that they are not broken.

Usually, the pump can easily be disassembled by taking off the upper drive gear and bottom cover, after which, the internal parts can readily be removed. Replace any gears which have an excessive amount of backlash. When assembling the pump, dip the gears in fresh engine oil as a means of priming the pump.

Clearance between the gears and cover may be checked by placing a steel scale across the face of the housing, and a feeler ribbon between the steel scale and gears. If the clearance is excessive, it may be reduced by grinding the lower face of the housing, using an abrasive compound evenly distributed on a perfectly flat surface.

CAUTION—Before replacing the oil pump and oil pan, the oil screen, oil tubes and lines should be thoroughly cleaned, being sure that all openings in the screen are free and clean. If the screen is crushed, it is better to replace it rather than attempt to make a repair.

OIL PRESSURE REGULATOR

Oil pressure is automatically controlled by a compression spring which controls the action of a relief valve. On some engines, the regulator is located on the right side of the crankcase, and on the left side on others. As a still further precaution against the possibility of abnormal pressure, some engines have an emergency relief valve incorporated in the pump body, which requires no service whatsoever.

Oil pressure should not be judged too high or too low until it is known whether the proper weight of oil is used, and the engine is warmed up to normal operating temperature.

As the engine bearings become worn, the oil pressure will be slightly lower, due to more oil escaping around the bearings. It is not advisable to try to correct this slight pressure loss by an adjustment of the pressure regulator, because the extra amount of oil being thrown off by the worn bearings is already over-oiling the cylinder walls.

If an adjustment is required, remove the protecting cap and turn the adjusting screw in (clockwise) to increase pressure and out (counter-clockwise) to decrease pressure.

SCAVENGER OIL PUMPS

Engines operating at extreme angles fore and aft are usually equipped with special oil pumps to prevent flooding the shallow end of the oil reservoir. Scavenger pumps are incorporated in the main pump driven from the front crankshaft pinion on model 6-WAKH, and as part of the main pump driven by spiral gears from the camshaft in models 145-HK, 145-HS, 140-HK, and 140-HS. Their action is entirely automatic, and no adjustment is required. **However, periodic cleaning of the screen surrounding the scavenger pump intake is very important and must not be neglected.**

CRANKCASE VENTILATOR

The crankcase ventilator breather should be inspected at least every 2,000 miles, and if a sludge formation is evident, remove

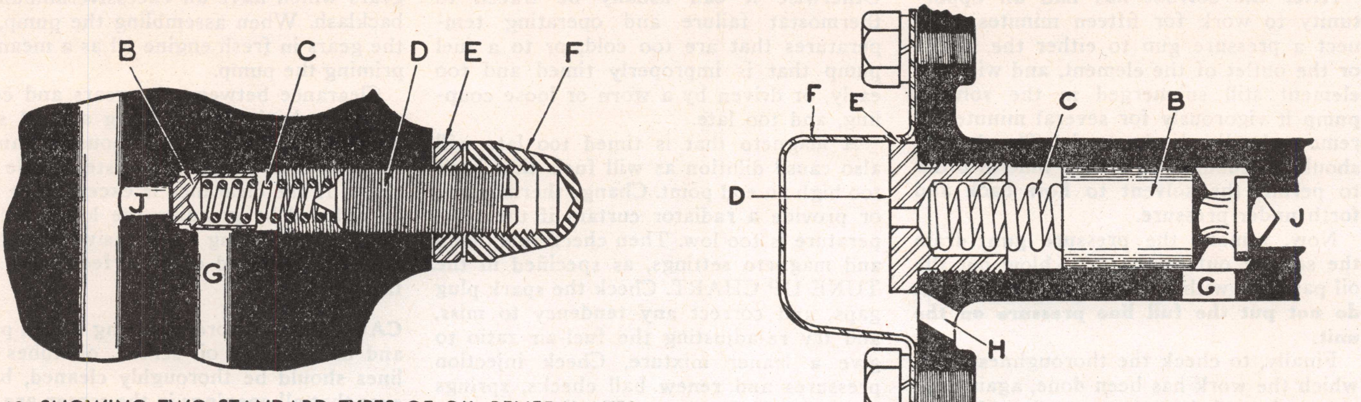


Fig. 12. SHOWING TWO STANDARD TYPES OF OIL RELIEF VALVES.

B—Plunger. C—Pressure control spring. D—Pressure adjusting screw. E—Adjusting screw lock. F—Protecting cap. G and H—Passages for overflow to crankcase when valve "B" opens. J—Oil pressure duct from main oil line.

the breather and clean it thoroughly in gasoline. Allow the breather to soak in the gasoline for about 30 minutes, then blow it out with compressed air, and at the same time, tap it lightly to dislodge any solid particles of sludge.

If the breather is fitted with an air cleaner, it should be removed and washed every 1,000 miles. After the element is washed, blow it dry with compressed air and, if the cleaner is of the oil-wetted type, dip the element in fresh engine oil before assembling. If it is of the oil bath type, wipe out the oil reservoir thoroughly with a clean cloth and fill it to the proper level with fresh engine oil.

NOTE—The interval at which the ventilator and air cleaner should be cleaned can only be determined by the type of service to which the vehicle is subjected. Vehicles operating in dusty or sandy areas require more frequent service than vehicles operating under more favorable conditions.

IMPORTANT—For vehicles operating in dust storm areas, the cleaner should be cleaned immediately after such storms occur.

OIL PRESSURE

The hot oil pressure at governed speed should register 25 pounds for VRZH engines and 40 pounds for all others. Oil pressure is controlled by an automatic spring-loaded relief valve built into the side of the crankcase in most models, but in the larger engines, it is part of the outside mounted oil pump or the oil filter base.

If the pressure drops suddenly or fluctuates violently, stop the engine and investigate. If the bayonet oil gauge shows the oil supply is adequate, it may be that it has been used too long and has deteriorated, or the strainer screen surrounding the oil pump intake is clogged with carbon.

The obvious remedy is to drain the crankcase, clean the oil pump strainer screen, and replace the old oil with new oil of the proper grade. If this does not correct the trouble, it is possible that dirt has lodged under the relief valve or an oil line is ruptured. In either case, the cause should be removed before starting the engine.

OIL FILTERS

Figure 10A shows a number of oil filters as used on Waukesha-Hesselman engines. Letters designating the illustrations of the various types correspond to the following paragraphs:

a. **Deluxe Oil Filter:** The Deluxe oil filter shown in Figure 10A has two replaceable elements, D, which require attention when the oil on the bayonet gauge **begins** to darken. Ordinarily, this will not be oftener than every 100 hours of operation. The elements are removed by merely unscrewing the covers, C, and lifting out by the wire holders provided. If the element sticks in the shell, it is necesary to break the vacuum by inserting a screw driver between the element and the shell. After removing the elements, unscrew the drain plug, G, to drain all dirt from the sump. Then replace the drain plug, insert new Deluxe cartridge, and replace the cover. Tighten the cover bolts by hand, do not use a wrench.

b. **Duo-Flow Filter with Throw-Away Element:** This filter consists of a base with drilled passages, central tube and a filter shell. Oil passes through the central tube, is forced through the white cotton waste and returns to the oil line through the drilled passages in the base casting. Servicing this filter merely requires unscrewing the retaining nut, A, which permits removal of the waste filled can and replacement with a new can. Another type of throw-away element filter has a filter can which screws directly into the base casting instead of having a retaining nut.

c. **Care of the Duo-Flow Ported Oil Filter:** There are two forms in which the Duo-Flow Ported filter is built. One of them has the filter shell in a vertical position standing above the cast iron base. In the other, the shell hangs below.

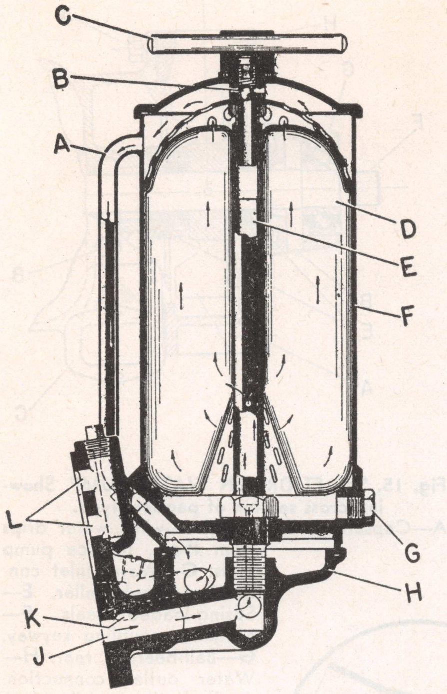
In the first type, with the shell above the base, before the shell is removed for any purpose, remove the plug, A, from the base and have a pail ready to catch the drainings to avoid spilling the contents of the shells over the engine. This precaution is not necessary with the second type where the shell hangs below the filter base casting. However, as soon as the retaining nut is removed, it is best to have a receptacle at hand to catch any spillage. As shown in Figure 10A, the Duo-Flow filter element is enclosed in a steel case which is held in place by the nut K. The filter element inside consists of a ¼" mesh screen-wire or stamped steel cage packed with white cotton waste—wool waste is not effective. Oil enters between the waste filled cage and the oil filter shell, is forced through the waste which catches the sludge and grit and then passes as cleaned oil through the central tube back to the crankcase.

Every 100 hours of service, remove the filter shell and the waste packed cartridge, and replace the old one with a complete new element.

Some Duo-Flow filters have repackable elements, in which case, the waste is held in the cage by removable end plates. With this type, the old waste can be removed and the element replaced with clean, white cotton, long fibre, machinists' waste which is free from rags. When replacing filter shells, be sure the gaskets are tight, and do not leak.

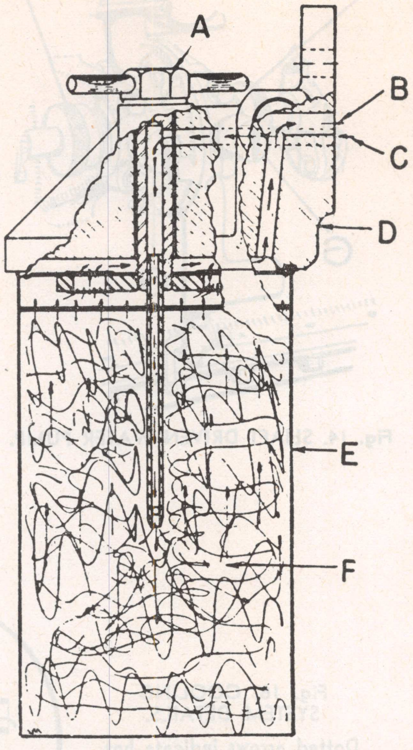
A safe rule is to clean or change filter elements with every change of crankcase oil; oftener if experience shows it to be necessary.

d. **Horizontal Type Duo-Flow Oil Filter:** Before dismantling the Horizontal oil filter, secure a pail of at least two gallons capacity to receive the sludge and muck caught in the filter shell. Hold the pail under the filter, and remove the drain plug, L, Figure 10A. After the case has been drained, unscrew the T-

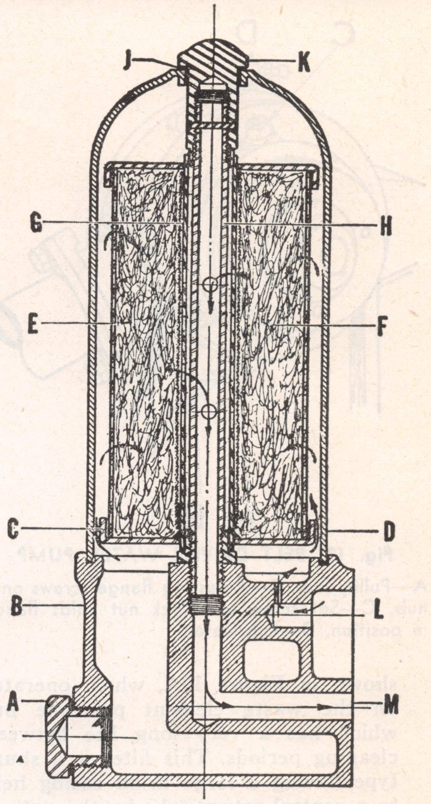

C
B
A
D
E
F
L
G
H
K
J

Type A—Deluxe oil filter.

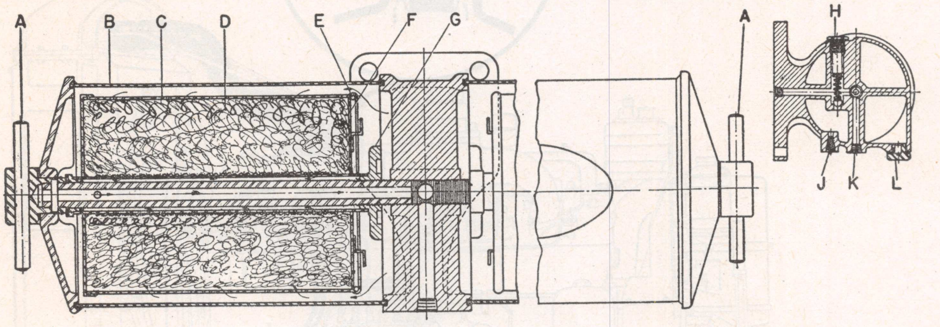
Fig. 10A. LUBRICATING OIL FILTERS USED ON THESE ENGINES. Refer to text for identification of parts as indicated by letters.



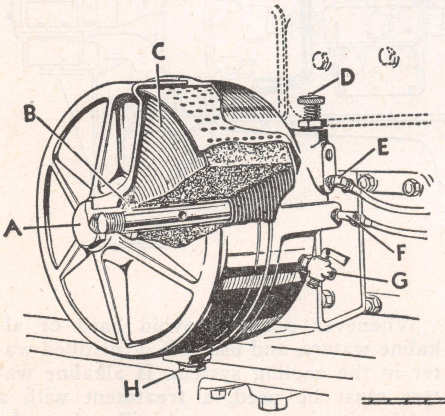
Type B—Duo-flow filter with throw-away element.


J
K
G
H
E
F
C
D
B
A
M

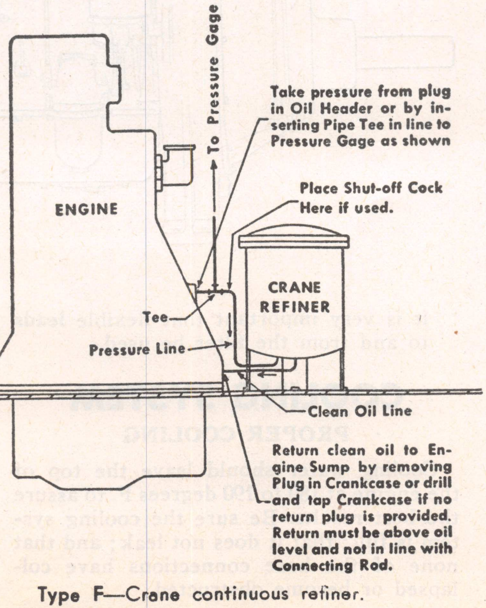
Type C—Duo-flow ported oil filter.


A
B
C
D
E
F
G
A
H
J
K
L

Type D—Horizontal type oil filter.



Type E—Super duty drum type oil filter.


To Pressure Gage
Take pressure from plug in Oil Header or by inserting Pipe Tee in line to Pressure Gage as shown
ENGINE
Place Shut-off Cock Here if used.
CRANE REFINER
Tee
Pressure Line
Clean Oil Line
Return clean oil to Engine Sump by removing Plug in Crankcase or drill and tap Crankcase if no return plug is provided. Return must be above oil level and not in line with Connecting Rod.

Type F—Crane continuous refiner.

handled nut, A, which is pinned to the central tube which screws out of the support casting, and permits the removal of the entire casing with the filter element, C. Unscrew the brass wing nut, G, and withdraw the complete filter element, C.

Wash out the shell with gasoline, then by compressing the spring ring, E, the head of the element cage may be removed and the old waste packing, D, withdrawn. Now wash the cage in gasoline and repack with 18 ounces of clean, white, long-fibre **cotton** machinist's waste.

Wool waste must not be used as it will not retain the impurities which are to be removed by filtering.

In re-assembling the unit, take care that the Vellumoid gasket at the base of the filter shell is not damaged and be sure the nut, A, is drawn tightly to prevent leaks. Both units should be serviced at the same time. Where filters are serviced between crankcase drains, be sure to add 4 or 5 quarts of oil to replenish the contents of the filter which have been withdrawn.

Early models of this filter were furnished with a **replaceable,** not **repackable** element. These can be converted to the repackable type with a set of parts available from the Service Department.

e. Drum Type Duo-Flow Oil Filter: For all big engines having a large oil supply, a Super-Duty filter has been designed,

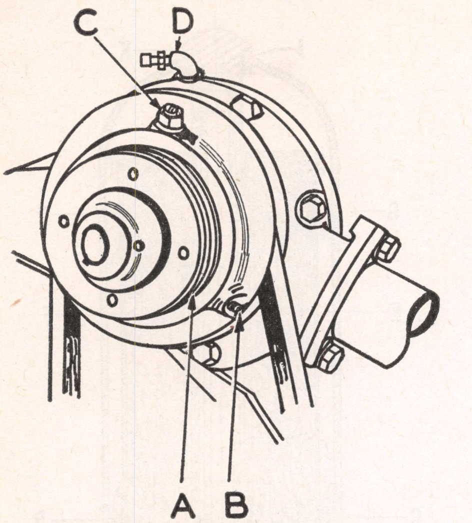


Fig. 13. BELT DRIVEN WATER PUMP

A—Pulley hub. B—Adjusting flange screws onto hub. C—Set screw with lock nut holds flange in position. D—Lubricator.

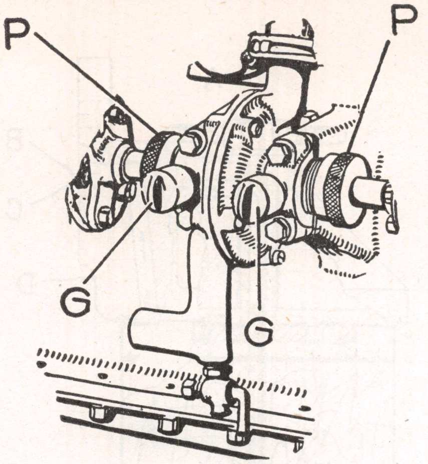


Fig. 14. SHAFT DRIVEN WATER PUMP.

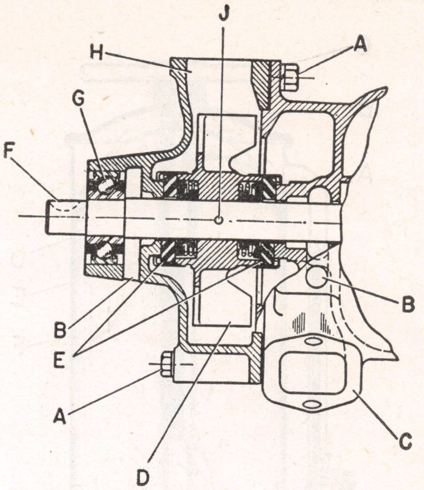


Fig. 15. SHAFT DRIVEN WATER PUMP. Showing cross section of packless type.

A—Capscrews. B—Tell-tales—when water drips from these, replace pump seals. C—Water inlet connection. D—Impeller. E—Spring-loaded seals. F—Magneto coupling keyway. G—Ball-bearing, rear. H—Water outlet connection. J—Shaft to impeller lock pin.

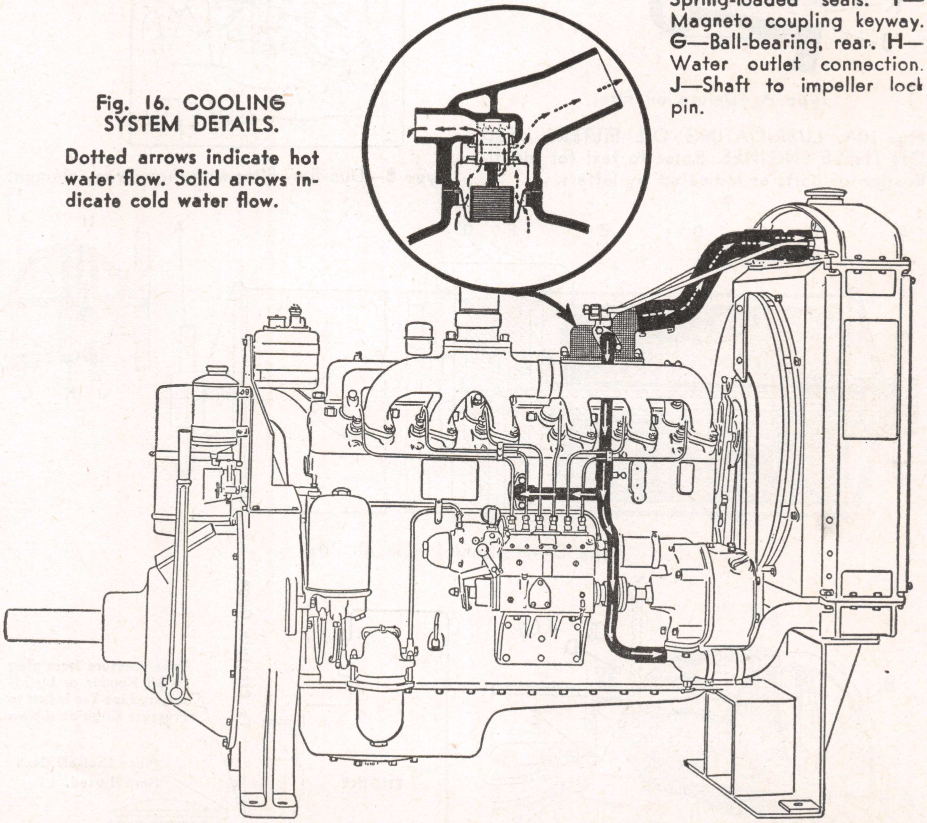


Fig. 16. COOLING SYSTEM DETAILS.

Dotted arrows indicate hot water flow. Solid arrows indicate cold water flow.

shown in Figure 10A, which operates on the waste element principle but which has a very long life between cleaning periods. This filter is a shunt type having a large drum casing held to a central return tube by the nut, A. It is mounted on a separate bracket attached to the engine.

For servicing, first, shut off the oil flow to the filter by closing the needle valve, D, then remove the drain plug, H, from the casing to drain the surplus oil and sludge. Next, remove the nut, A, which permits withdrawal of the cover and exposes a second nut, B, which holds the filter element head plate, C. With the header plate removed, the cotton waste packing can be withdrawn and fresh, clean waste inserted. Be sure to pack the new waste firmly and draw down the retaining nut, B, when the cage is filled. **Do not use wool waste under any circumstances.**

After re-assembling the case, open the valve, D, and the filter immediately goes into operation. The frequency of servicing, of course, differs with different engines in different duties. For this reason, the sampling cock, G, on the side of the case has been installed so that oil may be drawn from the filter for observation. This should be done daily and when the oil removed shows signs of becoming black, the filter element should be replaced.

f. **Crane Continuous Refiner:** This filter is used in some of the larger Hesselman engines and is mounted separately. Complete instructions for installation and use accompany each filter.

g. **Outside Connected Oil Filter:** Outside connected oil filters are built in most of the types described in the preceding paragraphs and should be renewed in the same manner.

In automotive installations when the filter is mounted on the dash or frame, it is very important that flexible leads to and from the filter be used.

COOLING SYSTEM

PROPER COOLING

Cooling water should leave the top of the engine at 180 to 190 degrees F. to assure the best results. Be sure the cooling system is full; that it does not leak; and that none of the hose connections have collapsed or become obstructed.

Whenever possible, avoid hard or alkaline waters, and use soft or distilled water in the cooling system. If alkaline waters must be used, a treatment with a good softening compound will reduce the scaling and prevent clogging of the water jackets and radiator.

After the engine is in full operation and conditions have stabilized, cooling water should enter at not less than 170 degrees F. and leave the top of the engine at 180-190 degrees F.

ENGINE WATER THERMOSTAT

If the thermostat is not functioning properly, remove the assembly from the water outlet and see if the bellows and valve are in good condition. If they are, test its operation by completely submerging it in water, heating the water gradually until it reaches the opening temperature of the thermostat, which is approximately 145 degrees. When the water reaches a temperature of about 170 degrees, the thermostat should be fully open.

NOTE—When taking temperature readings, agitate the water thoroughly. And if the unit fails to function properly, it should be replaced rather than attempt to make a repair. Before installing a new unit, it is good practice to give it a test as directed above.

Whenever the thermostat is removed for any cause, the by-pass line must be blocked to insure full flow through the radiator.

WATER PUMP, OVERHAUL

The pump commonly used on all engines is mounted on the side of the engine and is driven by a coupling through the timing gears.

To remove and repair the side-mounted type, take off the magneto (if equipped) and disconnect the coupling. Remove the bolts which fasten the pump to the water pipes and lift off the assembly.

These pumps are easily disassembled by simply removing the cover from the pump housing and when this is done, the internal parts are readily accessible for inspection and repairs.

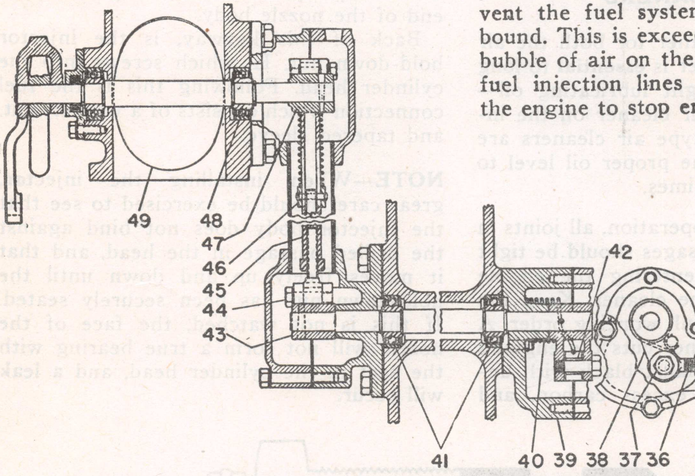


Fig. 17. GOVERNOR AND WATER PUMP ASSEMBLY USED ON MODELS 6-WALH and 6-WAKH.

Water Pump Maintenance: When the pump is down for inspection or repairs, be sure to inspect the bearings and replace if necessary. In any event, clean them and see that the oil passages are free to make sure that lubricant is reaching them.

If oil seals are used, be sure they are in good condition. Stoppage of the oil passages in the pump housing is the most frequent cause of the lubricant failing to reach the bearings.

DIESEL FUEL SYSTEM

NOTE—For detailed information on Diesel Fuel Injection Systems, see the Table of Contents on page 1.

OPERATING SEQUENCE

These engines are solid injection engines, that is, the fuel is introduced as a liquid, and not combined with the air as a carbureted vapor. The intake stroke of the engine fills the cylinder with air alone, which is compressed, and the fuel is not intoduced until after the compression stroke has been nearly completed. Near the top of the compression stroke, the liquid fuel is forced into the combustion chamber by a solid injection pump, Figure 18, through the atomizing spray nozzles.

The fuel injection pump has no lifting power, and fuel must be delivered to it either by gravity or under pressure by a small force pump. At least a three-foot head is required for a gravity feed to force the oil through the filters and keep the injection pump filled. If a gravity tank is used, it should be provided with a sediment trap, and shut-off valves so that the sediment and water can be drained from the fuel supply **daily.** If a fuel pump is used to lift the fuel from below the level of the injection pump, a **reliable** check valve in the suction line must be installed and all joints must be **absolutely air-tight** to prevent the fuel system from becoming air bound. This is exceedingly important, as a bubble of air on the discharge side of the fuel injection lines will sometimes cause the engine to stop entirely.

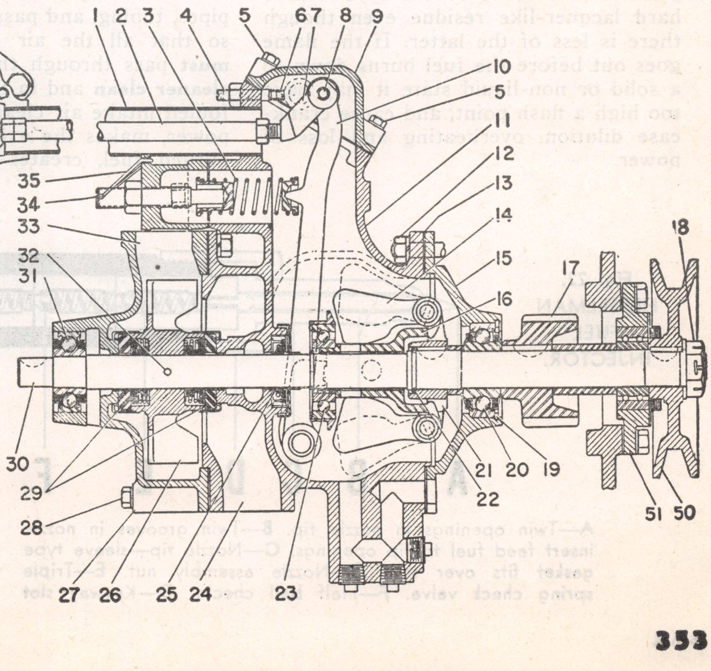
PROPER FUEL

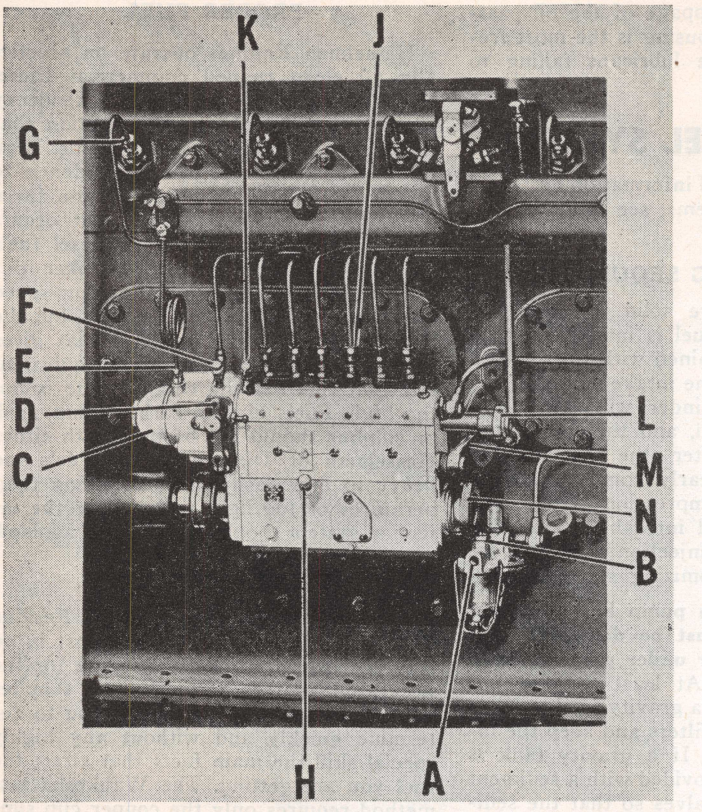
Hesselman Engines operate on practically all clean refined commercial Diesel Fuels of 60 cetane or less. A tendency towards fuel knock is an indication that the fuel has too high a cetane value. High cetane fuels have a greater tendency to knock under load than low cetane fuels. This is just the reverse of what occurs in a Diesel engine. Premium diesel fuels are unnecessary. Crude or bunker oils sometimes used in big bore, slow-speed Diesel engines should not be used, but the Hesselman will burn any fuel that gives satisfaction in Diesel engines of equivalent size and speed if the cetane value is not too high. Fuels high in carbon, gum, acid, or sulphur should not be used with either Hesselman or Diesel engines. Fuels too heavy to flow easily at surrounding temperatures or too light to lubricate the injection system should naturally be avoided.

TESTING FUEL

While the Open Cup Fuel Oil Residue Test which is described below must in no way be considered as a substitute for the accurate laboratory test your supplier should give you, it will enable you to determine quickly and without any highly special skill the main facts that affect the fuel you are getting. The Waukesha test method requires only the copper cup supplied with the engine, a sample of the fuel oil taken from the tank, and nothing more.

1. Fill the cup to the off-set rolled in the rim with the fuel sample.
2. Place the cup on a 2-inch bed of sand in the bottom of a pail sheltered from the wind or drafts.
3. Ignite the fuel in the cup by pouring half an ounce of gasoline on the surface and lighting the gasoline.





A—Fuel inlet. B—Supply pump check valve—to hold suction. C—Cap which protects vacuum control adjustments. D — "Start-Stop" lever shown in "running position." E—Vacuum connection to intake manifold. F—Oiler, and atmospheric line to vacuum control. G—Fuel injection nozzle. H—Oil level stick. J—Injection line connection. K—Air bleed cock. L—Fuel kick-off—non-reverse device. M — Fuel kick-off latch. N—Non-reverse trip dogs

Fig. 18. FUEL INJECTION SYSTEM.

4. Let the fuel burn out completely, and then examine the residue. If the point projecting from the center of the cup bottom is plainly visible, the fuel has less than 2% residue, and will be suitable from that standpoint.

5. Observe the character of the residue, and of two fuels each having 2% or less, choose the fuel with a soft, greasy deposit in preference to the type with a hard lacquer-like residue even though there is less of the latter. If the flame goes out before the fuel burns down to a solid or non-liquid state it may have too high a flash point, and cause crankcase dilution, overheating and loss of power.

AIR CLEANERS

An efficient air cleaner for both the air intake and the breather is **essential** to long engine life. Use a light lubricating oil—not fuel oil—in the air cleaner on the intake. Most oil bath type air cleaners are clearly marked for the proper oil level to be maintained at all times.

To insure efficient operation, all joints in pipes, tubing, and passages should be tight so that all the air entering the engine **must** pass through the cleaner. **Keep the cleaner clean** and in full working order. A fouled intake air cleaner cuts the engine's power, makes the exhaust black with unburned fuel, creates excess carbon, and will shorten engine life. A clogged breather induces oil pumping and bearing leaks.

HESSELMAN INJECTORS

The Hesselman injector, Figure 22, is a simple, open type injector in which are three check valves, E, in series, so arranged to prevent fuel dribbling from the end of the nozzle tip, and to stop combustion pressure from backing into the pump line.

The nozzle tip, A, which projects into the combustion chamber is covered, except at its extreme end, by a soft copper bushing which serves the purpose of a gasket as well as a medium for quickly conducting heat away from the tip to the walls of the cylinder head.

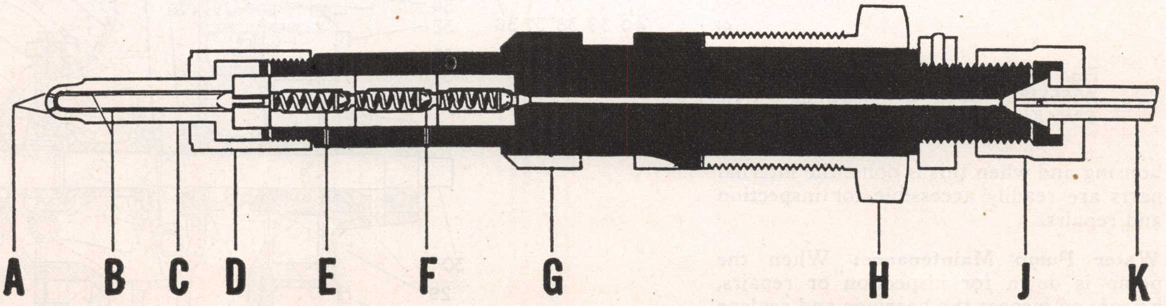
At the end of the nozzle tip, which is made of nitralloy steel, are two spray holes ranging in size from .012" to .029", and directed at various angles on each side of the center line of the cylinder depending on the engine model. The size of the holes and the angles for each different model are different from other models so that tips are not interchangeable.

To keep the spray holes in the same position with respect to the center line of the cylinder, the nozzle tip has a half round lug on the end where it joins the nozzle body which serves the purpose of locating the spray holes in a fixed position with regard to the rest of the assembly, and it, in turn, is located in a fixed position relative to the combustion chamber by dowels in the cylinder head which fit into a keyway, G, milled along the upper end of the nozzle body.

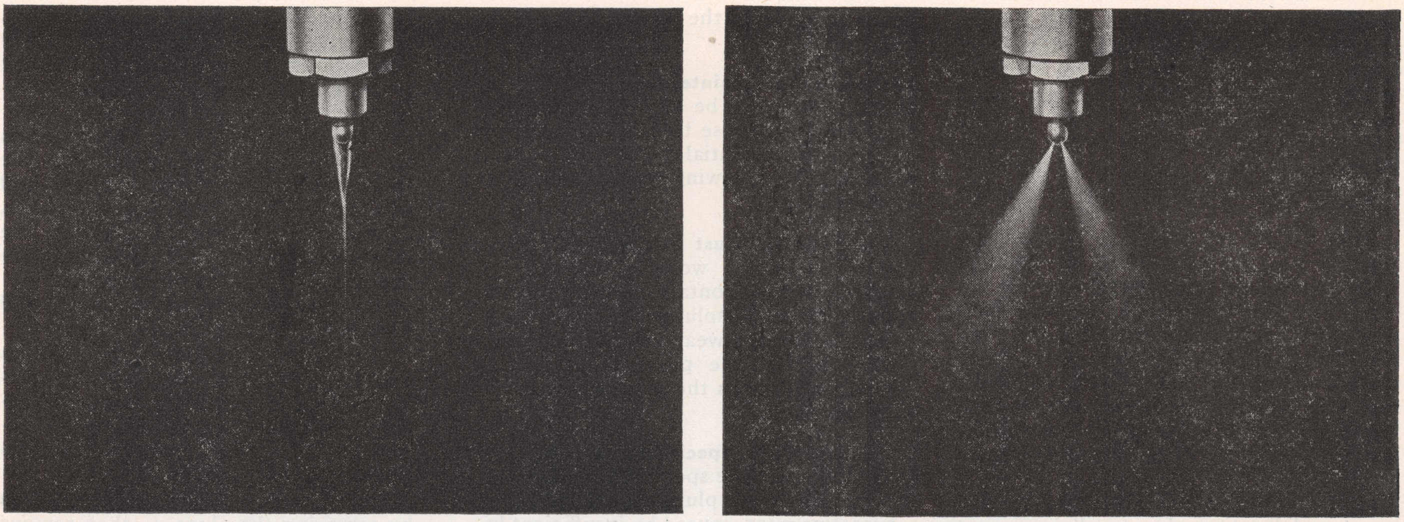
Back of this keyway, is the injector hold-down nut, H, which screws into the cylinder head. Following this is the fuel connection which consists of a washer, nut, and tapered sleeve.

NOTE—When installing the injector, great care should be exercised to see that the injector body does not bind against the drilled passage in the head, and that it moves freely up and down until the hold-down nut has been securely seated. If this is not watched, the face of the nozzle will not form a true bearing with the seat in the cylinder head, and a leak will occur.

Fig. 22. HESSELMAN FUEL INJECTOR.

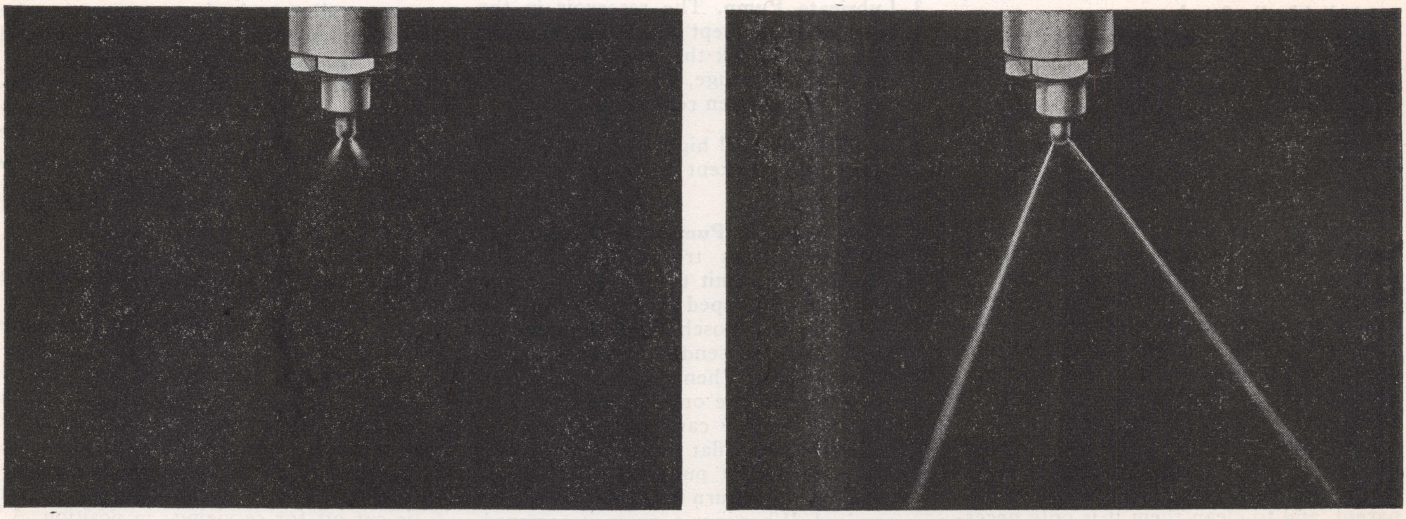


A—Twin openings in nozzle tip. B—Twin grooves in nozzle insert feed fuel to tip openings. C—Nozzle tip—sleeve type gasket fits over this. D—Nozzle assembly nut. E—Triple spring check valve. F—Half ball checks. G—Keyway slot locates nozzle in combustion chamber. H—Nozzle hold-down nut screws into cylinder head. J—Fuel line compression nut. K—Fuel line.



A—Indicates leaking check valves

B—Showing perfect spray pattern.



C—Indicates worn nozzle holes.

D—Indicates dirty holes or passages.

Fig. 23. HESSELMAN INJECTOR NOZZLE SPRAY PATTERNS.

Injector Inspection: It is advisable to test injection nozzles periodically. In automotive service the interval between tests should be from 10,000 to 15,000 miles and in stationary or industrial power plants, 2,000 to 3,000 hours. The test should include both opening pressure and spray pattern inspection.

Injector Opening Pressures: If a test on some reliable pressure testing device shows opening pressure to be below the limits indicated in the TUNE UP CHART, the ball checks and springs should be cleaned or replaced.

Checking Spray Pattern: To observe the spray pattern, remove the nozzles one at a time, connect to the fuel line and then run the engine on the remaining cylinders so that the injector to be tested sprays into the atmosphere.

Check the spray against those shown in Figure 23. When fuel comes out of the injector in a solid stream as in A, the balls or seats are worn, the springs deformed, or dirt is lodged in the valves. B shows two evenly atomized, symmetrical, fan-shaped sprays indicating the nozzle is in perfect condition. In C, the sprays run together, probably due to worn nozzle holes. And in D, dirt in the nozzle holes or canals has caused an uneven spray. In any of these cases, if cleaning does not correct the trouble, replace the worn parts or the entire injector.

Cleaning Fuel Injectors: To avoid possible layup, it is good practice to have available an extra set of injectors for use while servicing those which have been in operation. In disassembling an injector for cleaning, it is necessary to have a scrupulously clean spot cleared on the bench and to wash all grit and dirt from tools and hands as well as from the outside of the injector.

To remove springs and ball checks, place the injector in the holder furnished with the engine tool kit, and clamp securely in a vise with the tip up. Unscrew and remove nozzle assembly nut, D, Figure 22. Remove balls and checks and wash carefully in trichlorethylene; lacquer thinner followed by benzol will generally do a fair job if trichlorethylene is not readily obtainable. Dry with compressed air.

In reassembling the injector, follow Figure 22, taking care to avoid the entrance of dust and dirt, and see that the check valves are turned with the ball faces toward the outer end of the nozzle.

In order to disassemble and clean the nozzle tip and insert—a spare set of tips is much the surer and safer method of servicing—it is strongly recommended that the special tool No. 30545 designed for the purpose be procured from the Waukesha Motor Company Service Department together with the full instruction furnished regarding its use. This tool will prevent breakage of the nozzle tip and loss of the small locating pin at the end of the insert.

Without this special tool the insert may be withdrawn by securely clamping the small tang on the end of the nozzle insert, and gently tapping the body of the tip. Great care must be used to avoid burring or bending the tang and losing the small locating dowel. Always support the tip body to prevent bending the insert tang. Pliers should not be used if any other possible method of grasping the tang is available.

After the tip has been disassembled, examine the oil passages milled in the insert and remove any accumulated dirt or carbon, using a sewing needle or similar object. With hard brass wire not larger than No. 28 or .0126", poke through the two spray holes in the nozzle body and make sure they are perfectly open. Wash both insert and nozzle carefully in gasoline or kerosene and blow off dry with compressed air.

In re-assembly, be sure that the tip and insert and locating pin are all in correct position. **Do not try to interchange these parts with those of other nozzles as they are individually fitted.**

Should it be impossible to remedy trouble experienced with the fuel nozzle by a simple cleaning as directed above, replace it as a unit, and return the old one to the manufacturer for repairs. Write the Waukesha Motor Company for details of their flat rate exchange proposition.

Injector Routine Check-up: If the exhaust remains clean but the power falls off, (make sure it is not air-bound fuel lines), one or both of the spray openings of an injector may be clogged. To check this, remove the nozzles one at a time and connect them to the fuel line so that they can spray into the atmosphere.

Start the engine, and allow it to operate on the remaining cylinders. If either of the orifices is obstructed, it will be apparent, and to clean them it is only necessary to insert a thin, hard brass wire not larger than No. 28 or .0126 inch. If the obstruction is in the milled passages of the insert, it will be necessary to remove this part and clean as already explained. Hand cranking will not serve for this test as the fuel system can not be operated fast enough to get an accurate idea of the performance of the injection valve. When replacing the valve, make sure the dowel in the cylinder head nozzle opening fits into the slot in the nozzle body, G. Figure 22.

FUEL INJECTION PUMP

The fuel injection pump is fully described in the "Diesel Fuel Injection Systems" elsewhere in this book. Like the magneto, it must be gear driven and timed to deliver fuel to each cylinder at the precise moment needed. Its duty also requires it to meter each charge accurately so that each cylinder receives the exact amount of fuel that every other cylinder receives.

These two functions—precise timing and precise metering—are accurately adjusted before each engine is delivered, but they can be utterly destroyed by the operator's failure to observe the rules for maintenance.

Injection Pump Maintenance: The fuel injection pump must be kept in good working order, for precise timing and metering are absolutely essential to good engine performance. The following general rules must be observed:

1. **The Fuel Oil Must be Clean.** All filters must be in full working order at all times, and all containers kept scrupulously clean. Absolutely clean fuel prevents excessive wear on the finely finished fits of the pump plungers and valves, and keeps the metering and timing accurate.
2. **Observe Fuel Specifications.** The fuel oil must meet the specified requirements to prevent stuck plungers, acid pits, and excessive wear, caused by insufficient lubricating properties.
3. **Lubricate Pump.** The reservoir in the base must be kept filled with regular engine oil. Check the level regularly by the bayonet gauge, H, Figure 18, and add fresh oil when required.
4. **Avoid Leaks.** All high pressure fuel fittings must be kept tight—watch them for leaks.
5. **Fuel Injection Pump Replacement.** If the pump gives trouble, remove and return it as a unit the same as a magneto. If not equipped to service the pump, an American Bosch service station is near, and can send a replacement or make repairs. When time does not permit return of the original pump for repair, the factory can supply a replacement pump on a flat rate exchange basis. The replacement pump will be shipped prior to the return of the pump to be serviced. Whenever a pump is removed, it will be necessary to re-time it as described under "Injection Timing."
6. **Rules for Lay-up.** When the engine is to remain idle for two weeks or more, the possibility of sticking and corroding the fuel pump plunger and valves from fuel oil impurities, will be reduced considerably if, before stopping the engine and during the last half hour of operation, a special fuel mixture of 50% high grade lubricating oil and 50% kerosene is used instead of the supply tank fuel. The lubricating oil should be dewaxed, of a high grade, and SAE 20 viscosity. This procedure should also be followed before shipment of engines that may be enroute for any length of time because some fuels remaining in the fuel pump only a few days may cause operating difficulties when the unit is again to be started. See "Servicing Engine for Lay-up."

FUEL OIL FILTERS

All Hesselman engines require a fuel oil filter. The types used are illustrated in Figure 18A and described in the following paragraphs:

a. **Two-Stage Fuel Filter:** On some models, a two-stage filter, Figure 18A, is used in which the first stage having a metallic element with a scraper handle projecting from the top, is cleared of dirt without disassembly. This element removes all foreign particles which pass the strainer in the fuel supply pump, and two or three turns a day of the handle, C, will keep it in operation. Where the screen may have been removed from the fuel supply, and the operator has forgotten to replace it, this strainer will have to be cleaned oftener.

The second stage, connected in series with the first, has a cloth bag surrounding a metallic supporting core, and requires attention only at infrequent intervals—during the monthly inspection should be often enough.

At these times, drain the filter shells by removing the plugs, L, then remove the nuts, N, which hold the clamping rings to the body. The steel casings surrounding both elements can then be dropped so that both the elements and the casings may be easily cleaned.

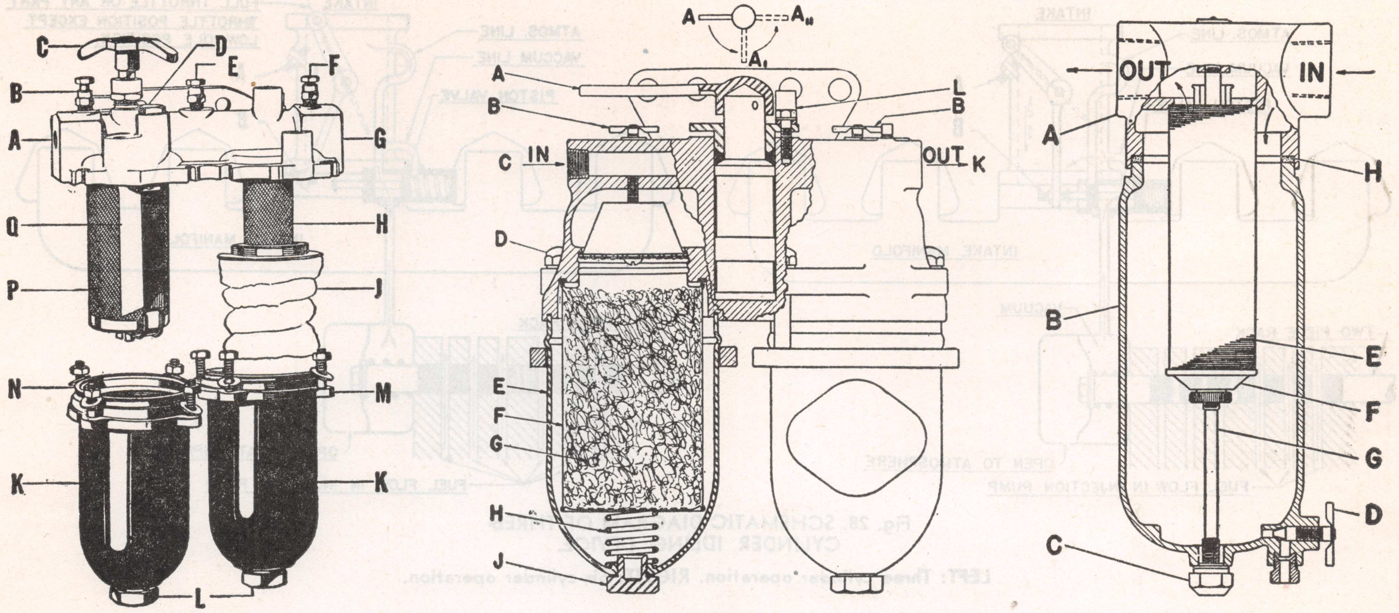
Remove the cloth bag, wash it thoroughly in gasoline, dry it with compressed air, and replace it. Both the filter shells should then be replaced, making sure that the gaskets are tight. Then follow instructions for "Starting the Engine."

b. **Twin Unit Fuel Filter:** The Twin Unit fuel oil filter, Figure 18A, is a waste-packed type which operates on the same principle as the waste-packed lubricating oil filters described in the "Engine Oiling" chapter. It is provided with a selective control valve shown in the diagram in three separate positions. In position, A, fuel flows through the left-hand element and the right-hand unit is cut off for servicing; in position, A,' fuel is flowing through both elements in parallel, **this is the normal running position;** with the handle in, A", position, the fuel flows through the right-hand element and the left-hand element is inoperative and may be serviced.

The frequency of servicing can best be determined by experience, but a monthly inspection for the first three months of operation will be sufficient to establish the routine periods for renewal of the elements.

To inspect or service this filter, first drain the filter shells, E, by removing the plugs, J. Have a two-quart container to catch the contents. The shells may then be taken down by removing the two nuts, D, on each supporting ring. Use care to prevent damage to the gaskets which must be in perfect condition to prevent leakage after reassembling, as the fuel oil is under pressure of from ten to twenty pounds from the fuel supply pump.

When the shell is removed, the filter element, F, consisting of a cotton waste packed canister, may be unscrewed, the perforated retainer on the top tilted and removed, and the cotton waste, G,



TYPE A
Two-stage fuel filter.

TYPE B
Twin-unit fuel filter.

TYPE C
Edge type primary fuel filter.

Fig. 18A. FUEL OIL FILTERS USED ON THESE ENGINES. Refer to text for parts identification as indicated by the letters.

withdrawn. The cartridge should then be repacked with six ounces of ordinary white cotton machinist's waste.

After servicing, it will be necessary to bleed the air from the filter case by opening the petcocks, B, and running the engine on the gasoline priming system until fuel flows from each petcock in an uninterrupted stream that is free from bubbles.

Then proceed with further bleeding of the injection pump and high pressure fuel lines if needed as described under "Starting the Engine" in the "Test the Fuel Lines" paragraph.

c. **Edge Type Fuel Filter:** Some models are equipped with a Zenith edge type filter, shown in Figure 18A, which filters the fuel before it reaches the primary fuel pump. The element of this filter is made up of a series of discs spaced .002" apart. Fuel passes from the outside of the element through the fine spaces, thus assuring the removal of foreign matter coarser than .002".

Cleaning routine will vary with the service and surrounding conditions. It should be inspected daily at first until experience shows how long it may be safe to operate between service periods.

If the engine stops for lack of fuel, this is the first place to investigate, if the supply tank is not dry.

To clean this filter, drain the case at the petcock, D, remove the shell and then take the element from the head so that the individual washers that make up the element will be separated slightly, and accumulated dirt will be loosened. Wash the element in gasoline or lacquer thinner and if the dirt is gummy, use a brush to loosen it. Then blow dry with compressed air.

When reassembling the unit, do not use a wrench on the knurled nut, F—hand tightening is sufficient. Be sure the gasket, H, is in good condition, and the nut, C, and copper washer are drawn tight to prevent oil and air leaks.

AIR CONTROL VALVE

As shown in the diagram, Figure 19, a simple, butterfly throttle in the air intake is the only speed regulating device. This is connected by linkage in the usual way to a governor, hand or foot control, and a tube connecting the air intake manifold to a vacuum cylinder on the fuel injection pump regulates the fuel supply by the vacuum in the manifold—closed throttle, high vacuum, small fuel charge; open throttle, low vacuum, large fuel charge. This vacuum control is illustrated in Figures 19 and 24.

THROTTLE BY-PASS

There are two types of intake by-pass valves shown in Figure 25 which are used in vehicle duty where Waukesha-Hesselman engines must be operated by hand or foot throttle, and controlled by the governor as well. An automatic spring-loaded valve bleeds air into the intake manifold through a by-pass, whenever the main butterfly is closed and the engine is being driven by the vehicle. This prevents the vacuum from reaching such a high value, and the air supply from being cut down so much that the engine suffocates from lack of air which would cause flooding, fouled spark plugs, and white smoke in the exhaust.

THREE-CYLINDER IDLING DEVICE

As an added refinement of the Waukesha-Hesselman and Multi-Fuel Oil Engines where low idling speed is desirable, a special fuel pump and intake manifold combination known as the three-cylinder idling device is required. Basically, this consists of a fuel pump in which the volume control rack is split so that, while under normal operating conditions the entire rack moves as a unit, for periods of idling, one-half of the rack is at full "off" position while the other half is feeding fuel to half of the engines' cylinders. As shown in Figure 28, the mechanism for controlling the split portion of the fuel rack is a small vacuum chamber mounted on the rack itself and connected to the intake manifold through a piston-type valve and flexible tubing.

The valve is incorporated in the throttle box itself or in a spacer placed between the intake manifold and the main throttle box and is actuated by an extension of the throttle lever with a screw and lock nut adjustment.

In full engine (six-cylinder) operation, the spring back of the piston valve pushes the valve out so that air from the intake manifold at a point above the main throttle is admitted to the vacuum chamber, and balances the atmospheric pressure on the opposite side of the diaphragm which divides the vacuum box into two compartments.

The spring shown inside the vacuum box forces the movable portion of the split rack to the right, and the rack moves as a

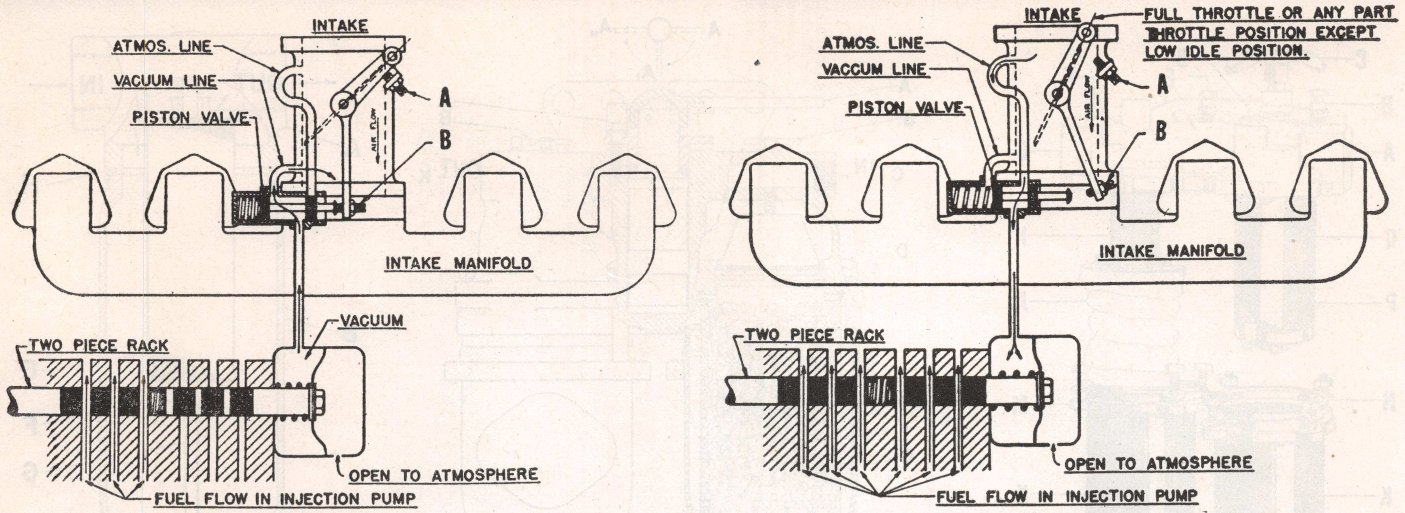


Fig. 28. SCHEMATIC DIAGRAM OF THREE-CYLINDER IDLING DEVICE.

LEFT: Three cylinder operation. RIGHT: Six-cylinder operation.

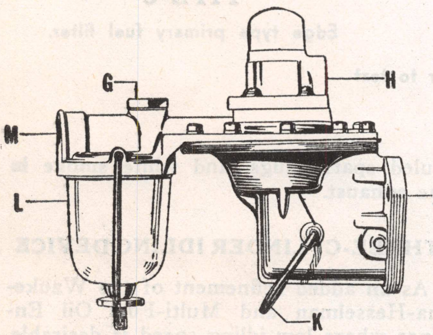


Fig. 20. FUEL DELIVERY PUMP. Diaphragm type.

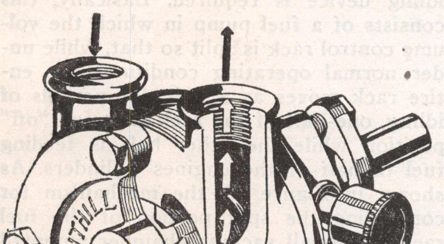


Fig. 20A. FUEL DELIVERY PUMP. Gear type.

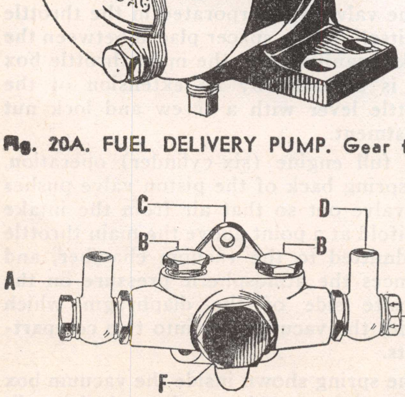


Fig. 20B. FUEL DELIVERY PUMP. American Bosch type

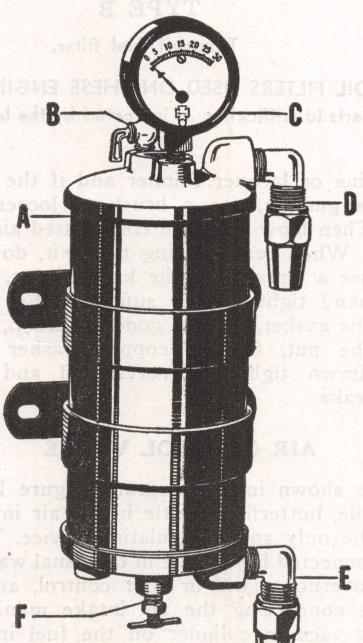


Fig. 21. FUEL SURGE TANK.
A—Tank. B—Relief valve to bleed air from fuel. C—Pressure gauge shows fuel delivery pressure. D—Fuel supply inlet. E—Fuel outlet—to injection pump. F—Drain plug.

unit permitting fuel injection to all (six) cylinders. As the throttle is closed, the lower extension on the throttle lever with the screw and lock nut adjustment, moves the piston valve in. This closes off the atmospheric line from above the main throttle, and opens a second port to the intake manifold below the main throttle.

With the main throttle closed, there is a high vacuum in the intake manifold which is transmitted to the vacuum box fastened to the fuel pump rack causing the diaphragm to move to the left as shown in the three-cylinder operation illustration. This shuts off the flow of fuel to three cylinders, and fuel is then fed only through the three which are shown open. The engine will then run at low speeds with only three cylinders pulling.

Idling speeds with all six cylinders in operation should not be lower than 600 rpm with large engines and may be as high as 800 rpm or 850 rpm with smaller sizes. Idling speeds on three-cylinder operation may be as low as 400-500 rpm depending upon the size of the engine.

FUEL DELIVERY PUMPS

There are three types of fuel delivery pumps used with Hesselman Engines. The smaller engines are usually equipped with the diaphragm type similar to those used for gasoline engines. Medium sized engines are equipped with the Bosch type pump bolted to the side of the injection pump as illustrated in Figure 20. The very largest engines may use the Bosch type pump or a simple gear type mechanical pump driven from one of the exposed drive shafts and mounted on a bracket on the side of the engine.

SURGE TANK

On large engines, there is provided an auxiliary tank, A, Figure 21, to which the delivery pump forces the fuel before it passes to the filters and injection pump. This small tank serves as a trap to receive the accumulation of air that may enter the system, and prevent its reaching the injection pump and fuel nozzles. The top of the surge tank has a vent cock, B, to release the air, as well as a pressure gauge, C, to show the pressure of oil in the fuel delivery system. The vent cock may be opened while the engine is running without interfering with its operation; do this at least once a day and keep it open until all the air is released, and fuel oil appears.

CONSTANT BLEEDING

Some installations may be found where a return line from the injection pump to the fuel tank provides a circulating supply

of fuel oil which automatically rids the system of air bubbles. It was found that this imposed an excessive duty on the delivery pumps, and was not essential to satisfactory operation as long as vent cocks were provided.

If too frequent bleeding seems to be required, it is doubtless due to leaks in the fuel lines between the supply tank and the discharge side of the fuel delivery pump; and locating and stopping the leaks will make one bleeding of the system as part of the daily starting routine entirely sufficient.

GOVERNOR MECHANISM

The governor for Waukesha-Hesselman Engines is designed for each particular engine model to do two main things: 1—to prevent damage from overspeeding and, 2—to maintain automatically constant speeds under varying loads while driving industrial machinery. **As the life of any machine falls off rapidly when it is speeded up beyond safe limits,** the governor must be kept in operation at all times to protect the engine against damage and abuse.

Centrifugal Governor Design: All Waukesha-Hesselman governors operate on the same principle. A set of revolving weights is pivoted to a driving spider so that they can move outward from the driving shaft as the rate of revolution increases. This outward movement is opposed by an adjustable spring so that the amount of movement for each engine speed can be controlled. The moving weights are connected through a lever and linkage to the air throttle butterfly valve, so that the valve opens or closes as the weights move in or out. When the engine is at rest, the throttle is wide open, and the weights are fully contracted.

All Hesselman governors are gear-driven so that their speed is always directly responsive to any change in engine speed. The illustrations show the typical forms of this mechanism, and except for possible minor variations in the arrangement of parts that may apply to special custom requirements, they are the standard designs for each model as designated below the illustrations.

Variable Speed Governors: From the foregoing, it is easy to see that by varying the spring tension opposing the weight movement, the governed speed of the engine may be varied, and for vehicle or other duty requiring speed variation with top speed definitely limited, the main governor spring is attached to a movable pivot at one end that can be connected either to a hand lever or foot throttle. Such an arrangement is standard on the large stationary engine, as shown in Figure 17. The vehicle type is shown in Figure 32, as it is built for automotive engines.

Governor Adjustment: Overspeeding has ruined more engines than hard work, so that governor adjustments to raise the speed beyond the safe limits as given in the TUNE UP CHART are always at the owners' risk. If, in special cases, it seems advantageous to increase the speed beyond that given in the chart, the Company's Service or Engineering Departments will gladly advise with you in this respect.

To decrease the maximum governed speed, reduce the spring tension by turning the adjusting screw in one direction, and to increase the speed, increase the tension by turning the screw in the opposite direction.

Governor Troubles: Most governor troubles are due to wear, producing **loose joints** in the operating rods and links, **sticking** joints, bent or deformed rods, or **dirt or** rust accumulation about pivots, **shafts or** connections.

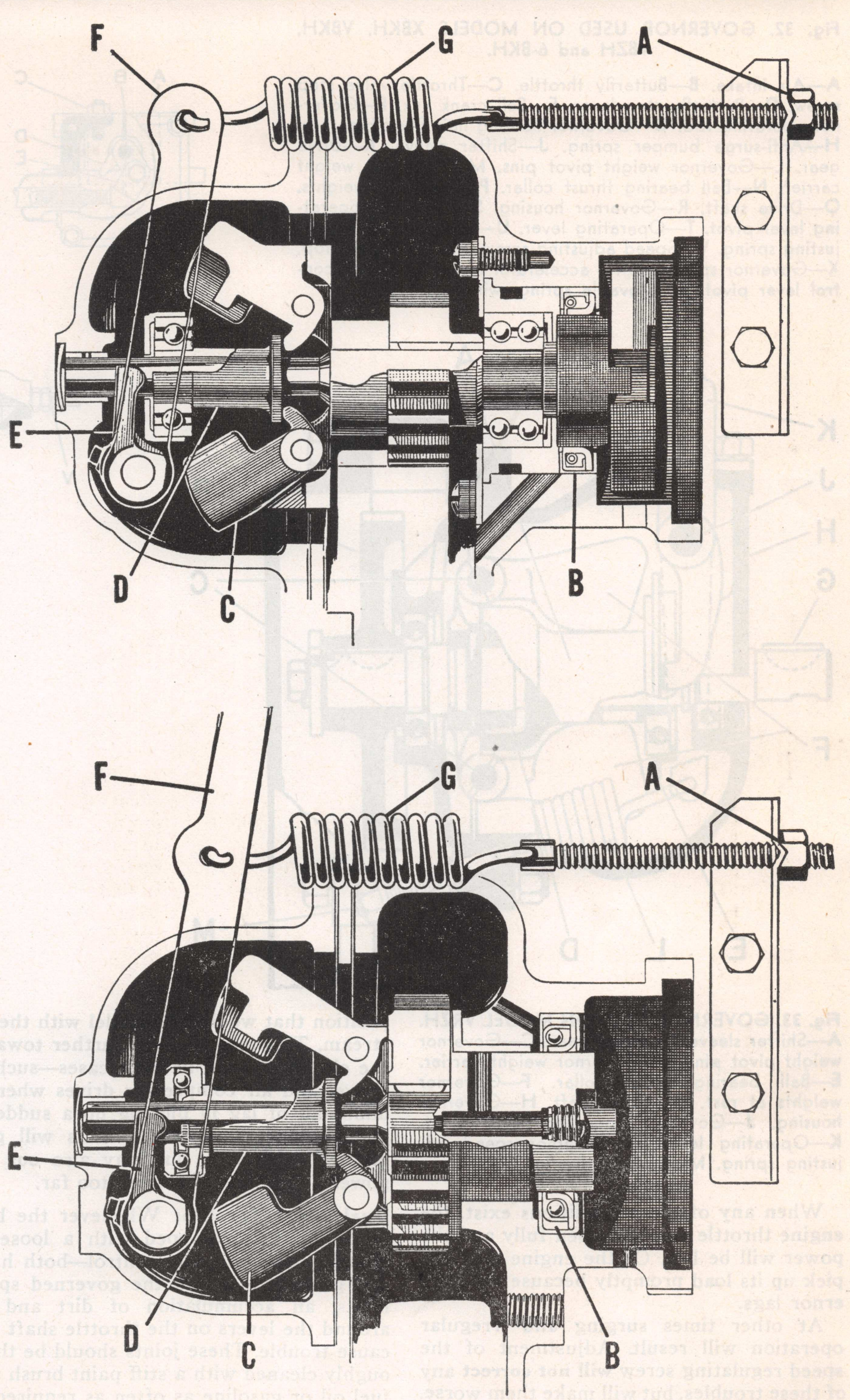
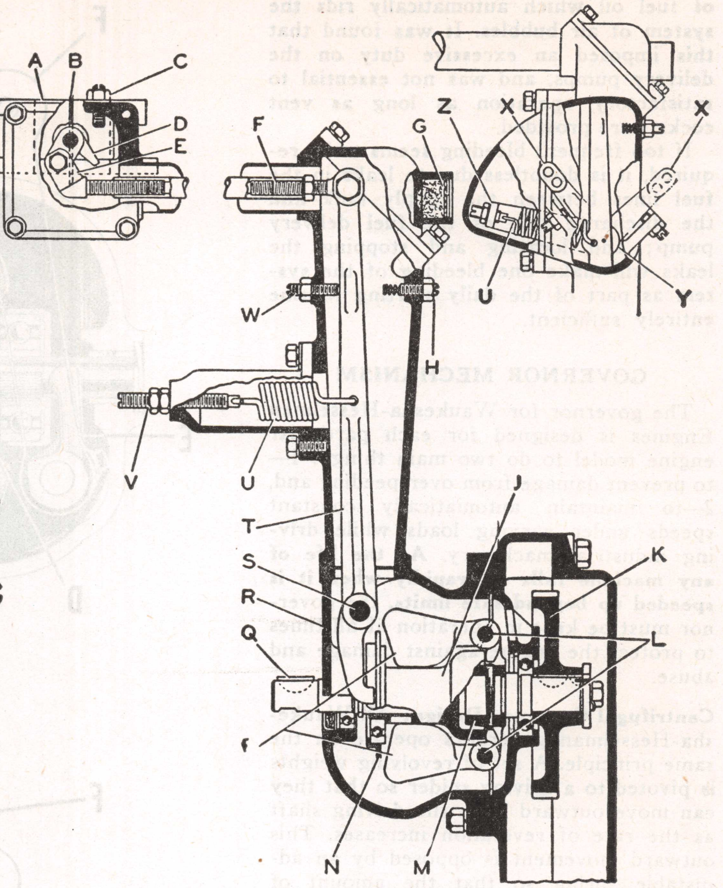


Fig. 31. GOVERNORS USED ON MODELS 130HS, 130HL, 140HS, 140HK, 145HS, 145HK

A—Speed adjusting nut. B—Oil seal. C—Weights. D—Shifter with ball bearing thrust. E—Forked thrust lever (inside). F—Operating lever (outside). G—Speed regulating spring.

Fig. 32. GOVERNOR USED ON MODELS XBKH, VBKH, VBZH and 6-BKH.

A—Air intake. B—Butterfly throttle. C—Throttle valve stop screw. D—Butterfly stop lever. E—Bell crank link. F—Governor operating rod. G—Governor housing hair filled breather. H—Anti-surge bumper spring. J—Shifter sleeve. K—Drive gear. L—Governor weight pivot pins. M—Governor weight carrier. N—Ball bearing thrust collar. P—Governor weights. Q—Drive shaft. R—Governor housing. S—Governor operating lever pivot. T—Operating lever. U—Governor speed adjusting spring. V—Speed adjusting screw. W—Governor stop. X—Governor speed control accelerator lever. Y—Speed control lever pivot. Z—Movable spring swinging lever.



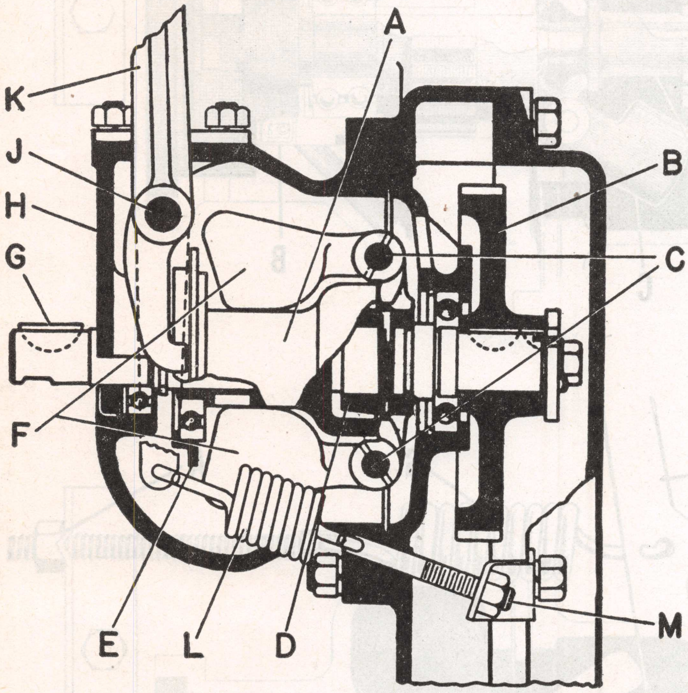


Fig. 33. GOVERNOR USED ON MODEL VRZH. A—Shifter sleeve. B—Drive gear. C—Governor weight pivot pins. D—Governor weight carrier. E—Ball bearing thrust collar. F—Governor weights at rest. G—Drive shaft. H—Governor housing. J—Governor operating lever pivot. K—Operating lever. L—Governor speed adjusting spring. M—Speed adjusting screw.

When any of these conditions exist, the engine throttle may not open fully and the power will be low. Or the engine may not pick up its load promptly because the governor lags.

At other times surging and irregular operation will result. Adjustment of the speed regulating screw **will not correct** any of these troubles, but will make them worse. The only remedy is to go through all the system of rods, levers, and connections, taking up the play or replacing the worn parts; clearing rust and dirt from shafts and connections, straightening any of the rods that may have become bent, and adjusting all connections so that they operate freely and smoothly without back lash or binding.

Setting the Butterfly: Whenever the link and joint system is overhauled as above, the butterfly should be set by adjusting the length of the reach rods so that it is from 5° to 7° towards the closed position from a position that would be parallel with the air stream. This may be even farther towards the closed position in some cases—such as shovel and air compressor drives where a minimum of lag in picking up a suddenly applied load is required. This will give greater sensitivity, but may also cut the power at full load if carried too far.

Dual Lever Throttle: Whenever the butterfly shaft is equipped with a loose or floating lever for dual control—both hand and governor—within the governed speed limits, an accumulation of dirt and oil around the levers on the throttle shaft will cause trouble. These joints should be thoroughly cleaned with a stiff paint brush and fuel oil or gasoline as often as required to prevent faulty governor action.

Resetting the Governor: If it should be necessary to dismantle the governor at any time for other adjustments—and it is only for that purpose it should ever be necessary to disturb this mechanism—there are some basic requirements that apply to all governors which should be observed.

These requirements can all be met if the governor parts are carefully marked before they are removed so that they will be re-assembled with the same adjustment and in the same places from which they were removed.

Most important, make sure that the operating rods with their adjustments, are accurately assembled exactly as before to prevent improper position of the butterfly valve. Also, be sure the lock nuts are in place and securely tightened to prevent change in the length of any of the linkage. Also notice carefully, and mark the position of the butterfly valve so that it goes back exactly as before. Close it, and with a pencil, mark the top side and the adjacent wall of the intake so that it is not reassembled upside down, or backwards.

If these precautions are followed, the governor should operate exactly as before when it is again put into service, provided the tension of the governor spring and the length of the operating rods have not been changed.

To secure the best operation, make sure that the lengths of the operating rods are adjusted so that the throttle stands a trifle towards the closed position when the engine is stopped. Variation from the speed shown in the TUNE UP CHART can be corrected by tension of the regulating spring. Increasing the tension increases the maximum speed, and decreasing the tension decreases the maximum speed.

VACUUM CONTROL UNIT

As shown in Figure 24, the entire vacuum control mechanism is enclosed in an aluminum casting bolted to the rear of the Bosch fuel pump. A nitralloy cylinder

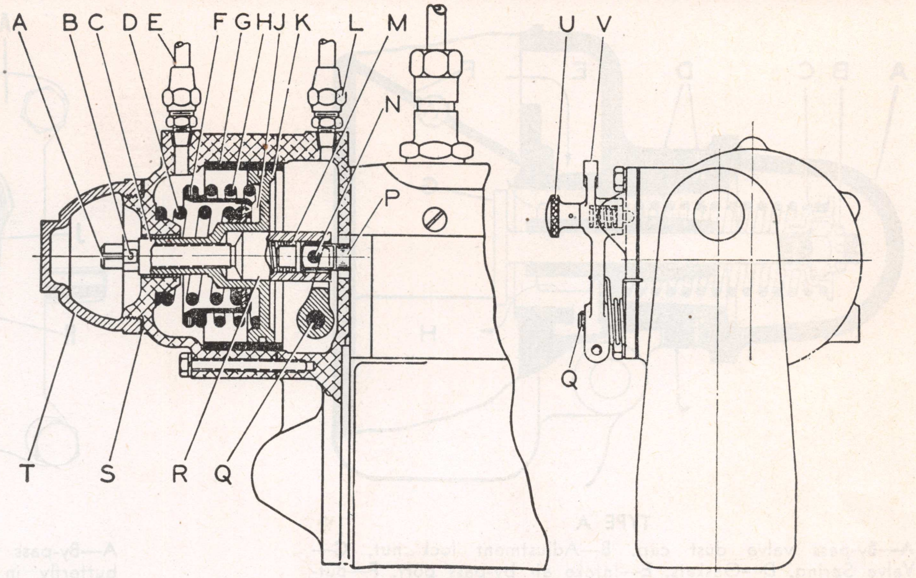


Fig. 24. VACUUM CONTROL UNIT.

A—Screwdriver slot to hold piston stem—insert while adjusting position of piston. B—Cotter or lock nut for locking adjustment. C—Hollow piston stem. D—Stiff inner spring for controlling fuel ratio from idling to 60 per cent load. E—Vacuum connection to intake manifold. F—Shims to regulate "free travel." G—Liner for vacuum cylinder. H—Outer spring which controls fuel ratio from 60 per cent load to full load. J—"Free travel" measured here. K—Vacuum piston with piston ring. L—Connection to atmosphere must be protected by cleaner. M—Auxiliary stop spring. N—Pin connecting Bosch pump fuel volume control rod to vacuum piston mechanism—held in place by spring yoke (not shown). P—Bosch pump fuel volume control rod. Q—Stop lever pivot pin. R—Stop spring housing. S—Gasket to protect mechanism from dirt. T—Remove this cap to make adjustments. U—Locking pin to hold stop lever in position. V—Stop lever.

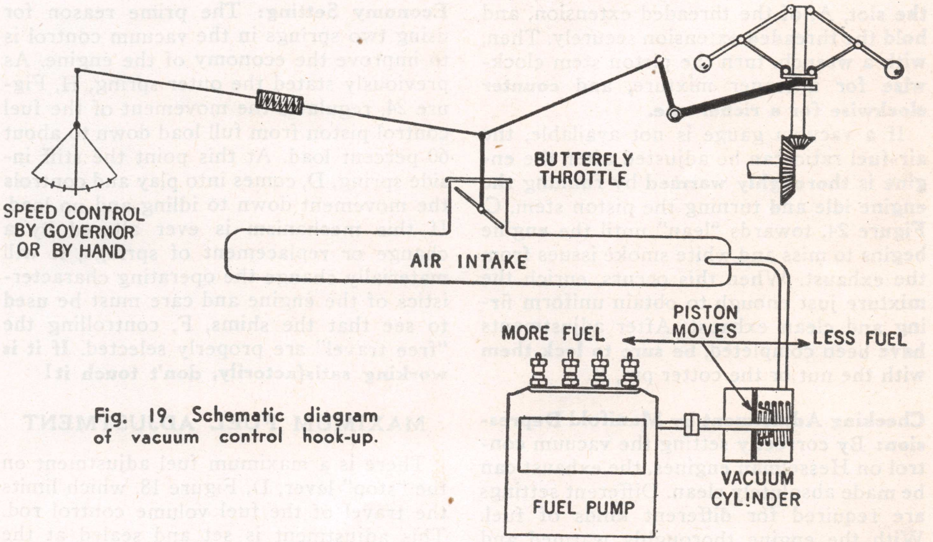


Fig. 19. Schematic diagram of vacuum control hook-up.

liner, G, is pressed into the housing, and is fitted with a piston, K, sliding in the cylinder. The piston has a hollow stem, threaded inside, which passes through a bushed hole in the back wall of the housing so that it travels freely back and forth. The space between the back wall and the piston is the vacuum chamber which houses the adjusting springs, and is connected at E by a tube to the intake manifold. The space on the other side of the piston is connected by a tube, L, to the atmosphere.

To prevent dirt from being sucked in, the atmosphere connection must be provided with its own air filter or connected to the intake between the butterfly throttle and the engine air cleaner. **This is important!** Screwed into, and extending through the hollow piston stem, is a threaded adjusting screw, the end of which is enlarged as shown at R, Figure 24, and counterdrilled to receive the auxiliary stop spring, M, and the operating extension of the Bosch pump fuel volume control rod, P.

An elongated slot is cut through the sides of the stop spring housing, R, through which the ends of the pin, N, project. This construction provides the free linkage needed to permit manual control of the fuel independent of the governor and vacuum in order to stop the engine.

The springs, D, and H, Figure 24, tending to push the piston to the right when fully extended, push the fuel pump volume control rod, P, wide open if there is no vacuum sucking the piston, K, to the left. When the air throttle butterfly, indicated in Figure 19, closes, the vacuum in the intake manifold increases, and draws the piston against the springs in the opposite direction, cutting down the fuel. The proper balancing of spring tension to the intake vacuum, controls the fuel-air ratio.

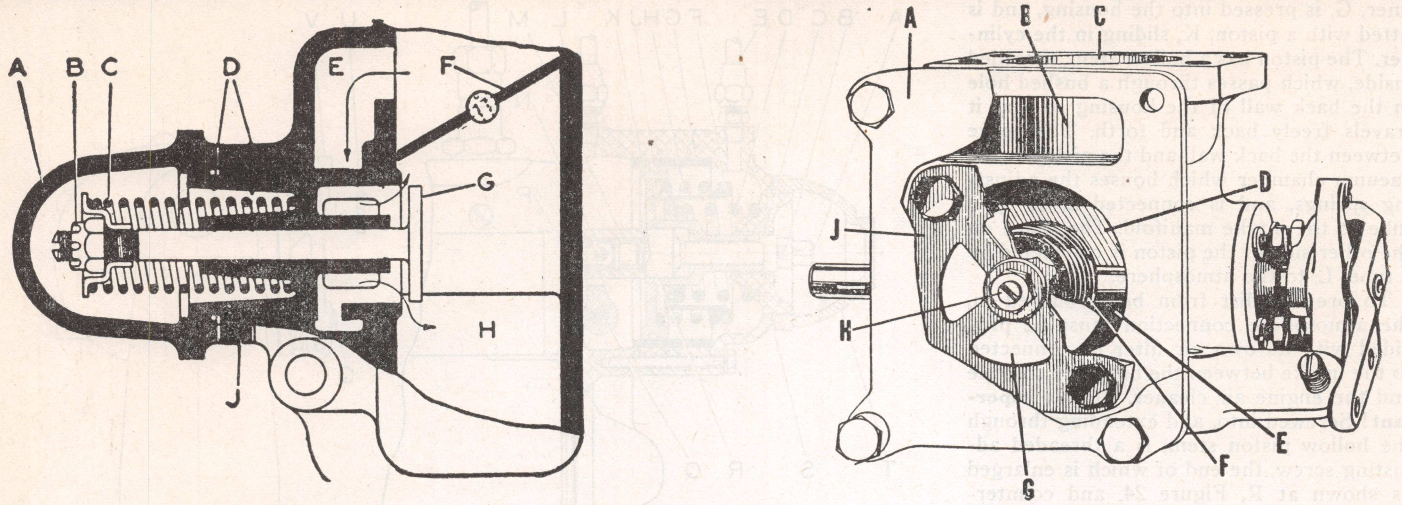
There is a lock nut in some models, and a cotter pin, B, in others, to hold the adjustments; the shims, F, are selected at the factory to give the correct "free travel" at J for the outer spring which controls operation from 60 percent to full load. The inner spring controls the fuel ratio from no load to 60 percent of full load. The cap, T, must be removed for adjusting the fuel-air ratio. At all other times it must be screwed tightly to its seat in order to prevent air or dirt from entering the mechanism.

Vacuum Control Adjusting: Whenever the engine is overhauled, the valves ground, the carbon cleaned, or any work done affecting or necessitating the removal of the cylinder head, tune-up of the vacuum control will be necessary. But before attempting any adjustments of this mechanism, for any reason whatever, check all other operating conditions which affect it—dirt or air in the fuel lines, fouled air or fuel cleaners, fouled spark plugs, leaky intake valves, faulty air intake by-pass adjustment, and clogged primer fittings.

Never change the adjustments or touch any part of the fuel injection system if the engine is operating smoothly, pulling its rated load and burning its fuel cleanly. Never make any adjustment when the engine is cold, always have it up to full operating temperature—180 to 190 degrees F. If it is a vehicle engine having an air intake by-pass valve, Figure 25, be sure to remove the cap, and block the by-pass valve so that it is inoperative during the adjustment of the vacuum control unit, and then check the adjustment of the by-pass valve **after** setting the vacuum control.

Adjusting Air-Fuel Ratio: The air-fuel ratio is commonly mentioned as a "richer or leaner mixture," and is controlled by the tension of the springs, D and H, Figure 24. The factory adjustments have been carefully made, and will usually be found satisfactory for most normal operating conditions. A change of fuel, or extreme changes in temperature or altitude may make it necessary to change these adjustments. It often occurs that an engine which has just been through a "carbon and valve job" will require a slightly richer mixture for the first day's run.

To make these adjustments, run the engine until it comes up to temperature—if there is an indicator to show water jacket temperatures, it should read 180 to 190 de-



TYPE A

A—By-pass valve dust cap. B—Adjustment lock nut. C—Valve Spring. D—Gaskets. E—Intake air by-pass port. F—Butterfly intake throttle. G—Vacuum-operated by-pass valve. H—Opening to intake manifold. J—By-pass valve body.

TYPE B

A—By-pass valve housing cover. B—By-pass port from above butterfly in throttle box. C—Main air intake—air cleaners connect here. D—Butterfly throttle in closed position. E—By-pass passage permitting air to reach engine through upper port and spring-loaded valve. F—Adjustable valve spring. G—Mushroom valve. H—Valve spring adjusting screw and lock nut. J—Removable valve cage assembly.

Fig. 25. TWO TYPES OF COASTING VALVES USED ON THESE ENGINES.

grees F. before starting, then remove the protecting cap, T, Figure 24. This will expose the adjusting screw lock nut or cotter pin, B, and the piston stem, C, which has **two flats** milled on the end to take a 5/8" **wrench.** Hold the piston stem and loosen **the lock,** B. Then insert a screw driver in **the slot,** A, of the threaded extension, and **hold the threaded** extension securely. Then, **with a wrench,** turn the piston stem clockwise for a leaner mixture, and **counter clockwise for a richer one.**

If a vacuum gauge is not available, the air-fuel ratio can be adjusted after the engine is **thoroughly warmed** by running the **engine idle** and turning the piston stem, C, Figure 24, towards "lean" until the engine begins to miss and white smoke issues from the exhaust. When this occurs, enrich the **mixture** just enough to obtain uniform firing and clean exhaust. After adjustments **have** been completed, **be sure to lock them** with the nut or the cotter pin, B.

Checking Adjustment by Manifold Depression: By correctly setting the vacuum control on Hesselman engines, the exhaust can be made absolutely clean. Different settings are required for different kinds of fuel. With the engine thoroughly warmed and idling at a fair speed, a vacuum gauge connected with the intake manifold will show a depression of between 19 and 21 inches of mercury, and with the engine operating at normal speed and full load, the manifold depression should not be more than 1¼ inches of mercury.

Changing Vacuum Control Springs: The springs, D and H, Figure 24, on the vacuum side of the fuel control piston are carefully selected and calibrated for each engine, and have a number etched thereon to identify them. Whenever replacement is required or difficulty in adjusting them is experienced so that correspondence with the factory is necessary, be sure to mention the number of the spring so that proper recommendation can be made. It is also helpful to know the kind of service in which the engine is being used.

Economy Setting: The prime reason for using two springs in the vacuum control is to improve the economy of the engine. As previously stated the outer spring, H, Figure 24, regulates the movement of the fuel control piston from full load down to about 60 percent load. At this point the stiff inside spring, D, comes into play and controls the movement down to idling and no load. If this mechanism is ever altered by a change or replacement of springs, it will materially change the operating characteristics of the engine and care must be used to see that the shims, F, controlling the "free travel" are properly selected. **If it is working satisfactorily, don't touch it!**

MAXIMUM FUEL ADJUSTMENT

There is a maximum fuel adjustment on the "stop" lever, D, Figure 18, which limits the travel of the fuel volume control rod. This adjustment is set and sealed at the factory to give maximum power with a clean exhaust. This **adjustment should not be changed** without express permission of the Factory Engineering or Service Departments. Many cases of consequential damage can be traced to excess fuel feed.

ADJUSTING COASTING VALVES

As shown in Figure 25, there are two types of intake by-pass used on Waukesha-Hesselman vehicle engines. Their use prevents flooding the cylinders with fuel oil while the vehicle is coasting with the throttle closed and the clutch engaged.

To adjust either type by-pass, **start the** engine and run it long enough under load to have it reach normal running temperature of 180 degrees F. Then remove the cap, A, Figure 25, which will expose the adjusting nut and springs, B, and C, and turn the nut clockwise two or three turns to keep the valve from opening. Then make any needed adjustments of the vacuum control—as already described—to secure good idling with the throttle in closed position.

When making this vacuum control adjustment, the throttle lever should be against the positive idling stop and the vacuum control adjusted to be midway between the point where the engine begins to falter from lean setting and the point where the engine smokes from a rich setting.

After the idle setting has been adjusted, reduce the tension on the coaster valve spring until the valve starts to flutter on its seat. Then increase the tension about 2½ turns of the adjusting screw to bring the valve firmly on its seat when the engine is idling. This setting will give about 21 inches manifold vacuum with the engine coasting.

To check the coaster valve setting, accelerate the engine to governed speed, close the throttle firmly against its idle stop, and by means of a vacuum gauge connected with the inlet manifold, observe the maximum vacuum. This should be from 20 to 21 inches of mercury. If the manifold vacuum exceeds this value, the tension adjustment on the coaster valve should be reduced until it falls within this range. Do not forget to tighten the lock nut, B, after the adjustment has been made. Replace the housing cap, A, and make sure that the gasket that seals it is in good condition and tight.

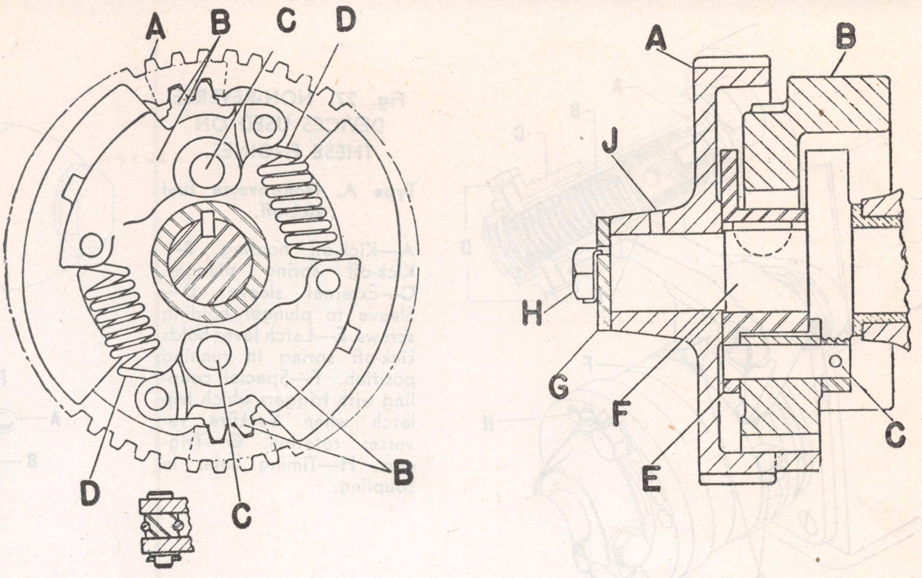


Fig. 26. FUEL PUMP AUTOMATIC ADVANCE MECHANISM.

A—Fuel pump driving gear. B—Centrifugal weight with teeth in outer rim. C—Weight pivot. D—Weight spring. E—Weight carrier plate. F—Fuel pump drive shaft. G—Thrust plate which holds gear on shaft. H—Cap screw and lock. J—Oil hole in gear hub.

ADJUSTING THREE-CYLINDER IDLING DEVICE

The most common danger in adjusting the three-cylinder idling device is the temptation to set it for idling speeds too low to give reliable performance at all times and under all conditions. Accordingly the following table of advisable idling speeds is given, because lower speeds can be obtained with apparent ease. These lower speeds, however, are only dependable for brief periods of idling, and if the period is prolonged will result in erratic operation, fouled ignition, and a tendency to dilution and fouled combustion chambers.

The first requisites to dependable adjustment of the three-cylinder idling system are, (a), proper adjustment of the main vacuum control as given above for setting the coasting valve, and (b), a fully warmed engine.

With these two conditions stabilized, back off the main idling stop screw, A, Figure 28, and close the throttle so that the piston valve contacting screw, B, engages the stem of the piston valve and pushes it back far enough to put the engine into three-cylinder operation. Observe the speed of the engine at this point. If the speed is lower than the three-cylinder speed given in the table for the model in question, adjust the main idling screw, A, to open the butterfly until the engine speed reaches the value given in the table for three-cylinder idling of the engine model in question.

If this should throw the engine back on six-cylinder operation, the adjusting screw, B, Figure 28, should be screwed in one or two turns to hold the engine on three cylinders. When the main idling screw has been set so that the three-cylinder idling speed is as given in the table, lock the adjustment, A, in this position.

The next step is to adjust for the moment or engine speed at which six-cylinder operation cuts in. Now open the throttle slowly, and observe the engine speed at which the vacuum box on the fuel pump rack pops to the right and cuts in the full six-cylinder injection. If the speed observed is higher than given in the table for six-cylinder operation of the engine in question, close the throttle and back off the adjusting screw. B, Figure 28, a turn at a time, and repeat the trial as before. When the proper adjustment has been found, lock the adjusting screw, B, in that position.

Properly adjusted, the three-cylinder idling action should be prompt and snappy.

TABLE FOR SETTING THREE-CYLINDER IDLING SPEEDS

Engine Model	3 Cylinder Engine R.P.M	6 Cylinder Engine R.P.M.
140-HS, 140-HK	500	800
145-HS, 145-HK	500	800
6-BKH	500	850
6-WALH, 6-WAKH	400	700

SERVICING DELIVERY PUMPS

Diaphragm type pumps sometimes are the cause of crankcase dilution when a leaky diaphragm causes the fuel to flow directly into the crankcase. Should it ever become necessary to service the diaphragm type of pump, do not use either the diaphragms or actuating springs for gasoline pumps of the same type and size. They are not heavy enough for this type of service and are not interchangeable with the parts to be replaced.

Oil engine pumps have much heavier diaphragms and much heavier springs to provide the higher pressure necessary to force the oil through the fuel lines and the filters.

NOTE—Servicing of the Bosch pumps should be referred to the nearest Bosch service station or, if equipped, see the "American Bosch" section of the "Diesel Fuel Injection" chapter.

Servicing the gear type pump will be most economically effected by returning the old pump as a unit and applying a new one. A regular replacement service is set up for this purpose. All three fuel delivery pumps are provided with glass bowl sediment traps and strainers either of the edge type or fine brass screen type which collect water and scale and should be emptied and cleaned periodically. After this operation, it will be necessary to fill the fuel lines and bleed them as described under their respective headings.

FUEL PUMP AUTOMATIC ADVANCE

The fuel pump drive which is used on automotive engines as shown in Figure 26 is arranged to advance the time of injection as the speed of the engine increases. It comes into action when the engine reaches sufficient speed and gradually increases the fuel pump advance to its maximum at top speed.

The driving gear, A, is mounted on an extension of the injection pump drive shaft, F, and is free to rotate so that relative movement between the shaft itself and the drive gear will advance or retard the injection pump without changing the mesh of the drive gear with its mate in the timing train of the engine.

Keyed to the shaft, F, is the weight carrier plate, E, and integral with the shaft is the flange into which are fastened two weight pivot pins, C. Two weights, B, have gear teeth cut on their outside rims which mesh with corresponding teeth cut on the inside of the overhanging rim of the main drive gear, A.

Movement of these weights around the pivots, C, is resisted by the springs, D, which hold the weights in the collapsed position shown in Figure 26 until the required engine speed is reached. At this speed, the weights overcome the spring resistance and start to move outwards towards the rim of the driving gear. This movement turns the shaft itself and advances the time of injection. It is limited by the overhanging rim of the driving gear.

The entire mechanism is flood oiled by the timing gear oiling system and requires no special servicing. It has no adjustments. When this automatic fuel advance mechanism is used, it is impossible to install the "Non-Reverse Fuel Pump Drive," shown in Figure 27, because it occupies the same space on the fuel pump shaft.

NON-REVERSE DEVICES

All engines are provided with either a non-reversible drive which immediately disengages the fuel pump should the engine begin running backwards or a fuel supply kick-off which stops injection. The disengagement device is a coupling in some

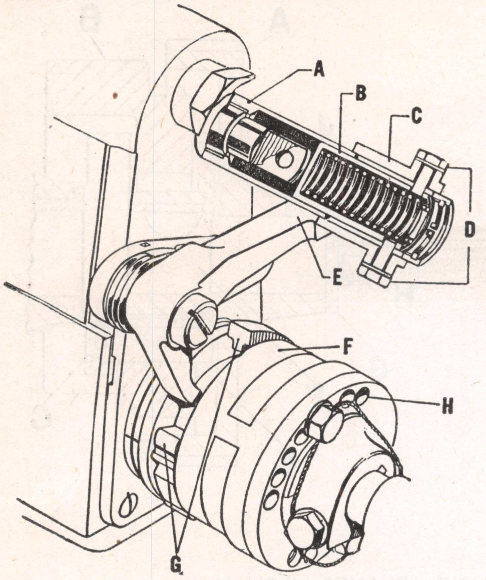
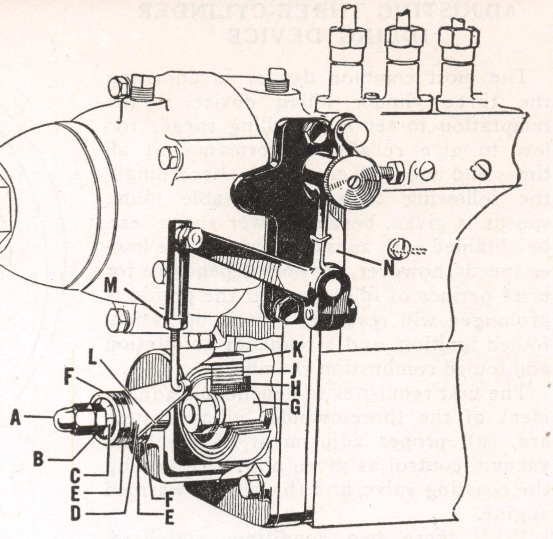


Fig. 27. NON-REVERSE DEVICES USED ON THESE ENGINES.

Type A. Non-reverse fuel kick-off.

A—Kick-off housing. B—Kick-off spring plunger. C—External sleeve. D—Sleeve to plunger holding screws. E—Latch lever holds kick-off spring in running position. F—Special coupling with triggers which trip latch when backfire reverses rotation. G—Triggers. H—Timing holes in coupling.



Type B. Non-reverse fuel kick-off.

A—Assembly nut. B—Lock nut. C—Spring washer compresses friction discs which drive the kick-off lever. D—Kick-off lever not keyed to shaft. E—Friction discs. F—Thrust washer. G—Fuel pump drive shaft. H—Slotted bushing supporting over-running spring. J—Flat coil spring packed in grease. K—Cup surrounding spring and integral with actuating shaft. L—Actuating shaft integral with spring housing cup. M—Linkage between lever "D" and fuel pump stop lever. N—Fuel pump stop lever.

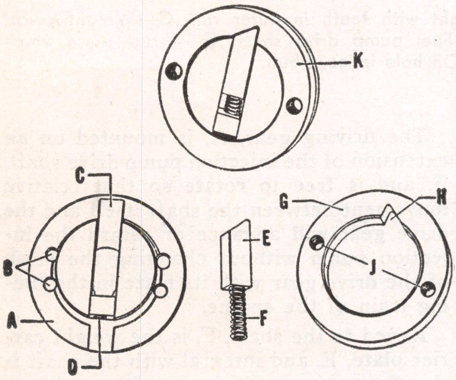
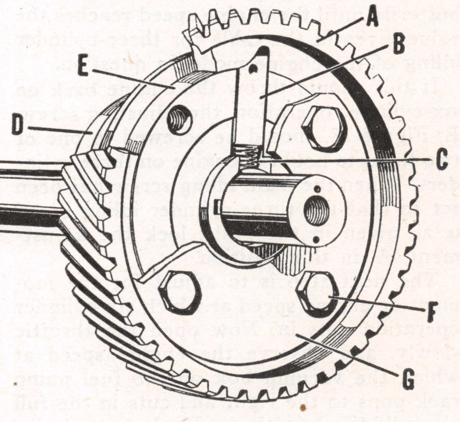


Fig. 27A. NON-REVERSE FUEL PUMP COUPLING.

A—Driving unit. B—Tapped holes for holding adjustable spider. C—Slot in which driving dog slides. D—Driving dog spring housing. E—Driving dog. F—Driving dog engagement spring. G—Driven member. H—Driving notch. J—Tapped holes for attachment to flange which is keyed and bolted to fuel pump camshaft. K—Driven member assembled to pump.

Fig. 27B—NON-REVERSE FUEL PUMP DRIVE. A—Fuel pump drive gear ring. B—Pawl. C—Pawl spring. D—Flange. E—Driving member. F—Retaining plate holding screws. G—Outer assembly retaining plate.



cases, as shown in Figure 27, and in other cases it is built into the driving gear.

The coupling type is provided with timing marks, H, and when used on a left-hand rotation fuel pump, it should be so assembled that the arrowhead, H, and the circle, immediately following the letter "L" and arrow on the face of the coupling will be in a position to line up with the graduations provided on the coupling flange.

If the coupling is to be assembled on a right-hand rotation pump, as shown in the "Ratchet Type Non-Reverse Coupling" in Figure 29, then the arrowhead and letter "O" adjacent to the letter "R" should be so assembled that they will line up with the graduations on the coupling flange.

If the coupling is not correctly assembled, the pump will not rotate at all. The pawl and notch disengagement device, described as the "Non-Reverse Fuel Pump Drive," in Figure 27B, is built into the driving gear and is not used in high speed engines which require the automatic advance of fuel injection, but is commonly found in engines for shovels, compressors, pumps, or oil field machinery and similar industrial equipment. The fuel kick-off devices will be found on some vehicle engines and in all cases where automatic injection advance is employed.

FUEL KICK-OFF

There are two types of fuel kick-off used to prevent reverse engine rotation in case of a backfire. **Type A,** Figure 27, consists of a plunger, B, enclosed in a tubular housing, A, which attaches to the end of the fuel pump opposite the vacuum control. Outside the housing is a sleeve, C, connected by two cap screws, D, to the spring plunger inside the tube. The spring is heavier than the auxiliary stop spring, M, Figure 24, so that when the trigger, E, which holds the spring plunger out of engagement, is released, the plunger moves to the left and pushes the fuel control rod to the stop position. Neoprene washers between the spring plunger and the case absorb the shock of the plunger when it is released.

When the engine is to be started, the fuel kick-off sleeve **must** be in the extreme outward position as shown in Figure 27, and held there by the latching lever, E. If it is not, the engine will not run. The spring is stiff, and may require some effort to compress it to the running position.

On the shaft of the fuel pump is a special half coupling, F, in which are pivoted two triggers, G. As long as the engine is rotating in the normal direction, these triggers are held out of engagement. When a backfire occurs, the trip end of the trigger, G, flies out, striking the latching lever, which releases the spring plunger and shuts off the fuel.

FUEL KICK-OFF—TYPE "B" MODEL

The type "B" fuel kick-off as shown in Figure 27, is built into the fuel pump and operated from the fuel pump drive shaft extension opposite the fuel pump coupling. It operates on the principle of the over-running clutch which permits free rotary movement in one direction but in the other direction automatically picks up and drives the auxiliary mechanism which is used to shut off the fuel injection.

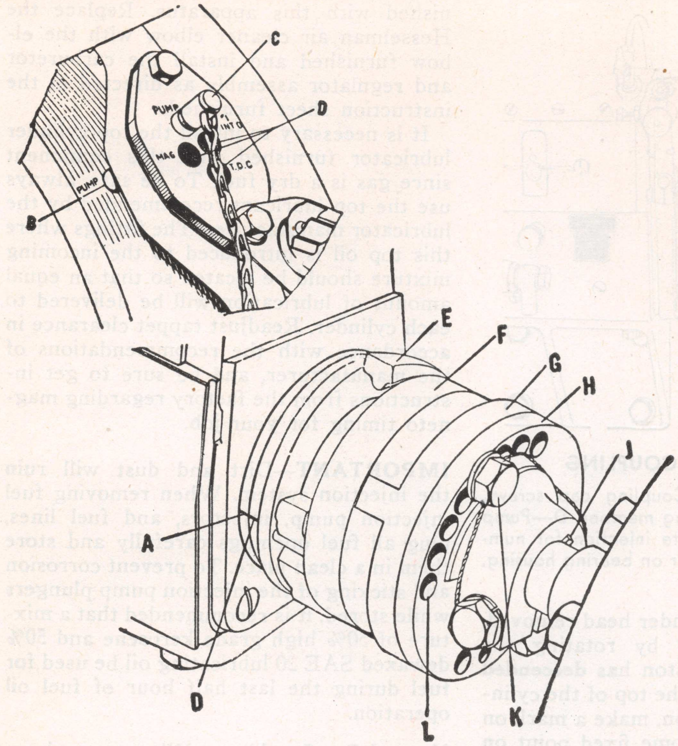


Fig. 29B. FUEL KICK-OFF NON-REVERSE COUPLING.

A—Timing mark on pump end plate. B—Timing mark on flywheel. C—Timing guide plunger. D—Timing guide plate—four holes indicate timing for magneto, fuel pump, dead center, and intake opening number 1 cylinder. E—Fuel kick-off triggers. F—Floating member. G—Adjustable drive member. H—Drive member fixed to engine shaft. J—Key. K—Capscrews which bolt fixed member to adjustable member. L—Multiple holes in drive permit close adjustment.

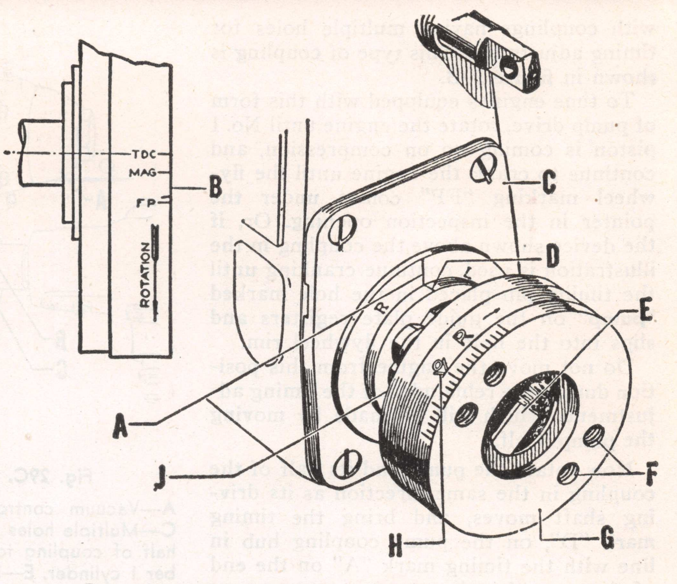


Fig. 29A. NON-REVERSE RATCHET COUPLING.

A—Timing mark on pump end plate. B—Timing marks on flywheel. C—Pump end plate. D—Pump coupling timing mark. E—Driving dog and spring. F—Tapped holes for adjustable spider. G—Driven member carries driving dog. H—Markings indicate assembly of coupling for right- and left-hand rotation. J—Flange fixed to pump shaft.

As shown in the illustration, on the fuel pump tapered shaft extension, G, is installed a thimble, H, which has a slot in the rim to take the turned over end of a flat coil spring, J.

As long as the fuel pump is running in the proper direction which tends to collapse the spring, no motion will be imparted to the surrounding cup, K. If the engine backfires which reverses the rotation of the fuel pump, the spring, tending to unwind, expands and grips the inside surface of the cup and rotates the cup and actuating shaft, L, with it.

This movement is carried through the shaft on which the cup is mounted to the lever, D, mounted on the outside end. This lever through the link, M, yanks the fuel pump stop lever from the running position to the stop position, and shuts off the fuel.

When the engine is again started, the coupling is automatically reset by the stop lever being manually placed in running position. To permit free movement in restarting and to prevent straining of the linkage, the lever, D, is driven by a friction clutch and is not keyed to the actuating shaft, L.

The clutch consists of a thrust washer, F, two friction washers, E, another thrust washer and a spring washer, C. Tension on the spring washer is adjusted by the nut, B, so that a pull of fifteen pounds on the end of the lever, D, will just overcome the friction. When so adjusted, the lock nut, A, should be pulled up to hold the adjustment.

The entire mechanism is enclosed in an aluminum housing and bolted to the end of the fuel pump. A good grade of ball bearing grease is used to pack the assembly inside the cup. No other lubrication is used.

FUEL PUMP TIMING WITH RATCHET TYPE NON-REVERSE COUPLING

In principle, fuel pump timing is the same as magneto timing. Assuming the pump has been removed entirely, and is being replaced by one of the same style, the most important operation is to make absolutely sure of perfect alignment. Misaligned pumps soon cause excessive coupling wear, and result in late timing with many accompanying troubles.

With the pump properly aligned, bolt it securely in place. Next, remove the two cap screws which fasten the driving members of the coupling together, take off the flywheel inspection cover plate, and turn the engine until No. 1 piston starts coming up on the compression stroke. Take note of the direction of the rotation of the fuel pump driving shaft as the engine is being cranked. This is important, as described later.

The flywheel markings should now be observed. (See "Locating Injection Point on Flywheel" if they are inaccessible.) As shown at B, Figure 29A, the flywheel has three marks stamped upon the rim—"FP", "MAG", and "DC"—which indicate the points at which the fuel pump and magneto are set, and the top dead center for No. 1 piston.

Continue to crank slowly (still on the compression stroke of No. 1 cylinder), until the mark "FP" is directly below the stationary timing pointer secured to the engine. Do not move the engine from this position during the remainder of the timing adjustments which will all be made by moving the pump itself.

Now rotate the pump and coupling by hand in the same direction as its driving shaft until the driving dog in the coupling catches. At this point, the coupling attached to the pump will be observed to have a timing mark, D, beginning to come into view. Immediately back of this coupling hub on the bearing end plate of the pump will be found a timing mark, A, directly in the center and above the shaft. Line up the mark on the coupling hub, D, with the mark on the end of the pump. Now, replace the cap screws at F in the driving members of the coupling. Make close adjustment by the graduations on the driving member, or by suitable combination of multiple holes if the coupling is of that type, and tighten the cap screws snugly and evenly. Since the cam of the fuel pump is arranged to give the proper firing order, the fuel leads from the top of the pump can be connected to the respective cylinders in direct sequence.

PUMP TIMING WITH FUEL KICK-OFF COUPLING

Fuel pumps which have Type A fuel kick-off device, Figure 27, will be equipped with couplings having multiple holes for timing adjustment. This type of coupling is shown in figure 29B.

To time engines equipped with this form of pump drive, rotate the engine until No. 1 piston is coming up on compression, and continue to crank the engine until the flywheel marking "FP" comes under the pointer in the inspection opening. Or, if the device shown above the coupling in the illustration is used, continue cranking until the timing pin placed in the hole marked **"pump"** on the guide plate registers and slips into the hole in the flywheel rim.

Do not move the engine from this position during the remainder of the timing adjustments which will be made by moving the pump itself.

Now rotate the pump and its half of the coupling in the same direction as its driving shaft moves, and bring the timing mark "D", on the pump coupling hub in line with the timing mark "A" on the end of the pump housing.

With the pump in this position, there will be two of the multiple holes in the flange of the driving member of the coupling in alignment with the driven member attached to the pump shaft. Insert the cap screws in these holes which line up, and draw them snugly and evenly into place. This type of coupling is to be preferred to the type in which the driving flange is slotted because, if the screws which hold the latter in place vibrate loose, the pump will be thrown out of time.

PUMP TIMING WITH PLAIN COUPLING

Engines having the Type B fuel kick-off device shown in Figure 27 or a non-reverse drive built into the gear train, are equipped with the "Plain Fuel Pump Coupling" shown in Figure 29C

To time with this type coupling, rotate the engine until No. 1 piston is coming up on compression, and continue to crank the engine until the flywheel marking **"pump"** lines up with the timing pointer in the flywheel inspection hole. Do not move the engine from this position during the remainder of the timing adjustments which will be made by moving the pump itself.

Now rotate the pump and its half of the coupling in the same direction as its driving shaft moves, and bring the timing mark, D, on the coupling hub in line with the indicator point, E, on the end of the pump housing.

With the pump in this position, there will be two of the multiple holes, C, in the flange of the driving member of the coupling in alignment with the driven member attached to the pump shaft. Insert the cap screws in these holes which line up, and draw them snugly and evenly into place.

RE-MARKING THE FLYWHEEL

When the flywheel markings become obliterated or a change of equipment is made requiring different timing for the fuel pump, it will become necessary to re-mark the flywheel.

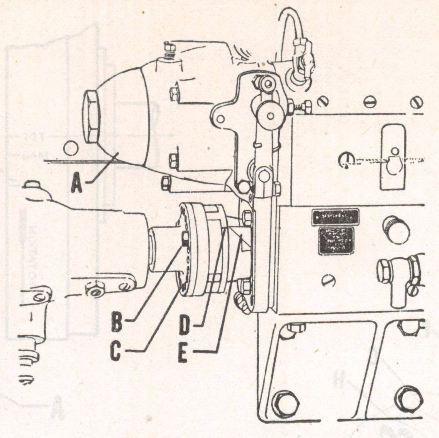


Fig. 29C. PLAIN COUPLING

A—Vacuum control. B—Coupling cap screws, C—Multiple holes in driving member. D—Pump half of coupling to indicate injection for number 1 cylinder. E—Indicator on bearing housing.

Starting with the cylinder head removed, first find dead center by rotating the crankshaft until the piston has **descended exactly one inch** below the top of the cylinder block. In this position, make a mark on the flywheel opposite some fixed point on the cylinder block of flywheel housing. Now rotate the engine in the opposite direction until the piston has descended again in the cylinder **exactly one inch,** and make another mark on the flywheel opposite the same fixed point. Halfway between these two marks, as measured by a tapeline laid on the rim of the wheel between them, is top dead center. Make a permanent mark with a prick punch or chisel to locate this point.

CONVERSION TO GAS FUEL

Since the compression ratio of Hesselman Engines lies within the same range as that commonly used for natural or artificial gas fuels, they may be easily converted to operate on gas. None of the internal mechanism is changed—rods, heads, pistons, crankshaft, etc., all remain the same. Necessary accessories for making the conversions are available for all models and may be secured from the factory.

The equipment includes: screw plugs to replace injectors, standard gas spark plugs to replace the Hesselman hot plugs, gas carburetor and regulator, manometer, air cleaner connections, gas strainer, top cylinder lubricator, and ignition switch.

Making the Conversion: Remove the fuel injection pump or disconnect it at the coupling so that it will not run when operating on natural gas. Remove or disconnect the fuel supply pump unless it is mounted on the injection pump, in which case this is taken care of when the injection pump is disconnected. Remove fuel injection tubing and injectors, replacing the injectors with solid screw plugs. Remove Hesselman spark plugs and replace with standard gas plugs furnished. Assemble the gas carburetor and regulator, strainer and manometer, according to the instructions furnished with this apparatus. Replace the Hesselman air cleaner elbow with the elbow furnished and install the carburetor and regulator assembly as directed in the instruction sheet furnished.

It is necessary to install the top cylinder lubricator furnished with this equipment since gas is a dry fuel. To be safe, always use the top lubricant recommended by the lubricator manufacturer. The fittings where this top oil is introduced to the incoming mixture should be located so that an equal amount of lubrication will be delivered to each cylinder. Readjust tappet clearance in accordance with the recommendations of the manufacturer, and be sure to get instructions from the factory regarding magneto timing for your job.

IMPORTANT—Dirt and dust will ruin the injection system. When removing fuel injection pump, injectors, and fuel lines, plug all fuel openings carefully and store them in a clean place. To prevent corrosion and sticking of the injection pump plungers while stored, it is recommended that a mixture of 50% high grade kerosene and 50% dewaxed SAE 20 lubricating oil be used for fuel during the last half hour of fuel oil operation.

Natural Gas Scrubbers: When natural gas is to be burned, it is essential to install suitable scrubbers, regulators, and line valves. If the Hesselman gasoline primer remains connected and is used, it will naturally assist in starting, and prevent flooding the engine with an over-rich gas mixture.

GASOLINE FUEL SYSTEM

For starting, a small supply of two or three quarts of gasoline, carried in a gravity tank, and mounted at some convenient spot above the level of the primer pump, U, Figure 3, is necessary. Because of the small quantity required, it does not pay to use anything but high test, easy starting gasoline.

NOTE—Do not use highly leaded gasolines for this purpose. The same care should be used in filling this tank to avoid the entrance of dirt and water as in filling the main fuel tank.

GASOLINE PRIMER CARE

Should the gasoline primer pump become difficult to operate, and require more pressure than usual, remove the primer nozzle, J, Figure 3, from the intake manifold, and reassemble it in the open to test the character of the spray. If the spray does not appear to be adequate, either as to volume or fineness, unscrew the hexagon fitting, C, Figure 30, and remove it, and if a spiral threaded extension, B, projects from the rear end, withdraw this carefully with a pair of pliers, and clean it. It does not screw out of the fitting, and should be free enough to be withdrawn with slight pressure on a pair of pliers. If the nozzle opening is obstructed, it can easily be cleaned with a small brass or

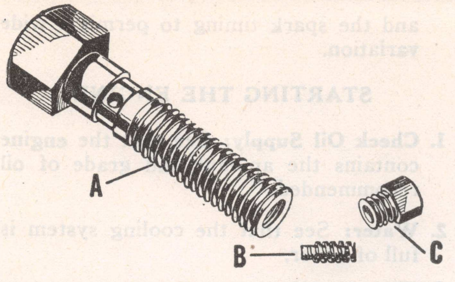


Fig. 30. GASOLINE PRIMER SPRAY NOZZLE.
A—Hollow cap screw—spray tip screws into its end. B—This fitting presses into spray tip "C." C—Spray tip which screws into hollow cap screw.

copper wire. An ample spray, and a finely divided spray is a great assistance in prompt and easy starting.

ELECTRIC SYSTEM

NOTE—For service information on Distributors, Magnetos, Generators, Generator Regulators, Starting Motors and Starter Switches, see the Table of Contents on page 1.

IGNITION SYSTEM

NEVER STOP THE ENGINE BY CUTTING OFF THE IGNITION

Firing Order: The standard firing order for all four-cylinder Waukesha-Hesselman Engines is 1-2-4-3. For the six-cylinder right-hand rotation Hesselman Engines it is 1-5-3-6-2-4, or 1-4-2-6-3-5 if the engine is a left-hand rotation unit.

GENERAL PRINCIPLES

The characteristics of the Hesselman cycle—except in the case of automotive engines and some big engines operating at widely varying speeds—do not require the usual advance and retard in the ignition or fuel injection system found in other internal combustion engines. The principal condition that must be met is the proper synchronizing of both the electric ignition and the fuel injection systems. The Tune Up Chart gives the normal advance in flywheel degrees for the fuel injection and the flywheel itself is marked plainly, indicating the point at which to set the injection pump and also the firing point for the magneto.

The magnetos used must conform to Waukesha Motor Company's specifications for Hesselman service. These magnetos produce a spark energy much greater than conventional magnetos used with gasoline engines.

TIMING AND IGNITION

As a preliminary to magneto timing, the breaker points must be set for a .012" to .016" gap. Magnetos may be held in place by four cap screws or by a strap, and connected to the drive shaft through an adjustable coupling with impulse device, A, Figure 34, for easy starting.

To time the magneto, crank the engine until No. 1 cylinder is moving upward on the compression stroke. As the piston approaches the top of the cylinder, there will come into view on the flywheel, a mark "MAG". When this is directly under the fixed pointer attached to the engine, the engine has reached the point at which the spark should occur. With the engine in this position, release the screws holding the adjustable part of the coupling so that the magneto is positively disconnected from the drive shaft. Then remove the interrupter cap, G, and distributor plate, F, Figure 34, from the magneto, and turn the magneto shaft until the distributor brush is in line with the distributor segment marked by the figure "1" on the face of the distributor plate.

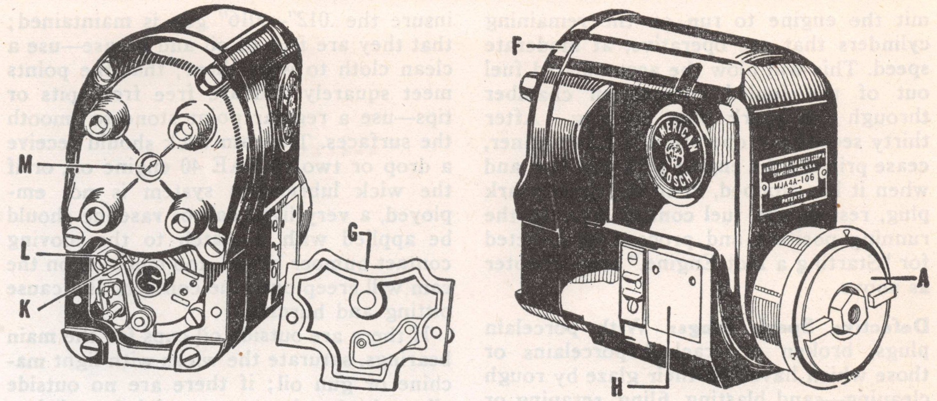


Fig. 34. HESSELMAN HIGH DUTY MAGNETO.
A—Impulse coupling. F—Distributor block. G—Breaker box cover plate. H—Cobalt chrome magnet pole. K—Moving breaker point. L—Stationary breaker point. M—Arrow on distributor arm—rotates in direction opposite to magneto and indicates which plug is being fired.

Continue to turn the magneto until the impulse snaps, then turn it backwards a half-turn and bring it forward until the breaker points, K, Figure 34, are just beginning to separate. This is the firing position.

This is the position at which the magneto should be coupled to the engine. Replace the distributor block, F, and cap, G, over the breaker box.

NOTE—If the engine begins to **miss fire** at any time, **shut down immediately** and examine the spark plugs. Running for any time with a fouled plug will make starting difficult or impossible, the result of the oil soaked combustion chamber. This is important, and we repeat **do not run any length of time with any cylinder not firing. Never ground the magneto to stop the engine.**

Spark Plug Cables: The wires may now be attached. It is always most convenient to remove the wires, and the cable supports as a unit, for in this manner the spark plug terminals are automatically in position when the cable support is replaced, and there will be less likelihood of connecting them improperly.

However, in case new cables are to be installed, the following procedure is easy to carry out. First, observe the arrow in the center window of the distributor block, or remove the distributor block, F, Figure 34, which will disclose the high tension cable terminals. If the engine has not been moved, the terminal to which the distributor arm points should be considered as No. 1 and connected by a high tension lead to No. 1 spark plug.

Usually, this distributor arm rotates in the opposite direction from the main magneto shaft. With this in mind, the next terminal to be connected would be No. 2 if it were a four-cylinder engine, or No. 5 in the case of a right-hand rotation six-cylinder engine. In this way, follow the terminals around, and connect the wires to them in the order that will give the proper firing sequence as indicated in the "Firing Order" paragraph.

SPARK PLUGS

Hesselman spark plugs are "hot" plugs, and have electrodes that project much further into the combustion chamber, and are much sturdier than conventional plugs used in gasoline engines. **Ordinary gasoline engine plugs** will not fire the charge in a Hesselman combustion chamber, and **cannot be used.** However, there are a number of popular American-made plugs on the market for Hesselman engines, that can be furnished by any well-stocked supply house. For Models 130-HS, 130-HL, 140-HS, 140HK, 145-HS, 145-HK, VRZH, 6-BKH, 6-WALH, 6-WAKH, use Champion 40, or Champion DL-8-CD for light duty; or for heavy duty, Defiance 149-9 plugs with point to shoulder dimension of 1 5/32" are recommended. Otherwise replace plugs with new ones of the same make and style as those removed. All plugs are for 18 mm tapped openings.

Fouled or defective spark plugs are the most common cause of missing. When **missing occurs, stop the engine at once.** Continued operation with one cylinder missing will flood the combustion chamber with unburned fuel oil. In this case, remove the spark plug, wash it in gasoline, and dry it thoroughly.

Do not replace the fouled plug until you have cleaned the excess fuel from the cylinder, as follows: First, shut off the fuel oil by holding the stop lever, D, Figure 18, in the "off" position, and then proceed to **operate the engine on gasoline** in the same manner as directed for "Winter Starting" in the "Starting the Engine" chapter. Permit the engine to run on the remaining cylinders that are operative, at moderate speed. This will blow the accumulated fuel out of the fouled combustion chamber through the spark plug opening. After thirty seconds of operation in this manner, cease priming the engine with gasoline, and when it has stopped, fit in the dried spark plug, restore the fuel control lever to the running position and proceed as directed for "Starting a Hot Engine," same chapter as above.

Defective Spark Plugs: With porcelain plugs, broken or cracked porcelains or those which have lost their glaze by rough cleaning—sand blasting, filing, scraping or grinding—will invariably cause "missing". Mica plugs in which the core is saturated with oil will do likewise. In either case, it is necessary to remove the faulty plug and replace it with a new one.

Varying Spark Plug Gap: Some spark plug gaps will not stay adjusted properly under full-load temperatures and as a result, missing will occur. For that reason, it is positively essential to use plugs like those in the original equipment as already mentioned.

Proper Spark Gap Important: Improperly adjusted gaps, caused by careless handling when cleaning, are responsible for much plug trouble. It is advisable to see that the spark plug points are set accurately at .018"—.020" with a feeler gauge to be certain of perfect starting and running performance. This should be a part of the routine weekly inspection.

Wiring Troubles: If the plugs are found to be in good condition, inspect all the wiring, and be sure all terminals are clean and making good contact, as the current will not carry through loose or corroded wires or terminals. Be sure no wires have been rubbing against some metallic part of the unit so that the insulation is worn or burned off at some spot causing a short circuit. Oil saturated and dirty wires may also cause missing.

Ignition Source: Another possible cause of missing is sticking of the magneto breaker points. If they are improperly adjusted, (.012"—.016" is the proper gap) or the condenser is defective, they are likely to pit or burn, and then to stick. Cleaning them with a fine point stone (never use emery or a steel file), will often remedy the trouble. If it is a bad condenser, however, cleaning the points will not correct the trouble, and either a new condenser must be installed or the ignition unit must be repaired.

Magneto Maintenance: Most magneto makers recommend periodic Service Station inspection of the magnetos, as a preventive measure to insure continuous operation while they are in service. It is advised that after 2500 hours of duty the magneto be removed and taken to the maker's nearest authorized service depot for a thorough cleaning and reconditioning. A weekly and monthly check-up on the job should include breaker points to insure the .012"—.016" gap is maintained; that they are free of oil and grease—use a clean cloth to wipe them; that the points meet squarely and are free from pits or tips—use a regular point stone to smooth the surfaces. The cam wick should receive a drop or two of SAE 40 engine oil, or if the wick lubrication system is not employed, a very light dab of vaseline should be applied with a match to the moving contact bumper block—too much oil on the cam will creep onto the contacts and cause pitting and burning.

If there are outside oil cups for the main bearings, saturate the wicks with light machine or gun oil; if there are no outside oilers the bearings are pre-lubricated during assembly, and require none between the 2500 hour re-conditioning periods.

Every month the distributor block should be removed, and wiped with a clean dry cloth to eliminate all traces of dust; and the brush track should be smoothed and polished with fine crocus cloth—never use emery—and the distributor brush examined to see that it moves freely in its holder. Any dust within the distributor opening should be blown out of the magneto with **dry air.**

CARE OF ENGINE

1. Extra care must be used in the installation of the fuel piping to insure tight joints that will not admit air bubbles to the fuel, and suitable check valves to prevent loss of prime by the supply pump. This is not so important with a carbureted fuel, but is **vitally** important with "solid injection" engines.
2. The fuel must be watched carefully to keep it clean. Fuel oils from steel drums and commercial containers often pick up scale, water, and sediment that will clog the fuel system. The filter opening of the fuel tank should have a brass strainer screen 100 mesh (.254 mm) in the form of a tube that extends well down into the tank to catch foreign particles. Gasoline requires practically no special precautions in this respect. Fuel oils do.
3. The specifications of the fuel are important. With gasoline, this need not be watched so closely.
4. The operating temperature must be kept near 180 degrees F.
5. Spark plugs must be kept adjusted. The proper gap is .018 inch. (.457 mm). The duty is very severe, and weekly inspection is necessary to keep them working at full efficiency.
6. Special ignition magnetos built for high duty are necessary. Ordinary magnetos will not operate satisfactorily.
7. Lubricating oil filters must receive periodical attention with much greater certainty than with gasoline engines. The carbon which they collect in an oil engine fouls the filter and clogs the lubricating system—a condition not found so often in gasoline engines.
8. The timing of both fuel pump and magneto are fixed, and must not be disturbed or changed. There is too close a relationship between the fuel injection and the spark timing to permit a wide variation.

STARTING THE ENGINE

1. **Check Oil Supply:** See that the engine contains the amount and grade of oil recommended.
2. **Water:** See that the cooling system is full of water.
3. **Fuel:** Be sure there is fuel in both the gasoline priming tank, and in the main fuel oil tank. **Strain the fuel oil** as it is poured from the barrel into the supply tank. **Do not** dump it in like gasoline which is carefully strained before it reaches the market. Use high test, easy starting gasoline in the primer tank—not ethyl gasoline.
4. **Drain Water from Fuel:** Whenever starting after a shut-down overnight or longer, always open the drain cock in the fuel tank sediment trap. Water condenses from the air and will always accumulate in the low spot in the fuel tank.
5. **Filling the Fuel Lines:** With any new engine, or one which has not run for some time, if its fuel tank and feed line is drained, to save needless cranking and delayed starting, fuel oil may be poured into the fuel filter casings after the main supply tank has been filled. **Do not introduce it at any point** that will reach the fuel injection pump **without passing through the filters,** for the slightest trace of grit or even lint may do great damage.
6. **Starting the Engine:** All Hesselman engines are started in the same way. First, the fuel supply lever, B, Figure 3, must be in the vertical position as shown, and the kick-off sleeve, Q, must be pulled to the right as far as possible to latch it. If a magneto grounding switch is supplied, it should be turned "on" and remain that way. If the engine has an automatic stop control, the re-set lever should be held in the running position until the engine starts. Gasoline from a small starting tank is sprayed into the intake manifold either by air pressure on the supply tank or by hand-operated primer either mounted on the engine and connected at M, Figure 3, on the dash in truck installations, or at some other convenient point. The engine is then cranked either by hand or electric or mechanical starter, and on the second or third revolution it will fire. As soon as the engine starts, continue to feed gasoline with the primer until the exhaust is clear and the engine runs evenly. Watch the exhaust for a quarter minute longer, and if smoke appears, one or two additional strokes of the primer will clear it up. Instead of the straight fitting, D, Figure 3, some small engines will be equipped with a vacuum bleeder valve, with a knurled valve stem projecting from the body casting. By pulling out the valve stem, a richer fuel mixture is

secured which may be required momentarily in starting if the engine will not settle down to even running by using the gasoline primer alone.

Any engine that still runs unevenly after following these directions for starting, probably has air bound fuel lines, and tests should be made. **Do not flood the engine by excessive priming.** All that is usually needed in warm or moderate weather is two or three strokes of the primer pump if the engine is in proper adjustment.

7. **Test the Fuel Lines:** If the fuel system was empty, and the fuel lines have been filled, continue to feed gasoline with primer and keep the engine running so that the delivery pump, S, Figure 3, will have time to fill the system. Within a minute or less, fuel should be coming out of the petcocks, P, Figure 3, on the filter body casting. As soon as it comes in a solid stream without any sign of air bubbles, close these cocks, and open the petcock, B, Figure 21, in the surge tank if the engine is a large one, or open the petcock in the injection pump itself at F, Figure 3, if there is no surge tank. Close these cocks also when the air ceases to pass with the fuel, and proceed in the same way to purge the lines until the injection pump is filled. Then close all these petcocks tightly.

   If the engine does not run smoothly on fuel oil after the low pressure side of the fuel system has been purged of air, there is probably air in the high pressure fuel lines, H, Figure 3, which must be released. To do this, simply loosen the nut which holds the fuel line to the injector, and let oil leak out for five or six impulses and then tighten it. Take each fuel line in turn, and when the last one is purged, the engine will be running smoothly.

   This is not a routine part of starting, but is likely to be necessary as part of the regular procedure with new engines being started for the first time. It is also necessary, in many cases, if the fuel supply becomes exhausted while the engine is running so that the supply pump can suck air into the system. **Never** open the fuel lines, petcocks, connections, or joints without taking great care to prevent dirt from getting in. **This is vitally important!**

8. **Starting a Hot Engine:** If an engine has been shut down for a moment and is to be started again before it cools, proceed as directed in Paragraph 6 except that less than one stroke of the primer will usually be sufficient. Use the least possible priming at all times as excessive use of the primer breaks down the cylinder wall lubrication.

9. **Hand Cranking Large Engines:** It is advisable to have two men available to start the large engines by hand. Have one stationed immediately in front of the engine to engage the starting crank, and assist the other one who is operating the crank with a rope looped over the handle. Large engines can be turned over easily in this way, and generally fire on the second or third quarter turn.

10. **Winter Starting:** For starting in winter, place the stop lever, B, Figure 3, to the left of the vertical in the full stop position to prevent flooding the engine with fuel oil because of the additional cranking needed with all engines in cold weather. Then prime the engine with gasoline and crank it the same as described in Paragraph 6. Should the engine, on starting, fire only once or twice, partially choke the intake air to obtain a rich gasoline mixture, prime and crank again, and with the richer mixture, the engine will run on gasoline as long as priming is continued. After a few seconds of operation on gasoline, restore the stop lever to the running position, and the engine will begin to function on fuel oil. Continue to prime it slowly with gasoline—this should be for less than a minute—until the engine runs evenly and the exhaust clears up.

11. **Avoid Flooding the Engine:** Should it be necessary at any time to crank the engine for inspection or other purposes, always place the lever, B, Figure 3, in the "stop" position to prevent flooding, and remove the spark plug cables to prevent accidental starting.

12. **Test Lubricating Oil Pressure:** The lubricating oil pressure may be tested by an oil gauge applied to any threaded opening entering the oil line or by putting a petcock in the same place, and opening it while the engine is running.

    Most manufacturers install an oil pressure gauge, but if the engine is not so equipped, one may be obtained at small cost, and any good mechanic can install it. **Oil pressure should be up to the specifications.**

STOPPING THE ENGINE

Never shut off the ignition to stop any Hesselman engine. If this is done, it will flood the engine with fuel oil and make starting impossible until each spark plug has been removed and dried. To stop a Hesselman engine, simply move the stop lever, B, Figure 3, as far as it will go in a counter-clockwise direction, and hold it there until the engine comes to rest. Do not forget that the fuel pump stop lever cuts off the fuel oil, and must be returned to the running position before the engine can again be put into operation. Be sure the kick-off sleeve, Q, Figure 3, is in the running position.

AUTOMATIC STOP CONTROLS

Some Hesselman engines are equipped with safety switches which will automatically cut off the fuel supply in case the oil pressure drops to 10 pounds or less, or if the water temperature exceeds 205 to 210 degrees F. In every case, this control will have a manual re-set lever which must be set and held in the running position every time the engine is started, for it will always go to the "stop" position whenever the engine is shut down, regardless of the reason. The lever must be held in the running position until the engine starts. After this, if the switch will not stay in the running position, stop the engine and check the oil supply and the condition of the oil pump screen.

SERVICING ENGINE FOR LAY-UP

When an engine is to be laid up for two weeks or more, considerable damage may be done unless the following suggestions are carried out:

1. Before final shut-down, empty the fuel tank, and in place of the regular fuel, put in a ten-gallon mixture of high grade light lubricating oil, 50%, and kerosene, 50%. Then run on this mixture for thirty minutes to insure the filling of the fuel system with this flushing compound. This flushing oil must be left in the fuel system to prevent rust and protect the pump and nozzles during the lay-up period.
2. Drain all water and lubricating oil from the engine.
3. With the piston down, through each spark-plug opening, spray at least one ounce of castor oil against the cylinder walls, and distribute the oil by cranking the engine for several revolutions.
4. Remove the ignition device and all of the fuel injection equipment and store it in a warm, dry place, making sure that the injection lines and nozzles are either plugged or stored in a pail of fuel oil to keep air and moisture from rusting their internal passages and parts.
5. Plug all openings in the engine including exhaust pipe outlet to prevent rusting or entry of any foreign matter.
6. Cover all the outside finished parts with a rust preventing compound, slushing grease or transmission oil. When restoring the engine to service, it is advisable to replace all water hose connections and pump packings.

NOTE—If the lay-up period is extensive, repeat the third operation every 90 days.

TROUBLE DIAGNOSIS

NOTE—The following suggestions are cures for minor troubles. For more details, consult that part of the text which is most likely at fault.

Symptoms:

Engine misses on fuel oil at idling and light load; white smoke in the exhaust.

Cause and Cure:

(a) Fouled spark plugs. Continue to prime with gasoline while engine is running on fuel oil until missing ceases. If it does not, stop the engine, clean the spark plug in the missing cylinder.

(b) Incorrect vacuum (too low). Checking idling vacuum.

Symptoms:

Engine misses at all loads, no smoke or only occasional puffs of white smoke in exhaust.

Cause and Cure:

(a) Leaky suction line, air in fuel. Check over the fuel supply system, and vent fuel pump.

(b) Magneto or fuel pump timing off.

Symptoms:

Engine runs well at idling and part load, but does not pull its full load, although the exhaust remains clean.

Cause and Cure:

(a) Check fuel supply system and filter, and remove possible obstructions. Vent fuel injection pump.

(b) In case of gravity feed, give more head. With fuel supply pump, check to see if it is working satisfactorily.

(c) Spray nozzles clogged; take out one injector at a time, mount on pump so it can spray in the air and while running the engine on the other cylinders, check the fuel spray.

Symptoms:

Engine runs well at idling and part load, but does not pull its full load, showing dark exhaust smoke.

Cause and Cure:

(a) Fuel mixture too rich. Check vacuum control adjustment.

(b) Possible restriction in air cleaner.

(c) Leaky engine valves, may need grinding.

Symptoms:

Engine "pings," drops in speed, exhaust manifold very hot, dark smoke in the exhaust.

Cause and Cure:

(a) Engine is overloaded. The load should be reduced.

(b) Fuel unsuitable.

DIESEL FUEL INJECTION PUMPS

There are five different makes of fuel injection pumps used on Commercial Diesel truck engines, namely: American Bosch, Cummins, Excello, G.M.C. and Timken. Their purpose is to meter the fuel accurately, and to deliver it precisely at a definite moment in a definite time, under high pressure, to the spray nozzle by which it is injected in the respective cylinders of the engine. The G.M.C. and Cummins systems, however, deliver the fuel under low pressure up to the nozzle where it is then injected under high pressure.

Before describing the general principle and operation in detail, it is well to mention a word of caution. Before the fuel injection system of any make is altered or adjusted in any way, and particularly before any parts are removed for inspection, the operator should carefully check the following points to be sure that the cause of the difficulty is really in the injection system. Too much stress cannot be laid on these instructions, as there is very little which can go wrong in the fuel pump, and there is likewise little or nothing inside the fuel pump which can need adjustment, or to which adjustment is possible. Experience has shown that a high percentage of suspected trouble lies outside of the fuel pump. Tampering with the pump in search of difficulties which are not there, is almost certain to cause trouble.

There is no fault which can exist in the fuel system, which cannot be detected by tests from the outside, that is, without disassembling any part of the pump. One should not change any part of the pump without knowing: 1—The nature of the fault he desires to remedy. 2—The location and action of the parts which cause the fault. 3—The proper procedure for correction of the fault.

For details such as recommended pump timing, governor adjustment, control rod stop setting, nozzle discharge pressure, and other general information, refer to the section describing the unit on that particular make engine.

AMERICAN BOSCH

Figure 1, 6-Cylinder "B" Size Pump.

Operation: It will be noted that the pump consists chiefly of a self-contained drive within an aluminum alloy housing, with camshaft compartment in the lower half and six pump element assemblies (3) in the upper half. The camshaft compartment contains the camshaft (14) which runs in ball bearings (12) supported by the end plates (8 and 9). Felt cushions (50) in the closing plugs (45) in the housing base facilitate lubrication of the cams and roller followers of the tappet assemblies (42). Directly above these are located the plunger and barrel assemblies (3), control sleeves (4) with toothed segments (5), plunger return springs (40), spring seats (39 and 41) and the control rod (37).

The upper part of the housing contains the fuel sump, delivery valve assemblies (23) with gaskets (24), delivery valve springs (25), delivery valve holders (17) and nipple nuts (68) for connection of the discharge tubings.

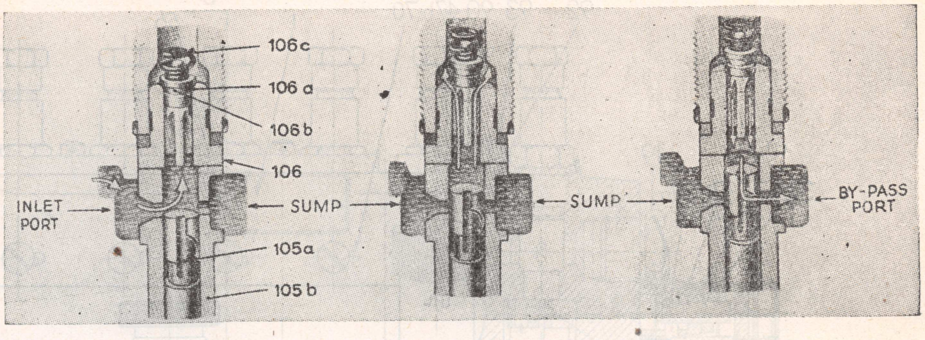


Fig. 2. Cross section of barrel with various plunger and delivery valve positions.

Through the inlet connection, the fuel enters the sump in the upper part of the housing. As soon as the upper edge of the plunger (see Fig. 2), during its downward stroke, opens the two radial opposite ports in the barrel, known as inlet and by-pass ports, the fuel rushes into the barrel while the plunger is at the bottom of its stroke (see "A," Fig. 2).

During the first part of the upward stroke of the plunger, some of the fuel in the barrel is displaced back into the sump through the inlet and by-pass ports, until these two ports are completely closed. Shortly afterwards, the fuel is placed under pressure, the spring-loaded delivery valve is lifted off its seat, and the fuel is delivered through the discharge tubing into the spray nozzle, whence it is discharged into the combustion chamber of the engine (see "B," Fig. 2).

Delivery of fuel ceases as soon as the helix on the plunger passes the by-pass port in the barrel, for at this instant the pressure chamber communicates with the sump by way of the vertical groove and helix on the plunger, allowing the fuel not yet delivered in the discharge tubing to by-pass back into the sump (see "C," Fig. 2).

The termination of the fuel delivery, which also controls the quantity of fuel delivered per stroke, is varied by turning the plunger in its barrel, that is, by bringing the helix into various positions with relation to the by-pass port. To accomplish this, a control sleeve (107a, Fig. 3) is slipped over the barrel (105b), the sleeve being provided with a toothed segment (107b) at its upper end and with two longitudinal, opposite slots at its lower end in which the cross flange of the plunger (105a) is guided. The teeth of the gear segment engage corresponding teeth on the control rod (107d) and, by shifting the latter, either manually or automatically by means of a governor, the plunger is rotated in its barrel in either direction.

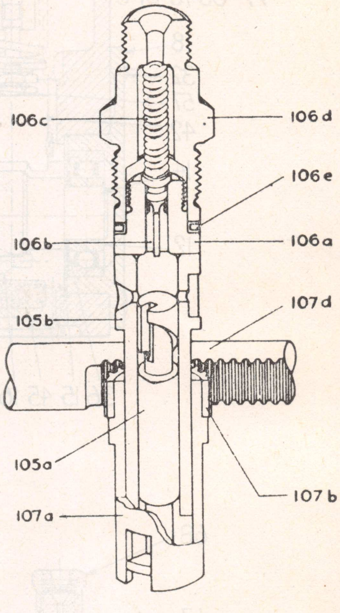


Fig. 3. Sectional view of fuel injection pump element with delivery valve assembly and delivery valve holder.

The less the control rod is moved away from its "stop" position and the less the plunger is thereby turned in its barrel, the sooner the helix opens the by-pass port

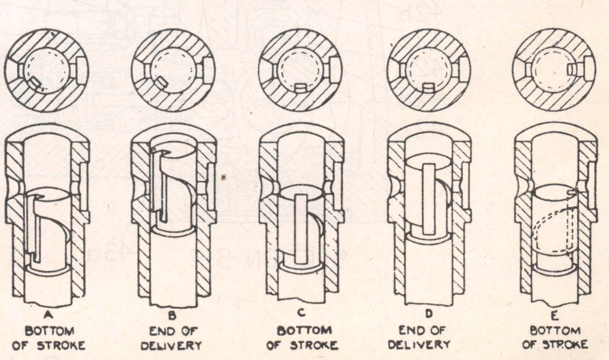
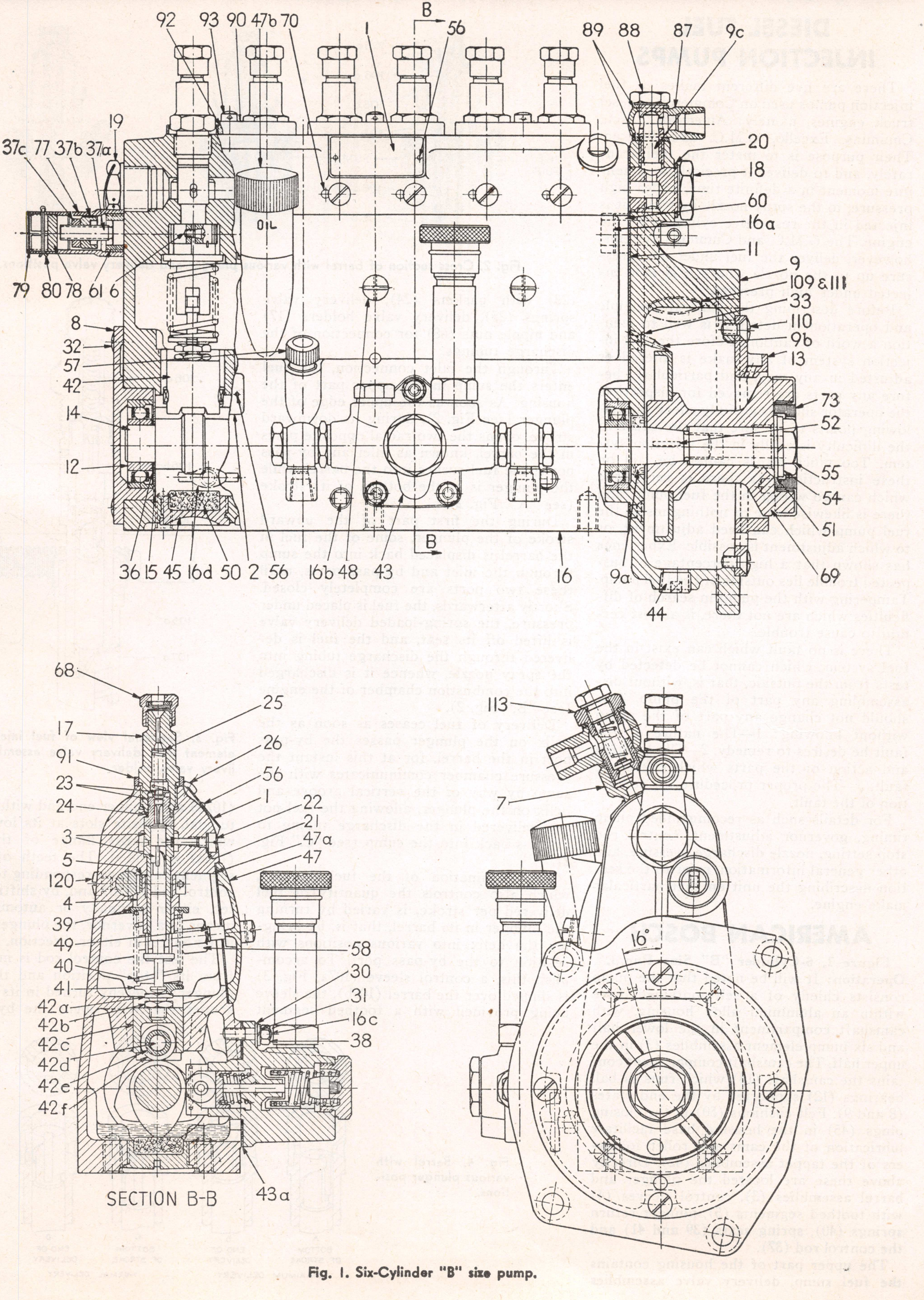


Fig. 4. Barrel with various plunger positions.


B
B
92
93
90
47b
70
1
56
89
88
87
9c
19
37c
77
37b
37a
20
18
60
16a
11
OIL
79
80
78
61
6
9
109 & 111
33
110
9b
13
8
32
57
42
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12
73
52
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54
51
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36
15
45
16d
50
2
56
16b
48
43
16
9a
44
68
17
91
23
24
3
5
120
4
39
49
40
41
42a
42b
42c
42d
42e
42f
25
26
56
22
21
47a
47
58
30
31
16c
38
43a
113
7
16°
SECTION B-B

Fig. 1. Six-Cylinder "B" size pump.

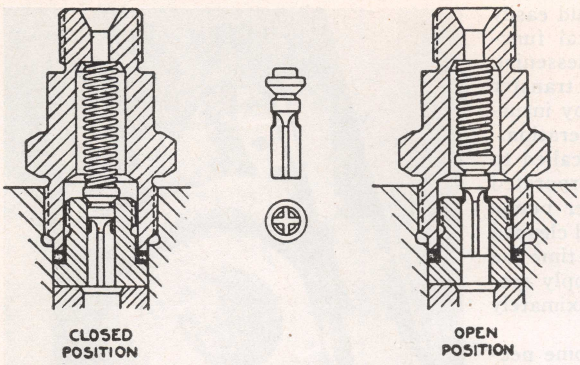


Fig. 5. Cross section of delivery valve assembly.

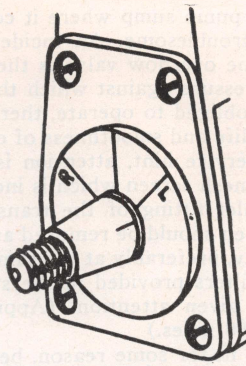


Fig. 7. Pump and plate reference marks.

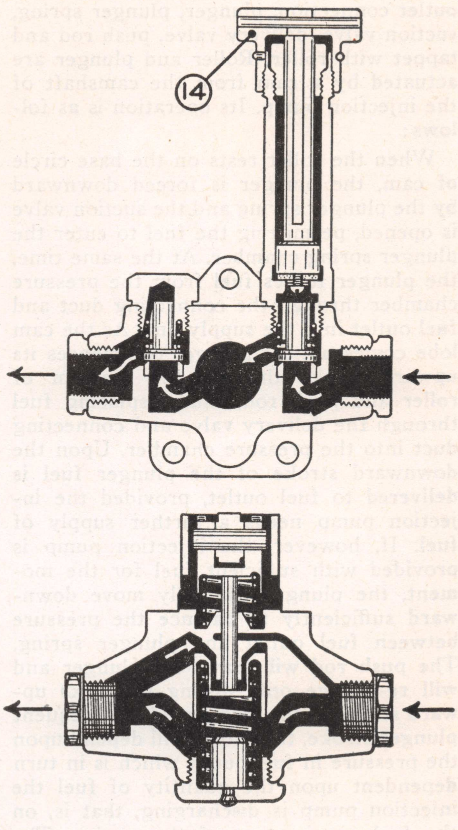


Fig. 6. Fuel transfer pump.

and the smaller the fuel delivery per stroke will be (see Fig. 4). The farther the control rod is moved away from its "stop" position and the farther the plunger is turned in its barrel, the later the helix opens the by-pass port and the larger the fuel delivery per stroke will be.

For maximum fuel delivery, the plunger, by moving the control rod farthest away from its "stop" position, is turned farthest in its barrel, resulting in very late opening of the by-pass port by the helix, that is, in the maximum effective plunger lift. For zero delivery, with the control rod in the "stop" position, the plunger is turned in its barrel until its vertical groove registers with the by-pass port. In this position, the pressure chamber in the barrel is in constant communication with the sump during the entire mechanical stroke of the plunger; therefore, no fuel is delivered by the latter.

When the helix of the plunger uncovers the by-pass port in the barrel during the latter part of the upward stroke, the pressure in the barrel is immediately released and the delivery valve is quickly returned to its seat by the combined action of its spring and the great difference in pressure which then exists between the barrel and the discharging tubing. This closes off communication between the pressure chamber in the barrel and the nozzle until the next delivery stroke takes place. In returning to its seat, the delivery valve performs a double function: first, it prevents excessive draining of fuel from the discharge tubing during by-passing, as well as during the suction stroke of the plunger; second, it relieves the pressure in the discharge tubing. This pressure relief is accomplished by means of the accurately lapped relief or displacement piston provided on the delivery valve proper below its conical seat and above its flutes (see Fig. 5).

Before the delivery valve actually reseats after the helix of the plunger has uncovered the by-pass port in the barrel, it reduces the pressure in the discharge tubing by increasing the volume therein by a quantity equal to the volume of the relief piston, for the latter slides down into the delivery valve seat with a plunger-like action. As a result of this rapid reduction in pressure, the nozzle valve at the other end of the discharge tubing "snaps" to its seat, thus instantaneously terminating the fuel injection from the spray nozzle and thereby eliminating "dripping."

The external control of the fuel delivery per stroke is accomplished by means of the control rod, one end of which is usually connected to the governor of the engine. There is a certain amount of dead movement of the control rod in its "stop" position, that is, the rod must be moved by about 3/16" from its full stop position before delivery of fuel commences. From that point on, however, the quantity of fuel delivered is directly proportional to the movement of the control rod.

In Diesel engines, speed and power output are controlled solely by a variation of the amount of fuel injected into the combustion chamber. This variation of the amount of fuel delivered by the injection pump to the nozzles is regulated by the simple and foolproof action of the helix on the plungers.

The external control of this action is by means of the control rod (see 107d, Fig. 3).

In automotive applications, this control rod is connected to a governor either directly mounted on the end of the injection pump housing or separately on the engine itself. The governor operating lever is connected to a foot accelerator linkage.

On four stroke cycle engines, the injection pump is driven at half engine speed and on two stroke cycle engines at engine speed.

The lobes of the cams on the camshaft of this pump are symmetrical and it can therefore be driven in either clockwise or counter-clockwise rotation as required.

The cams are arranged on the camshaft in the same order as the firing order of the majority of engines, so that it is almost never necessary to cross the fuel delivery tubings leading from the injection pump to the injection nozzles.

INJECTION PUMP LUBRICATION

The fuel injection pump will require but little maintenance between overhaul periods other than that of maintaining clean lubricating oil of the correct grade and level in the camshaft compartment. The oil in this compartment should be drained by means of drain plug provided in the housing base each time the engine crankcase oil is renewed, using the same grade and viscosity of oil as recommended for the engine. Between oil changes, the level of the lubricant in the camshaft compartment of the injection pump should be checked by the oil level stick which is provided. If the oil level tends to rise in the camshaft compartment, it is due, in all probability, to seepage past the injection pump plungers and the excess should be drained off by opening the overflow cock located in the side of the pump housing. Seepage of fuel oil into the camshaft compartment should not cause any concern since fuel oil is depended upon to lubricate the plungers in their barrels and will cause no harm to the camshaft, the ball bearings or the tappet assemblies. **This oil level should, however, not be permitted to build up excessively and it should therefore be checked every 500 miles.**

FUEL TRANSFER PUMP

In practically all automotive installations, the fuel supply tank is located below the fuel injection pump level, and gravity feed is therefore not possible.

Therefore, a fuel transfer pump is attached to the fuel injection pump and actuated by the camshaft of the latter. Its functions comprise the lifting of the fuel from the supply tank and delivering it under pressure to the injection pump.

The American Bosch Transfer Pump is of the variable stroke, self-regulating plunger type, the stroke being limited by the pressure in the delivery tubing, thus automatically adapting the quantity of fuel delivered to the quantity discharged by the injection pump.

It consists mainly of an aluminum-alloy housing provided with inlet connection and outlet connection, plunger, plunger spring, suction valve, delivery valve, push rod and tappet with roller. Roller and plunger are actuated by a cam from the camshaft of the injection pump. Its operation is as follows:

When the roller rests on the base circle of cam, the plunger is forced downward by the plunger spring and the suction valve is opened, permitting the fuel to enter the plunger spring chamber. At the same time, the plunger forces fuel from the pressure chamber through the connecting duct and fuel outlet into the supply line. As the cam lobe comes up, the plunger commences its upward stroke through the medium of roller and push rod, thus displacing fuel through the delivery valve and connecting duct into the pressure chamber. Upon the downward stroke of the plunger fuel is delivered to fuel outlet, provided the injection pump needs a further supply of fuel. If, however, the injection pump is provided with sufficient fuel for the moment, the plunger will only move downward sufficiently to balance the pressure between fuel outlet and plunger spring. The push rod will leave the plunger and will re-engage only during the next upward stroke of the plunger. The subsequent plunger stroke, therefore, will depend upon the pressure in fuel outlet which is in turn dependent upon the quantity of fuel the injection pump is discharging, that is, on the fuel requirement of the engine. The greater the pressure in the delivery line, the smaller the lift of the plunger, for in that case the plunger spring can only expand slightly.

If there were a constant fuel requirement, it would suffice to deliver the fuel to the injection pump by the action of the upward-moving plunger, through the delivery valve and into the fuel outlet. If the injection pump, however, should discharge into the combustion chamber of the engine, only a portion of the fuel delivered by the supply pump, an excessively high pressure ultimately would be built up in the fuel outlet. Such a condition is prevented in the American Bosch Transfer Pump by the provision of the connecting duct between fuel outlet and pressure chamber beneath the plunger.

It is not common practice to allow the pressure in the supply tubing to be limited automatically by variation of the stroke of the transfer pump plunger only. It is preferable to employ a fuel supply system of the return-flow type, in which the pressure is limited by a spring-loaded overflow valve usually placed at the injection pump opposite its fuel inlet connection (113, Fig. 1). The installation of such an overflow valve, adjusted to an opening pressure of 13 to 15 lbs. per sq. inch has been provided on the injection pump so that the fuel may be passed entirely through the injection pump sump and back into the supply tank, carrying with it any air or gas that may have entered the system through leaks, or that may have been present in the fuel initially and released by heat or agitation. The return-flow system naturally prevents the accumulation of air or gas within the injection pump sump where it could easily become troublesome. An incidental function of the overflow valve is the lessening of the pressure against which the transfer pump is obliged to operate, thereby insuring long life and smoothness of operation.

As a service hint, attention is called to the fine mesh screen which is incorporated in the inlet fitting of the transfer pump. This screen should be removed and cleaned frequently, preferably at the same time the fuel oil filters provided in the supply system are given attention. (Approximately every 5,000 miles.)

Should it, for some reason, become necessary to disassemble the transfer pump, care should be taken to reinstall this inlet fitting on the proper side, since, except for the screen, it is identical with the outlet fitting. A guide is provided by an arrow stamped on the hexagon head of the inlet union retaining screw, indicating the proper direction of fuel flow.

An additional feature of the American Bosch Fuel Transfer Pump as applied to the fuel injection pump, is the hand-operated positive priming pump, located directly above the transfer pump inlet valve. It consists chiefly of a plunger fitted into a simple barrel. Pinned to the top of the plunger stem is a knurled disc serving as handle for the manual operation. This disc has a lower cylindrical extension with an internal thread which engages in the threaded top end of the barrel and permits the fastening of the plunger when the hand priming pump is not in use. Its function is as follows:

When the plunger is pulled up, the transfer pump inlet valve is raised off its seat and fuel flows into the hand priming pump barrel, due to the created suction. The inlet valve remains open as long as there is upward motion of the priming pump plunger but seats as soon as this motion ceases. Upon pressing the priming pump plunger downward, the fuel contained in the priming pump barrel is forced into the transfer pump pressure chamber. Then the transfer pump outlet valve opens and the fuel is forced into the supply tubing leading to the injection pump.

The use of this hand priming pump not only permits the filling of the entire supply system as well as the injection pump sump, but also makes it possible to displace the air from the high pressure discharge tubings whenever this becomes necessary.

For the latter function, however, it is essential that the injection pump control rod be placed into full stop position and that the high pressure discharge tubing nipple nuts at the nozzle holder inlet studs be loosened to allow ready escape of the air trapped in the tubings.

FUEL PUMP TIMING

The importance of accurate injection timing cannot be overstressed, for upon it depends, to an appreciable extent, the operating characteristics of the engine. Engine manufacturers have spent much time and effort in determining the correct time of injection for most satisfactory engine performance, and it should not be departed from. This timing position may be set or checked by using the fuel pump coupling marks, or by the flow method, which is the more accurate of the two.

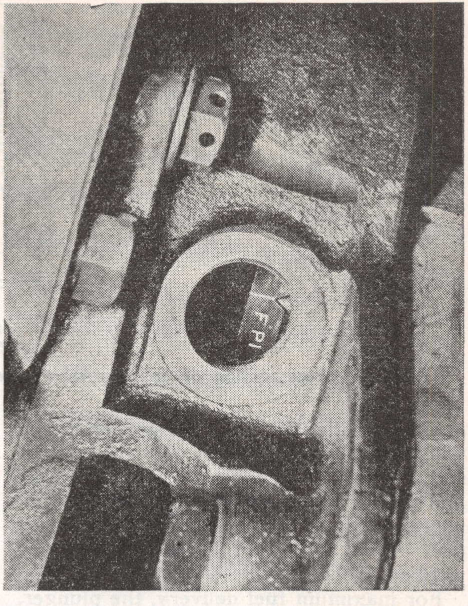


Fig. 9. Fuel injection timing mark.

TIMING FUEL PUMP TO ENGINE BY COUPLING MARKS

All fuel injection pumps of **APE** type are provided with timing reference markings on the fuel pump camshaft extension and endplates, respectively as illustrated in Fig. 7. The longitudinal marking on the camshaft is properly transferred to the pump half of the drive coupling, whether this is of American Bosch or the engine manufacturers. The injection pump endplates carry two reference lines marked R and L, denoting clockwise and counterclockwise rotation.

When the reference mark of the camshaft extension or coupling half registers with lines marked R and L, (Right and left hand rotation respectively), it indicates that the upward movement of the plunger in the pump cylinder No. 1, has just closed the fuel inlet port and that the oil within the barrel is now about to be placed under pressure, often referred to as port closing position. Some manufacturers provide their own reference marks for this same pump position as shown by Fig. 9.

Before attaching the injection pump to the engine, turn the engine over by hand until the pump timing position recommended by engine builder appears directly in line with either a scribed line or pointer usually located in the center of the timing hole in the bell housing. Be sure cylinder No. 1 is just completing the compression stroke and beginning the expansion. The flywheel of practically all engines are provided with some suitable marking to facilitate the proper position of piston for No. 1 cylinder, before top center. Usually the

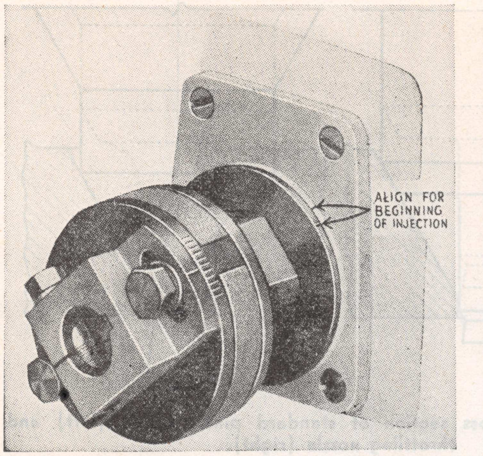


Fig. 10. Fuel pump timing.

flywheel is marked off in degrees from ten to forty, with numerals.

Then install pump assembly, tightening all attached screws, but leaving the rear half of coupling loose from the front half, so pump shaft can be rotated while drive shaft remains stationary at the recommended flywheel position, established by the engine builder.

The marks on the two coupling halves should then be arranged in such a manner as to have the proper reference marking alignment between the timing marking on the pump half of the coupling with the respective marking on the pump endplate or pointer as the case may be.

TIMING BOSCH FUEL INJECTION BY FLOW METHOD

Rotate flywheel by means of hand crank until the proper timing position as recommended by the engine builder appears in the timing hole in bellhousing. Be sure number 1 piston is just completing the compression stroke and beginning the expansion.

Install pump assembly, tightening all attaching screws, but leaving the rear half of pump coupling loose from front half so pump shaft can be rotated while the drive shaft remains stationary.

Connect all fuel suction and discharge pipes from fuel tank to pump. Install all high pressure fuel lines except to No. 1 cylinder. Place governor or throttle lever in wide-open or full load position and prime pump as described under that heading further on, then remove pump delivery valve holder 106D illustration No. 3 from No. 1 cylinder. Remove delivery valve 106B and spring 106C **but not the seat 106.** Replace delivery valve holder finger tight.

With governor lever still in full open position, operate hand pump until fuel oil starts to flow freely out of delivery valve holder, then rotate pump shaft by hand (engine drive shaft stationary) until the pump plunger of the No. 1 cylinder just starts rising, being sure to turn pump in proper rotation.

Operate the hand prime pump slowly at the same time, to keep the fuel oil flowing out of No. 1 delivery valve holder, then turn pump coupling slowly in proper rotation until flow of fuel oil just stops. Repeat this operation two or three times until a movement of less than 1/64" on the circumference of the Bosch coupling, see Fig. (10), is the difference between fuel flowing and not flowing.

This operation determines where the pump plunger just closes the fuel port and begins the period of building up pressure in the lines and nozzle, see "B" Fig. (2) so that injection can start, and it is very necessary that adjustment be extremely accurate.

When this position is established connect the front and rear half of the coupling together with capscrew, provided these screws are tight so no slippage can occur. It is usually good practice to re-check this setting after all connections are tight. This should be done by backing up the engine ten or twenty degrees ahead of the proper setting, to take out all backlash, then have someone turn the engine over very slowly by hand crank until the flow again just stops coming out of No. 1 delivery valve, while operating the hand pump slowly, if the setting has not changed, it should be at the same flywheel position.

Remove delivery valve holder and replace the delivery valve and spring. Install delivery valve holder, tightening firmly. Be careful not to get any dirt or any other foreign matter in or on any of these parts.

Connect No. 1 fuel line to pump and start engine. The engine may run uneven for several minutes, but if this continues stop and re-check timing.

SPRAY NOZZLES AND NOZZLE HOLDERS

The function of these units is to direct the metered quantity of fuel received from the injection pump into the engine combustion chamber in a definite spray pattern and in such a manner as to produce the most efficient engine performance.

Figure No. 11 shows a typical American Bosch nozzle holder and nozzle assembly with "A" indicating the holder, and "B" indicating the spray nozzle.

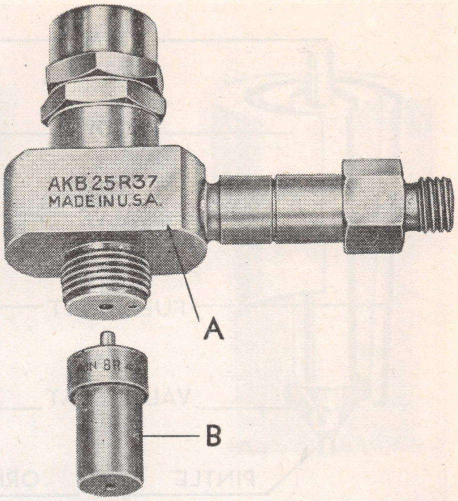


Fig. 11. Typical nozzle holder, spray nozzle and cap nut.

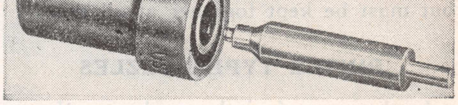


Fig. 12. Nozzle body and valve.

American Bosch spray nozzles are of the closed, differential-needle, hydraulically operated type. They utilize a spring-loaded valve with a seat at or near the spray orifice to close the orifice after each injection of fuel into the engine combustion chamber. The valve is operated hydraulically by the pressure of the fuel oil being delivered by the injection pump.

Most standard American Bosch spray nozzles used in commercial trucks consist of only two parts; the nozzle body and the nozzle valve, shown separately in Figure 12. These parts are made of allo

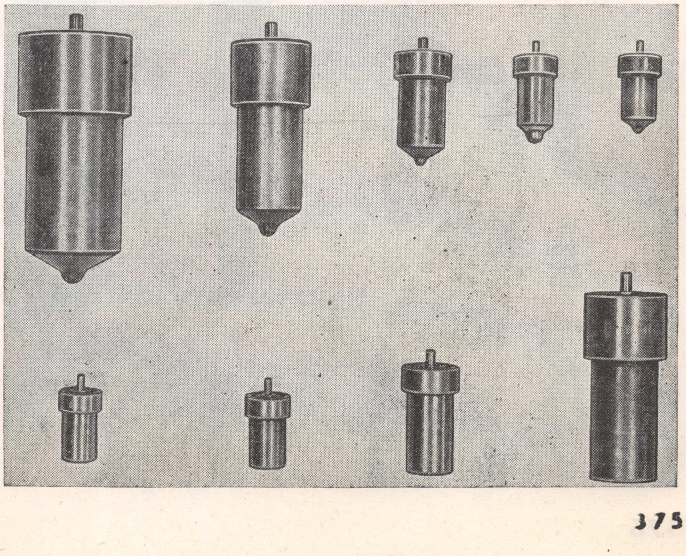


Fig. 11A. Upper row—Various sizes of hole type nozzles. **Lower row**—Various sizes of pintle type nozzles.

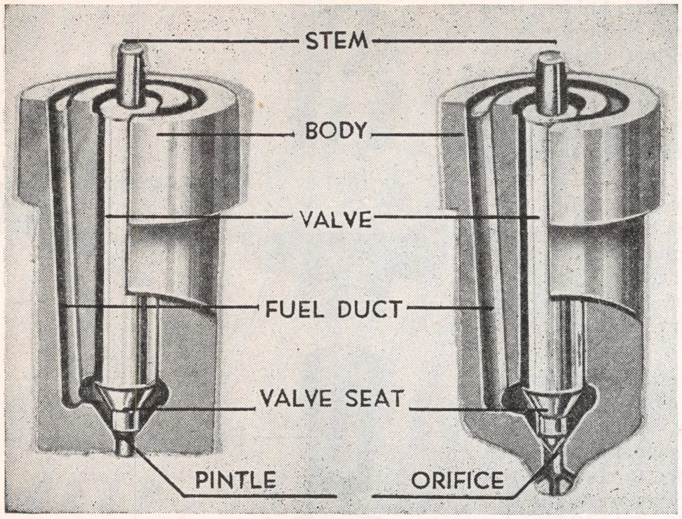


Fig. 13. Phantom cross section of typical pintle nozzle (left) and hole nozzle (right).

steel, heat-treated by special methods to minimize wear and promote durability. The body and valve of both nozzle types are lapped to form a mated assembly. The lapped fit is so close that measurement of it is impracticable except by a specially designed hydraulic instrument. Therefore, body and valve cannot be exchanged singly, but must be kept together at all times.

PINTLE TYPE NOZZLES

In the case of pintle nozzles, as shown in Figure 13, the nozzle valve carries an extension at its lower end in the form of a pin (called pintle) which protrudes through the closely fitting hole in the nozzle bottom. This requires the injected fuel to pass through an annular orifice, thus producing a hollow, cone-shaped spray, the nominal included angle of which may be from 0 to 60 degrees, depending upon the combustion system requirement. The projection of the pintle through the nozzle orifice induces a self-cleaning effect which is an important feature, discouraging accumulation of carbon at this point and appreciably increasing the permissible length of service without attention.

Pintle type nozzles are generally used in engines having precombustion chambers, divided chambers and air or energy cells.

HOLE TYPE NOZZLES

The hole type nozzles have no pintle but are basically similar in construction to the pintle type. They have one or more spray orifices which are straight, round holes through the tip of the nozzle body beneath the valve seat (Fig. 13). The spray from each indivdual orifice is relatively dense and compact, and the general spray pattern is determined by the number and arrangement of the holes. As many as eighteen spray holes can be provided in the larger American Bosch nozzles and the diameter of these drilled orifices may be as small as .006". The spray pattern may or may not be symmetrical, depending on the engine combustion chamber design and fuel distribution requirements.

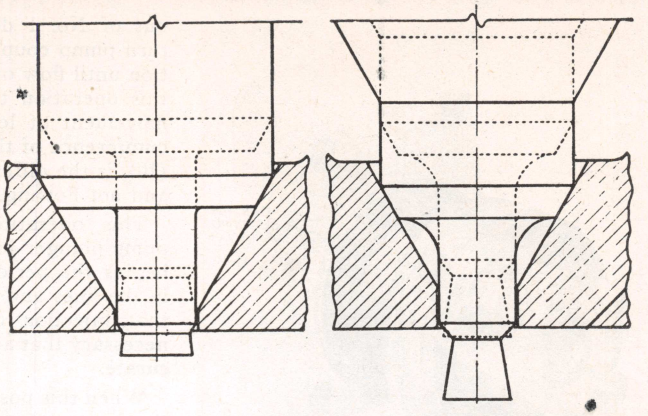


Fig. 15. Typical cross section of standard pintle nozzle (left) and throttling nozzle (right).

Hole type nozzles are generally used in engines having open chamber combustion systems.

THROTTLING TYPE NOZZLES

American Bosch throttling nozzles of the pintle type are extensively used to obtain maximum performance from small-bore high-speed engines. This type of nozzle has a throttling or delay characteristic whereby only a small amount of fuel is allowed into the combustion chamber at the beginning of injection, the rate of fuel flow being then progressively increased as the valve lifts higher.

The construction of the throttling nozzle is similar, as shown in Figure 15, to that of the standard pintle type, except that the pintle extends much farther from the nozzle body and the nozzle orifice is much longer.

NOZZLE HOLDERS

The nozzle holder is used to hold the nozzle in its correct position in the engine cylinder and to provide a means of conducting fuel oil to the nozzle. The holder also contains the necessary spring and means of pressure adjustment to provide proper action of the nozzle valve.

The component parts of the American Bosch nozzle holder, as shown in Figure 16, consist of a steel-forged holder body with drilled passages for conducting the

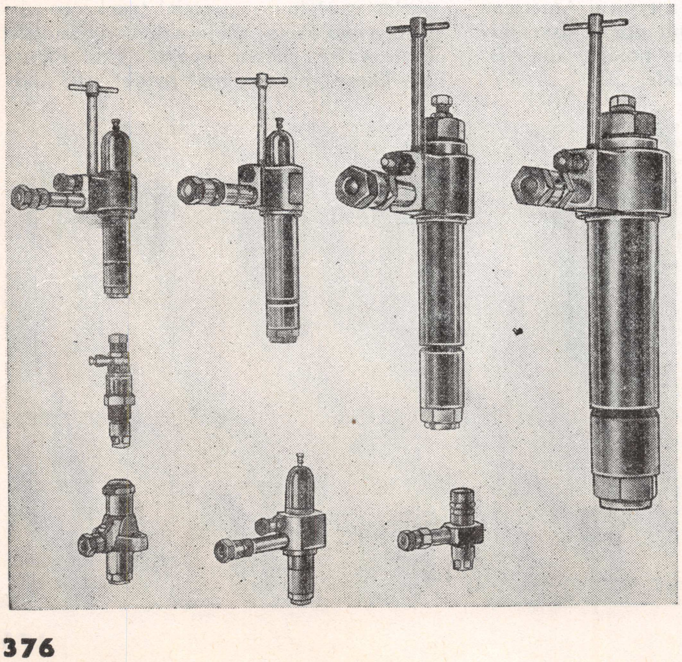


Fig. 16. Group of eight typical nozzle holders.

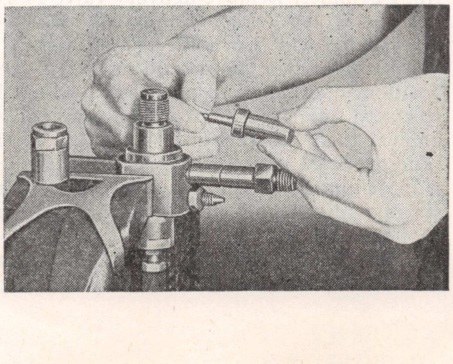


Fig. 16A. Removing nozzle from nozzle holder.

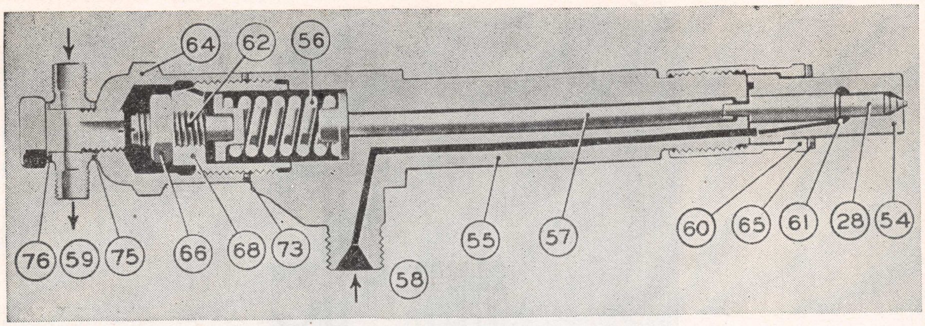


Fig. 17. NOZZLE AND HOLDER ASSEMBLY.

28—Pintle. 54—Nozzle body. 55—Nozzle holder. 56—Pressure adjusting spring. 57—Spindle. 58—Inlet. 59—Leakoff or drip lines. 60—Nozzle cap nut. 61—Pressure chamber. 62—Adjusting screw. 64—Nozzle holder cap. 65—Gasket. 66—Lock nut. 68—Spring retaining cap. 73, 75, 76—Gaskets.

fuel from the inlet connection to the nozzle. The lower end of the body is provided with an accurately ground and lapped surface which makes a leakproof and pressure-tight seal with the corresponding lapped surface at the upper end of the nozzle. This feature eliminates the necessity of a gasket and permits the nozzle to be easily removed from and reassembled to the holder. The nozzle is secured by means of the cap nut as shown.

At its upper end, the nozzle valve has an extension of reduced diameter, referred to as the "stem", which makes contact with the lower end of the spring-loaded spindle. Adjustment of nozzle valve opening pressure is accomplished by means of the spring pressure adjusting screw, or in some types of holders by means of spacers between spring and spring seat.

Operation of the American Bosch nozzle and holder assembly is simple and positive. The metered quantity of fuel from the injection pump enters the holder through the inlet connection and passes through connecting ducts to the pressure chamber just above the nozzle valve. At the instant the pressure of fuel acting on the differential area of the valve exceeds the pre-determined spring load, it will lift the valve from its seat and fuel will flow from the nozzle until delivery from the pump ceases. Then, a positive, instantaneous cut-off of fuel occurs as the valve is snapped to its seat by the spring force which eliminates the possibility of after dripping or dribbling.

A certain amount of seepage of fuel between the lapped guide surfaces of the nozzle valve and its body is necessary for lubrication. This leakage oil accumulates around the spindle and in the spring compartment, from which it drains through the leak-off connection provided for that purpose.

DISASSEMBLY AND CLEANING OF THE SPRAY NOZZLE

Before loosening any lines, apply kerosene or fuel oil freely to all connections, in order that dirt and grease may be removed. Detach high-pressure tubing and leak-off lines, covering their open ends with cloth or paper caps to protect against the entrance of dirt. Remove the holding nuts and pull assembly from the engine, being careful not to strike the end of the nozzle against any hard surface. A pry bar may be necessary to break it loose from carbon deposit caked around holder and tip.

After removing nozzles from engine, work in **clean** surroundings with **clean hands, on one nozzle at a time,** to avoid possible mix-up of parts. Place nozzle holder assembly (see Fig. 17, 55) in a vise, and remove cap nut (60) with a tappet wrench. Remove body (54) from cap nut. If held by carbon or tight gasket (65) hold nut in a brass bushing or sleeve of proper size and drive out body with a piece of wood, being sure not to hit pintle tip.

NOTE—Keep the pintle (28) with its body (54) as these parts are lapped to fit each other, and they will not fit when interchanged.

Remove protecting cap (64) and spring retaining cap (68) and take out pressure adjusting spring, (56) and spindle (57). Wash all of these parts in gasoline and blow dry with compressed air. The carbon around the nozzle body (54) may be scraped off freely after being soaked in fuel oil or kerosene. The carbon formation around the end of the nozzle body and pintle hole should be very carefully cleaned with a brass wire brush after soaking in Bendix cleaner. Do not use steel brush, sand paper, or sharp tools of any kind, as a fine scratch mark at the tip, will spoil the nozzle spray. The pintle seat in the nozzle body (54) should then be cleaned with a special brass tool designed (must not be steel) for this purpose, see (Fig. 18). The small orifice in the nozzle body through which the pintle protrudes should be cleaned by inserting a round wood tooth pick, turning it around several times. **Never attempt to clean this orifice with a drill or reamer of any kind.**

Wipe pintle (28) on a piece of mutton tallow, insert in nozzle body (54) and work in and out with a circular movement until the pintle is free. At times submerge in a can of clean fuel oil to flush the parts until the pintle is entirely free, and will drop of its own weight when held vertically. See Fig. 19. **The use of lapping compound of any kind is not recommended for this operation.**

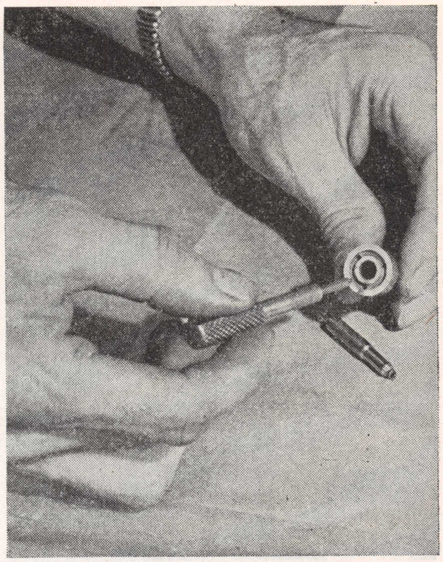


Fig. 18. Cleaning pintle seat with special brass tool (don't use steel).

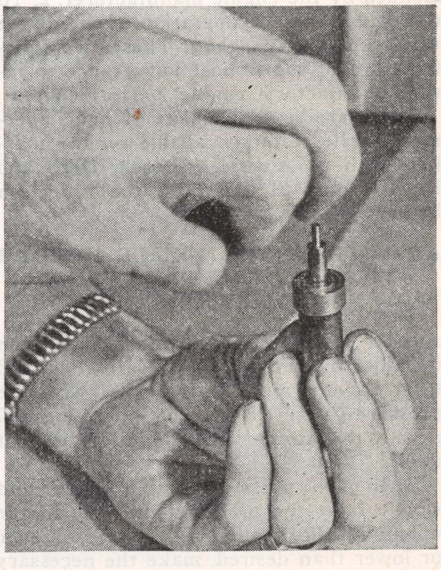


Fig. 19. Pintle should drop in body by its own weight.

The orifice of the hole type nozzle requires special cleaning needles that may be purchased at any authorized American Bosch service station.

Clean cap nut (60) thoroughly, as any carbon on its inside diameter or shoulder will disturb the centering of body (54). After cleaning the body and pintle thoroughly, it should be reassembled on the nozzle holder (55) using a special centering tool Fig. 20 which is available at any American Bosch service station. The centering tool is required to hold the body (54) concentric with the holder (55). **This is important, and assembly should not be attempted without its use.** Install spindle (57) and spring (56) being careful not to over-tighten cap nut (68). The nozzle is now ready for bench test as described below:

NOZZLE BENCH TESTER

A nozzle tester has two purposes: 1. To adjust nozzle holders so that the nozzle

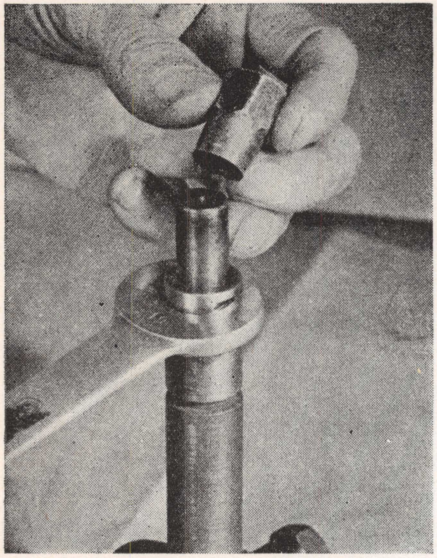


Fig. 20. Using special centering tool to hold body concentric with holder.

will open at a desired pressure, recommended by the engine manufacturer. 2. To test and check the operation of the nozzle valve and seats, sealing. These two functions are of the utmost importance to insure satisfactory engine performance.

There are several makes of hand operated nozzle testers available on the market, such as American Bosch, Deco and Buda. Figure 21 illustrates the American Bosch Tester.

ADJUSTING THE NOZZLE HOLDER TO THE DESIRED OPENING PRESSURE

After the nozzle and holder have been installed on the stand, operate the hand lever rapidly for a few strokes with the pressure gauge closed. This operation will permit the nozzle valve definitely to seat itself.

Open the pressure gauge valve and slowly raise the pressure until the nozzle opens. If the opening pressure is higher or lower than desired, make the necessary adjustment by turning the pressure adjusting screw of the nozzle holder clockwise if the opening pressure is to be increased; or counter-clockwise if the opening pressure is to be decreased. If no pressure adjusting screw is provided in the nozzle holder, vary the thickness of the pressure adjusting washers. Add washers if the opening pressure is to be increased and use thinner washers where the opening pressure is to be decreased. Repeat the above procedure until the desired opening pressure is obtained.

TESTING THE OPERATION OF NOZZLES

When the desired nozzle opening pressure has been obtained, slowly depress the hand lever of the test stand and observe whether the nozzle remains tight up to approximately 300 lbs. per square inch less than the nozzle opening pressure.

Turn the handle to close the pressure gauge and depress the operating lever rapidly in succession (at least 150 strokes per minute) and observe the nozzle spray pattern. If the nozzle functions correctly, the spray will be of closed formation and show no side streamers.

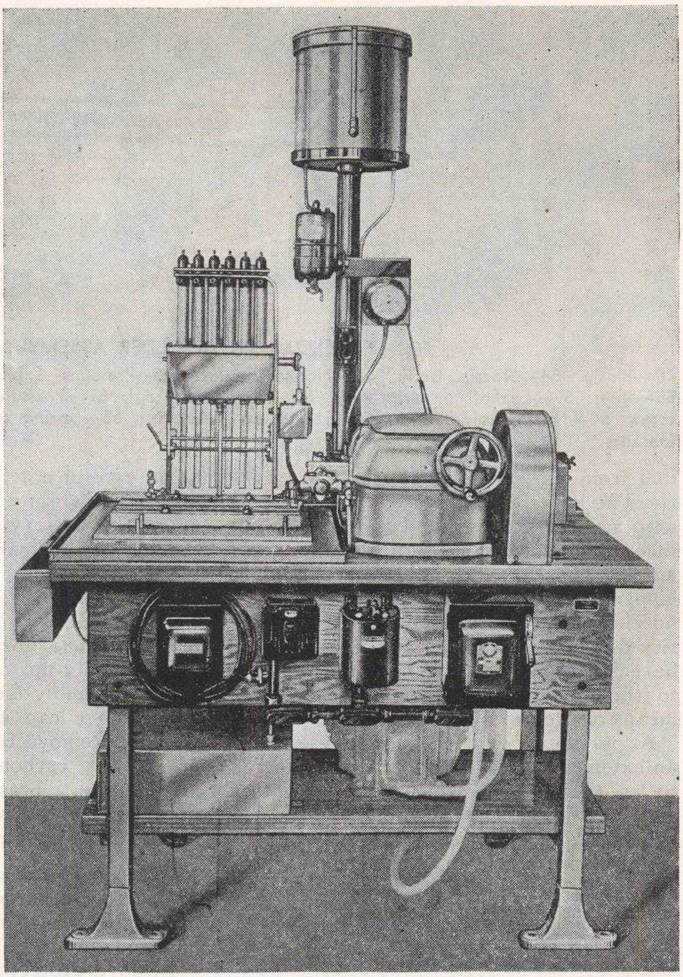


Fig. 21. Front view of American Bosch Diesel test stand.

Nozzles, which do not dribble at a pressure of 300 lbs. per square inch less than the set opening pressure and show a closed nozzle spray without side streamers at 150 strokes per minute, possess the characteristics necessary for proper engine operation.

NOTE—When the nozzle opening pressure at which the nozzle will be used is shown, all tests are to be made at that pressure. If the nozzle opening pressure is not known, use 1700 lbs. per square inch for the pintle type nozzle and 2400 lbs. per square inch for the "multiple hole" R, S, T and U size nozzles.

Chattering of the nozzle valve, noticeable when slowly operating the hand lever of the test stand, indicates correct functioning of the nozzle. Chattering is pronounced in standard pintle and hole type nozzles, and faint in throttling nozzles.

REASSEMBLY TO THE ENGINE

Thoroughly clean the nozzle recess in the cylinder head before re-inserting the nozzle holder assembly. Particular attention should be paid to the seating surfaces, in order that no small particles of carbon will cause the assembly to be cocked or permit blow-by of the combustion gases. No hard or sharp tools should be used for this cleaning operation. A round piece of wood or brass, properly shaped, is very effective.

Some engines are provided with a copper sleeve in the cylinder head which acts as a seating surface for the nozzle holder cap nut. Other manufacturers use a soft copper gasket between the seat in the cylinder block and the nozzle cap nut. In both cases, it is essential that there be no carbon flakes on these seating surfaces and wherever a gasket is used, it should be replaced with the same type.

The assembly should be carefully inserted, in order that the nozzle tip does not strike against the recess wall.

The assembly securing screws or nuts should be tightened evenly, in order that there will be no cocking of the unit.

High-pressure lines and leak-off connections should be replaced and tightened.

If the performance of the engine still indicates difficulties with the nozzle, it should be removed and sent to an authorized American Bosch service station, where complete test equipment is available.

VENTING AIR AND PRIMING THE FUEL SYSTEM

The most common cause of trouble with the fuel injection equipment, is air or

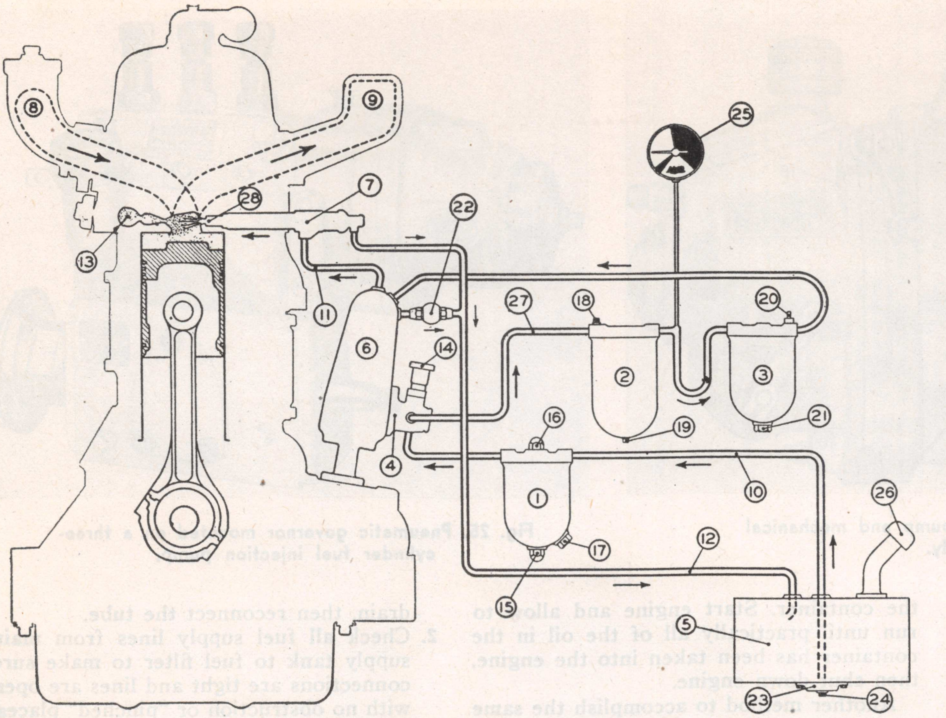


Fig. 22. FUEL DIAGRAM.

1, 2, 3—Filters. 4—Transfer pump. 5—Fuel tank. 6—Injection pump. 7—Injection nozzle. 8—Intake manifold. 9—Exhaust manifold. 10—Fuel line. 11—High pressure lines. 12—Return fuel line. 13—Energy cell. 14—Hand priming pump. 22—Pressure relief or overflow valve. 25—Pump pressure guage.

gas binding the fuel system, which usually results in poor starting and engine stopping.

This failure is caused by allowing the fuel pump to run out of fuel from one of the following reasons: 1. Fuel tank allowed to become empty. 2. Air leak in the suction line between the tank and the fuel transfer pump. (Assuming that the supply is lower than the Fuel Transfer pump). It must be realized that merely refilling the fuel supply tank or re-establishing the fuel supply after stoppage because of lack of fuel, will not remove the trapped air in the fuel system. If the engine stops or fails to start, first make sure the "stop" control has been moved to the position of running.

Whenever any fuel line between the discharge side of the transfer pump (4) (see fuel diagram Fig. 22), and the injection pump (6) is removed or even loosened, the system must be bled of air. This is also true even when the cartridge (2 and 3) is renewed, or when filter (1) is drained. When the engine is equipped with a hand priming pump (14) loosen the check valve fitting (22) and by using the hand priming pump, pull the fuel from the tank and force it through the filters (2 and 3) located between the transfer pump (14) and the injection pump (6).

It is best to leave the vent cock (18 and 20) open, (see diagram 22) until all the air is out of the system up to this point, then close vent cocks and pump fuel into injection pump until a solid stream of oil comes through the opening created by loosening the check valve fitting. Then tighten this connection. Usually it is not necessary to open and vent the system at different points, but merely operate the priming hand pump (14) until the pressure indicated by the gauge reaches the check valve (22) discharge pressure, which is usually 13 to 15 lbs. per square inch. Continue pumping a few moments longer to release completely all air past the check valve.

In the event the injection pump is not equipped with a hand priming pump feature, proceed as follows: A small can of two or three quarts capacity should be obtained, and a ⅜" copper or flexible tube attached to, or near the bottom of the tank. A nut, suitable for attaching a ⅜" copper or flexible tube to a ⅜" tube elbow should be assembled on the other end of the tube. To prime pump, it is only necessary to disconnect one end of the line (27) leading from the transfer pump to the fuel filter at the elbow installed in the filter (2). Hang this small can above the fuel pump, (6) and connect the tank tube to the filter elbow. Fill the tank with clean fuel oil. Oil will then flow through the filter and connecting tube, into the fuel reservoir in the injection pump, if the filter is clean.

It is not usually necessary to bleed the high pressure lines. It is even permissible to remove one or two of these lines and replace them without bleeding air, due to the fact that the engine will start and run even though missing on a few cylinders, until the air is forced out through the nozzles. After a few minutes operation the engines should pick up and run smoothly.

Should these lines be opened to bleed air crack the connection only at the nozzle end. Do not completely unfasten, as dirt may be introduced. Operate the priming pump that will develop sufficient pressure to open the injection pump check valves, and can be used to bleed the high pressure lines to all of the injector nozzles, provided the injection pump overflow line (12) to supply tank is first plugged and the injection pump control rack is placed in the shut off position. Then operate priming pump (14) until clean fuel, without air or bubbles, is forced through.

To bleed lines when no priming pump feature is supplied, work the pump plunger up and down by means of a screwdriver (see Fig. 23) until clean fuel with no air

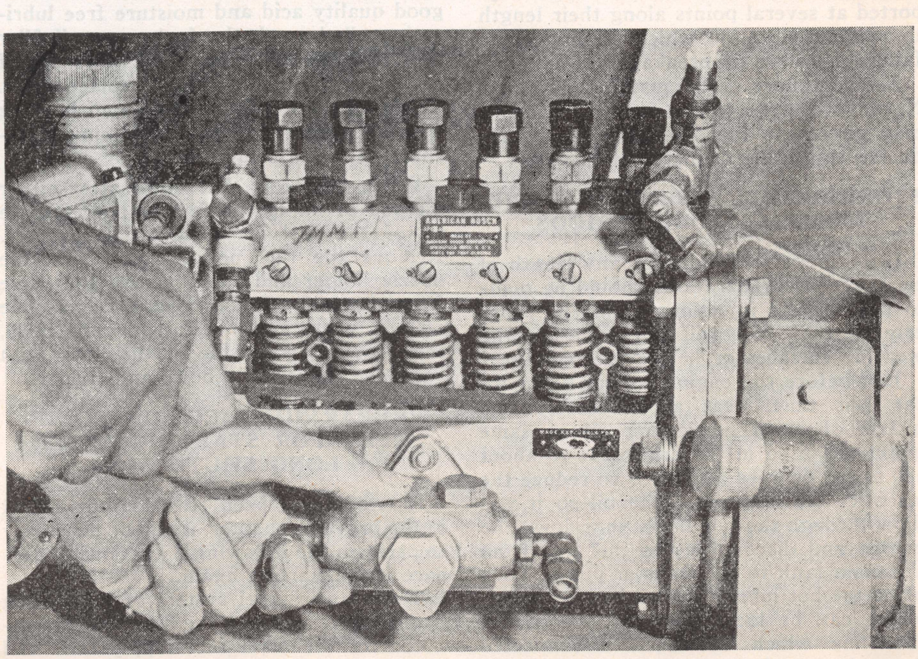


Fig. 23. Method of bleeding fuel lines when no priming pump is supplied.

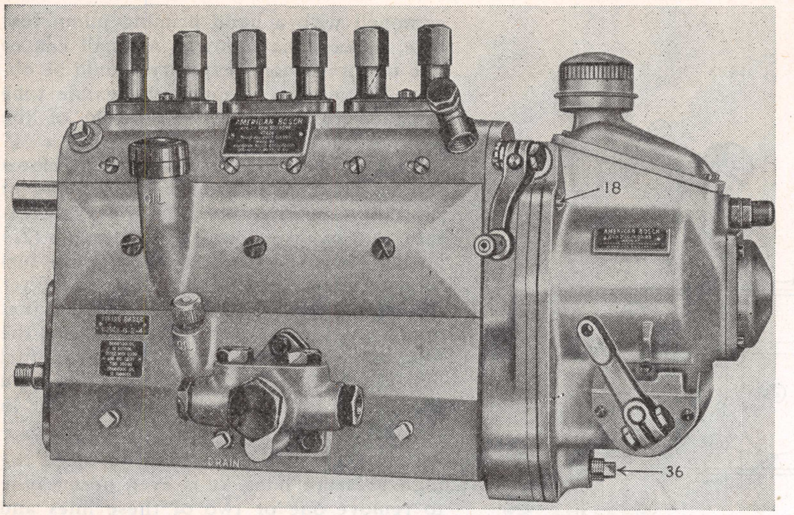


Fig. 24. Six-cylinder fuel injection pump and mechanical governor assembly.

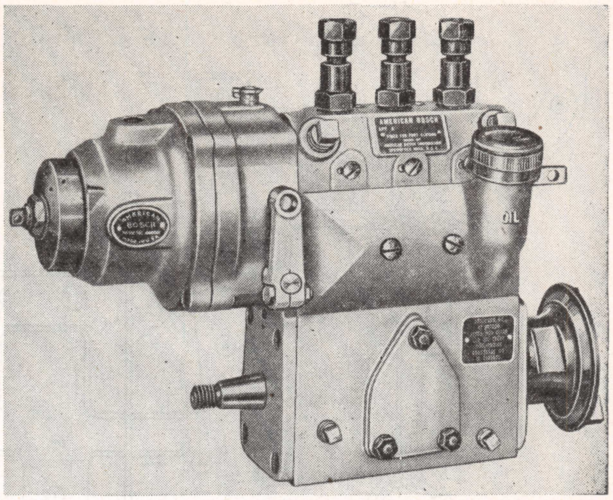


Fig. 25. Pneumatic governor mounted on a three-cylinder fuel injection pump.

or bubbles flows freely, then tighten high pressure fuel line nut at the nozzle. Continue the same operation on all cylinders, being sure the pump control rack is in the **full open position.**

HIGH PRESSURE FUEL INJECTION LINES

The high pressure discharge tubings, which carry the fuel under high pressure, are made of high tensile steel and most connections are fashioned with integrally swaged and reinforced tube ends. All lines should be of equal length, the latter having been determined by the engine manufacture on the basis of extensive trials of be best suited to injection characteristic required by the engine. It is therefore important that their length or inside diameter never be changed.

These lines should also be well supported at several points along their length to prevent vibration which might lead to failure because of breakage.

Should failure occur, install a new line. Never attempt to weld a failure, since this may affect the fuel characteristic by reducing the inside diameter of the tube.

STORING FUEL INJECTION EQUIPMENT FOR LONG PERIODS

If engine is to be idle for any length of time, special preparations should be made to prepare the injection equipment properly so that rust will not form on the wearing surfaces or in the fuel system.

Just before the engine is shut down for the last time, heat approximately two quarts of clean lubricating oil of same quality as used in the crankcase to about 180 to 200 degrees F. This is to reduce the viscosity (thickness) of the oil so it will flow through the fuel lines. Shut down the engine and disconnect the fuel line from the main tank to the transfer pump. Then place the hot lubricating oil in a container which can be located so the end of the fuel line which has been disconnected from the supply tank can be inserted in the container. Start engine and allow to run until practically all of the oil in the container has been taken into the engine, then shut down engine.

Another method to accomplish the same result is, after the engine has been shut down, to attach the two or three-quart tank, pouring about 2 quarts of this heated lubricating oil into it, disconnect the suction line from the tank to the transfer pump, either at the pump or at the tank, so that when the engine is started, fuel from the main tank will not be pumped all over the surrounding equipment. Start engine and allow to run until most of the oil in the small tank has passed into the fuel pump. Then shut down engine.

After engine is shut down, tape a small piece of gasket material over the breather hole on the fuel injection pump cover or inspection plate. Fill the fuel pump **full** of good quality acid and moisture free lubricating oil through the fuel pump oil filler hole. Fill the pump until oil flows out of this oil gauge hole and then replace cover. This procedure will fill the pump housing with oil, protecting the fuel pump camshaft, tappet assemblies, etc.

When engine is shut down after either method of filling the fuel system, remove all of the fuel or spray nozzle holders. Remove the fuel nozzle body from the nozzle holder and then remove the valve from the body. Put a coating of vaseline on the valve and return valve to body, then cover the outside of the body with vaseline. Reassemble body and holder.

PREPARING INJECTION EQUIPMENT FOR STARTING AFTER LONG SHUTDOWN

If engine has been stored as described in the previous chapter, it will be necessary to perform the following operations to prepare it for starting again.

1. Drain entire fuel system of lubricating or special oil. Open the drain on the bottom of the main fuel supply tank and allow all water and sediment in tank to drain, then reconnect the tube.
2. Check all fuel supply lines from main supply tank to fuel filter to make sure connections are tight and lines are open with no obstruction or "pinched" places.
3. Remove nozzle holders and wipe vaseline from outside surface of each nozzle. Do not wipe the vaseline off the valve in the valve body. Prime pumps and lines as described in the chapter under that heading.
4. When priming the fuel lines from pump to nozzles, connect the nozzles to the fuel lines and test as already described.
5. If nozzles do not function properly clean as already described.
6. Turn engine by hand three or four revolutions to spread the lubricating oil on the walls and bearings and start oil circulation.
7. Install fuel or spray nozzles and connect lines tightly.
8. Drain lubricating oil filtrator of all water and sediment.

AMERICAN BOSCH DIESEL GOVERNORS

There are two basic types of American Bosch governors: one a centrifugal mechanical governor and the other a pneumatic governor operated by vacuum of the engine intake manifold. Both are directly connected to American Bosch type APE fuel injection pumps without external linkages, and form a compact interconnected pump and governor unit.

Figure 24 illustrates a type GV mechanical governor mounted on the right-hand end of a six-cylinder injection pump, and Figure 25 illustrates a type AEP/MZ pneumatic governor mounted on the left-hand side of a three-cylinder injection pump.

BOSCH VARIABLE SPEED MECHANICAL GOVERNORS TYPE GVA OR GVB

The prime purpose of these governors is to serve as a means for pre-setting and

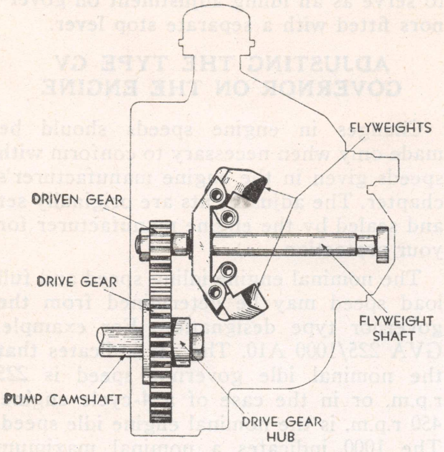


Fig. 26. Gear mounting on GV type governor.

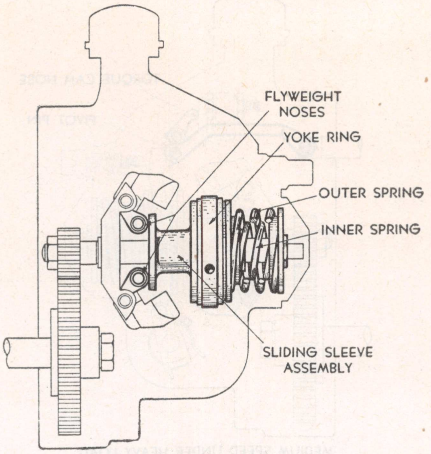


Fig. 27. GV type governor.

maintaining within close regulation any desired engine speed within the nominal idling and nominal maximum speed range, irrespective of engine load. In addition, these governors control the engine idling speed to prevent stalling and the maximum speed to prevent racing.

OPERATION OF THE GOVERNOR

Operation of the GV type American Bosch governor is easily understood and will be explained with the aid of Figures 26 and 31.

Figure 26: The governor drive gear is mounted on the end of the pump camshaft extending into the governor housing and engages with a smaller driven gear mounted on the flyweight shaft.

A friction clutch is built into the drive gear. The clutch is so designed that it causes the drive gear to slip on its hub momentarily whenever sudden changes occur in the speed of the pump camshaft. This feature assures smooth operation of the governor flyweights and helps to minimize governor wear.

The governor weights are attached to the flyweight shaft and rotate with it, at speeds higher than the camshaft, thus providing accurate governor control at all engine speeds.

Figure 27: As the weights revolve, centrifugal force tends to throw them outward, moving the weight noses longitudinally along the shaft. This movement is opposed by the governor spring or springs acting through the sliding sleeve assembly. The higher the speed, the greater the centrifugal force, and the longer the movement of the sleeve compressing the springs. If the speed is lessened, the spring force will exceed the centrifugal force of the weights and the sleeve will move toward the pump. Thus, any change in speed changes the position of the sliding sleeve assembly.

The complete sleeve assembly rotates with the flyweight shaft and springs, except a ring located between two ball thrust bearings. Two holes in the outer circumference of this ring serve as sockets for the pivot screws connecting the sleeve with the yoke.

Figure 28: The lower end of the yoke is attached to the yoke hub by means of a pivot pin. The yoke hub extends over the operating lever shaft, but is not directly connected to it. The adjacent shaft hub is firmly secured to the shaft and both hubs are interconnected through a double torsional spring. (An enlarged drawing of this feature is shown in Figure 29.) The ends of the spring straddle a lip on each hub and spring tension tends to keep these two lips in line with each other. Should the two become separated during the operation of the governor due to an overloaded engine, etc., the spring will bring them back in line as soon as the engine returns to normal.

Figure 30: A movement of the operating lever will rotate the shaft hub and the yoke hub, thereby causing the yoke to turn about the pivot screws. This movement changes the position of the pump control rod, for the upper end of the yoke is connected through a linkage to the control rod. The fuel quantity will be increased or decreased depending upon the direction of the operating lever movement.

An adjustable maximum fuel delivery stop plate is provided in the majority of GV governors, varying in shape to suit the individual engine builders' requirements. An extension or torque cam at the upper end of the yoke contacts the stop plate during full throttle position only, and will vary in angle with respect to the cam plate to meet certain fuel flow characteristics established by the engine builder. The control rod travel is therefore limited by the position of the stop plate, again established by the builder, and usually sealed.

Figure 30 illustrates a governor with the engine operating at high speed under load. The operating lever shaft hub and the yoke hub are in line with each other, and the yoke, pivoting about the pivot screws, has forced the torque cam against the stop plate thereby giving the maximum control rod movement. The weights are extended due to their revolving speed.

If the engine load were to be suddenly removed, the speed would increase, the weights would move outward still further, forcing the sleeve away from the pump, and the control rod would move to a position of less fuel delivery. This condition is known as **"High Idle,"** i.e., high speed with no load.

The bumper spring is so designed that it touches the yoke only at high idle speeds in order to eliminate the possibility of engine surges. It is **not** to be used for low idle speed adjustments.

Figure 31 illustrates a governor with the engine operating at medium speed, under

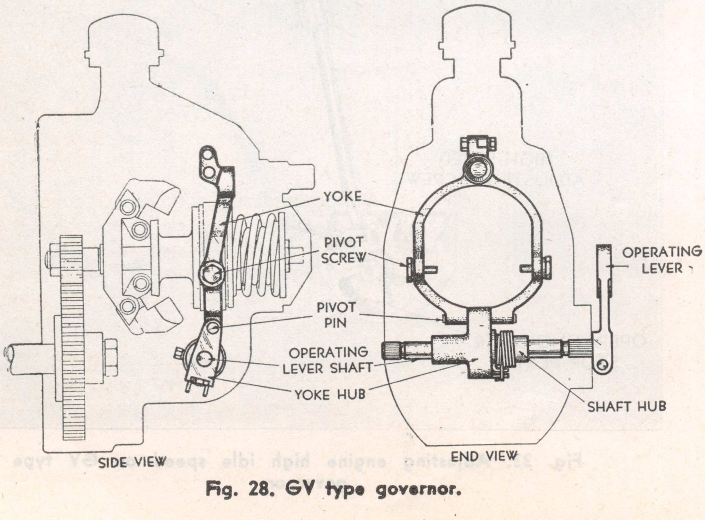


Fig. 28. GV type governor.

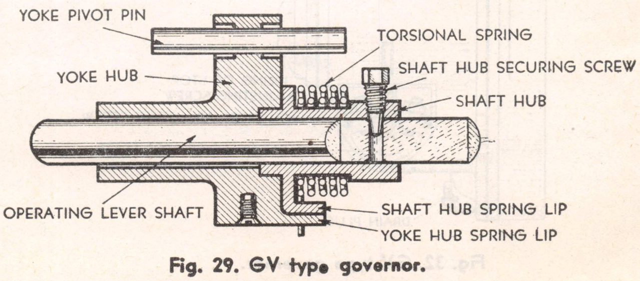


Fig. 29. GV type governor.

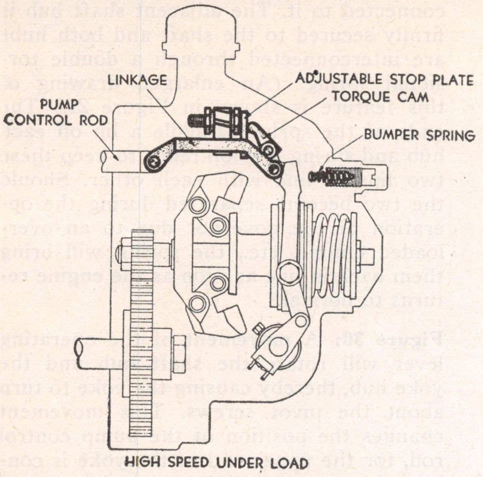


Fig. 30. GV type governor.

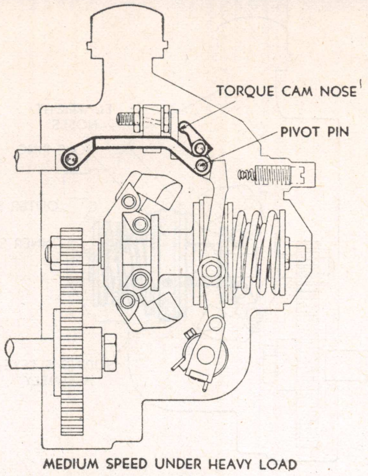


Fig. 31. GV type governor.

heavy load. The reduced speed has caused the weights to collapse somewhat from the position shown in Figure 30 and the sleeve has been moved toward the pump by the spring forces.

The yoke, connected to the sleeve, has also been drawn toward the pump. Movement at its upper end is limited by the stop plate and therefore the yoke pivots about the torque cam nose with the movement being absorbed by rotating of the yoke hub against the torsional spring. Notice that the two hubs are not in line with each other. As soon as the engine speed is restored, the torsional spring will force the yoke hub back to its normal position.

The torsional spring also prevents the operating lever from being forced into different positions by load changes and absorbs any inertia shocks which are created by sudden acceleration or deceleration of the governor masses. This feature is particularly appreciated in automotive installations where ease of foot accelerator movement is desirable to lessen driver fatigue.

Comparison of the control rod positions in Figures 30 and 31 will show that the control rod has moved slightly toward increased fuel delivery. This movement results from the pivoting of the yoke about the cam nose during the drop in speed. This is an important feature of the American Bosch GV governor, enabling slightly greater fuel quantities per stroke to be delivered at lower engine speeds and thereby improving the torque characteristic of the engine.

The angle of the torque cam in relation to the yoke affects the quantity of fuel increase at the lower speeds. **It is very important that once this angle has been set by the engine manufacturer, no changes be made in the angle since serious damage to the engine might result.**

Figure 32: A stop plate is rigidly pinned to the operating lever shaft and two adjusting screws are provided on the governor, one to limit the movement of the operating lever in the direction of high speed, and the other to limit the stop position, or to serve as an idling adjustment on governors fitted with a separate stop lever.

ADJUSTING THE TYPE GV GOVERNOR ON THE ENGINE

Changes in engine speeds should be made only when necessary to conform with speeds given in the engine manufacturer's chapter. The adjustments are originally set and sealed by the engine manufacturer for your protection.

The nominal engine idling speed and full load speed may be determined from the governor type designation. For example, GVA 225/1000 A10. The 225 indicates that the nominal idle governor speed is 225 r.p.m. or in the case of a 4-cycle engine, 450 r.p.m. is the nominal engine idle speed. The 1000 indicates a nominal maximum governor speed of 1000 r.p.m., or in the case of a 4-cycle engine, 2000 r.p.m. is the nominal maximum engine speed under full rated load. When the engine is under no load, the speed will increase above this governed figure to what is termed a high idle speed. This speed is shown in the engine manufacturer's chapter.

Warm up the engine thoroughly before attempting to make any governor adjustments.

Figure 33 illustrates a governor being adjusted for high idle speed. The bumper spring has been withdrawn and the operating lever, in this case at the rear of the pump and not showing in the photograph, has been moved toward full load position until the stop plate on the lever shaft has contacted the high speed adjusting screw. This screw is always the one nearer to the injection pump regardless of the governor mounting. When the engine reaches its maximum speed, check by means of a tachometer whether this is the high idling speed as specified in your engine chapter. If the speed is too low, raise the high speed

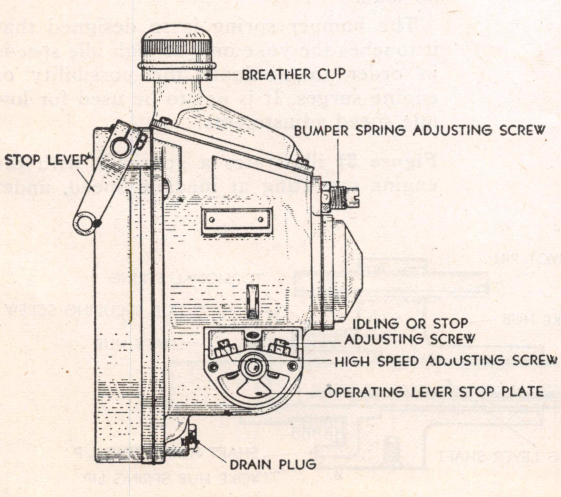

BREATHER CUP
BUMPER SPRING ADJUSTING SCREW
STOP LEVER
IDLING OR STOP ADJUSTING SCREW
HIGH SPEED ADJUSTING SCREW
OPERATING LEVER STOP PLATE
DRAIN PLUG

Fig. 32. GV type governor.

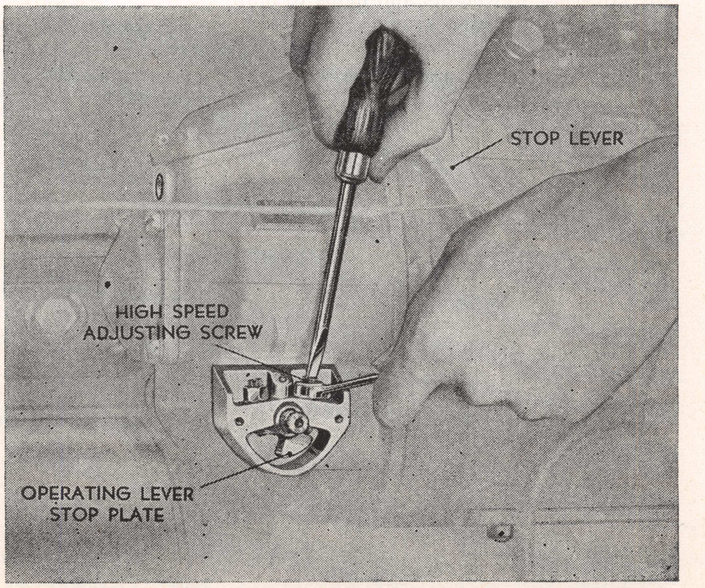


Fig. 33. Adjusting engine high idle speed on GV type governor.

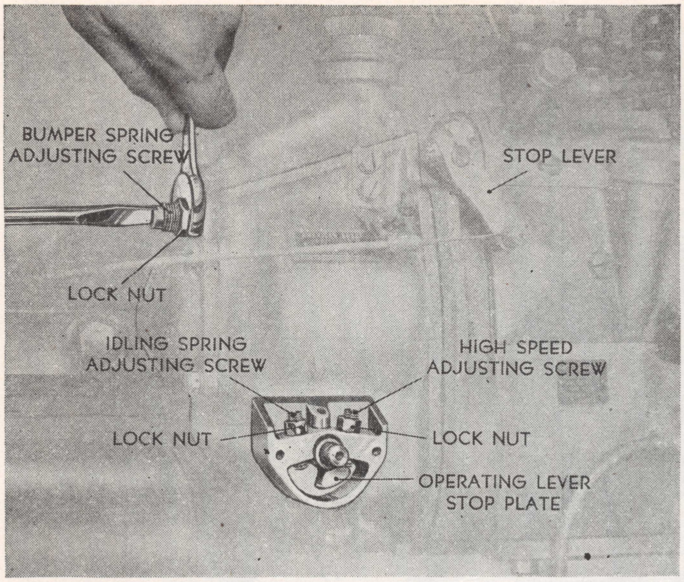

BUMPER SPRING ADJUSTING SCREW
STOP LEVER
LOCK NUT
IDLING SPRING ADJUSTING SCREW
HIGH SPEED ADJUSTING SCREW
LOCK NUT
LOCK NUT
OPERATING LEVER STOP PLATE

Fig. 34. Adjusting the high idle bumper spring on GV type governor.

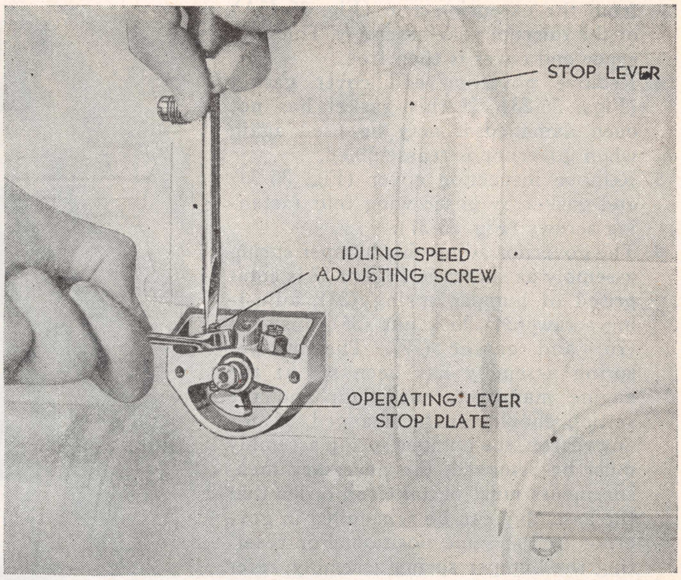


Fig. 35. Adjusting engine low idle speed on GV type governor.

adjusting screw and, if the speed is too high, lower the screw. After the correct speed is obtained, secure the adjusting screw by means of the lock nut and re-check the speed, making sure that the stop plate on the governor operating lever shaft is in contact with the adjusting screw.

Figure 34 illustrates the adjustment of the high idle bumper spring. With the engine still operating at the high idle speed, the bumper spring adjusting screw should be turned in until the button on the end of the spring just touches the pocket in the fulcrum yoke assembly without any appreciable increase in engine speed. **If the pump control rod oscillates rapidly back and forth at high idle speeds, screw in the bumper spring slightly further until the control rod is reasonably steady.** Re-check the engine speed with a tachometer and be sure that no excessive speeds have resulted from the bumper spring adjustments. It may be necessary to lower the high speed adjusting screw slightly.

Those governors which are equipped with a shutoff lever at the top of the governor housing as illustrated in Figures 32 through 35 use the screw farthest from the injection pump as an idling adjustment. Some governors are not provided with a shut-off lever, in which case, the screw is used as a positive stop with the idle speed being secured with the hand throttle.

Figure 35 illustrates a governor being adjusted for low idle speed. Move the operating lever in the direction of less speed until the engine reaches the correct idle speed. Hold the operating lever in this position and screw in the idling adjusting screw until its lower end touches the stop plate on the operating lever.

On governors not equipped with the stop lever, slowly move the governor operating lever in the direction of stop until it comes to a position at which the engine stops. Hold the operating lever in this position and screw in the set screw until its lower end touches the stop plate on the operating lever shaft. Lock the set screw in this position. The stop position of the operating lever brings the control rod of the injection pump into the zero fuel delivery position and not to the dead stop position of the control rod. After locking the screw, start the engine and re-check for a positive stop.

The nominal idling and maximum speeds controlled by the governor cannot be varied to any great extent because they depend entirely upon the characteristics of the spring combination contained in the governor unit, usually established to suit the individual engine builder.

MAINTENANCE

All governor covers should be securely fastened in place to prevent dust from entering the assembly. The governor compartment, the pump spring compartment and the pump camshaft compartment are interconnected and have a common lubricating oil sump. It is important that the correct oil level be maintained at all times. The pump housing is provided with an oil level fitting which allows excess oil to drain from the pump and governor.

The oil should be changed each time that the engine crankcase oil is changed. At such time, the oil should be completely drained from both units by means of drain plugs located in the bottom of the pump housing and a drain plug illustrated in Figure 32 at the bottom of the governor compartment. The compartment should be refilled through the breather cap on the pump inspection cover with clean engine oil, preferably SAE No. 30. Add only enough oil to reach the pump oil level fitting.

SERVICE INSTRUCTIONS

In the event it is necessary to dismantle the governor, it is suggested that the complete fuel injection pump assembly be removed from the engine. The injection equipment can then be taken to a clean table or work bench. When removing the units from the engine, the following precautions should be taken:

1. Before breaking any oil lines from the pump, thoroughly clean the equipment with fuel oil. When the lines are removed, the openings on the pump should be covered or plugged to prevent dirt from entering the system.
2. Remove inspection cover of injection pump. Slowly turn the engine over until it is noted that the plunger of the pumping element closest to the pump drive coupling is in its top position. If the engine is left in this position and the adjustment of the coupling is not touched, the pump can be reinstalled in this position on the engine without the necessity for retiming.
3. Disconnect the engine throttle linkage from the governor operating lever. Do not remove the governor operating lever from its shaft or alter its position.
4. Remove complete injection pump and governor assembly from engine.

DISMANTLING THE GOVERNOR

(After Injection Pump Assembly is Removed from Engine)

1. Remove pipe plug (Fig. 36) and drain all lubricating oil from governor unit. As there is an open connection between the injection pump camshaft compartment and the governor, the governor should be tilted downward in order that all oil may be drained.
2. Remove six governor housing fastening screws. Four are located on the front side and two are on the rear of the governor housing.
3. Carefully withdraw governor end cover approximately one inch away from the housing and then slightly shift the governor assembly in a side ways movement toward the inspection cover side of the pump in order to disengage the control rod linkage pin (Fig. 36-54)

from the extension arm (Fig. 36-45A) of the fulcrum yoke assembly. The governor end cover is then free.

4. Remove governor end cover gasket (Figs. 36-23). If this gasket has not been damaged it may be used again when governor is reassembled.
5. Remove inspection cover (Fig. 36-30) and gasket by unscrewing four fastening screws (Fig. 36-31).
6. The governor adjustable bumper spring assembly as shown in Figure 37 is comprised of bumper spring (33), adjusting screw (34), lock nut (35), dust cap (76) and gasket (77). The bumper spring assembly has been set at the engine manufacturer's plant and the setting should not be changed. If, for any reason, the bumper spring assembly must be removed, the necessary measurements must be taken in order that the assembly can be reinstalled in governor in the same position. For resetting the bumper spring assembly, refer to the chapter under "Adjusting the Type GV Governor on the Engine."
7. The position of the governor operating lever is important. Some governors have a scratch line across the end of the lever shaft which registers with a mark on the operating lever. On those governors where there are no marks on the operating lever or shaft end, a scratch mark must be inscribed on the lever and shaft before disassembly, in order that these two parts can be clamped together in their proper relative positions when the governor is reassembled. The operating lever can be removed by loosening the operating lever clamp screw.
8. The setting of the stop plate (Fig. 38-37) has been made at the engine manufacturer's plant and this adjustment should not be altered. The stop plate assembly should not be removed from the governor unless it is necessary in order to make replacement of parts. The upper front edge of the stop plate should line up with the locating lines which have been inscribed on the top machined surface of the governor end cover (see Fig. 38). If there are no markings on the governor end cover, a small line should be inscribed on both sides of the top machined surface of the cover directly in line with the upper front edge of the plate. These marks

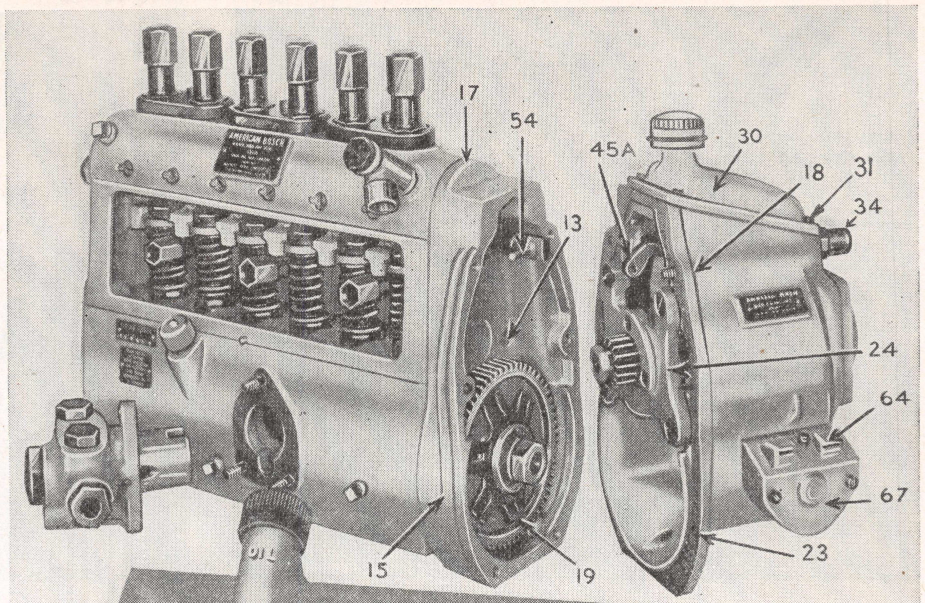


Fig. 36. Removing GV type governor end cover assembly.

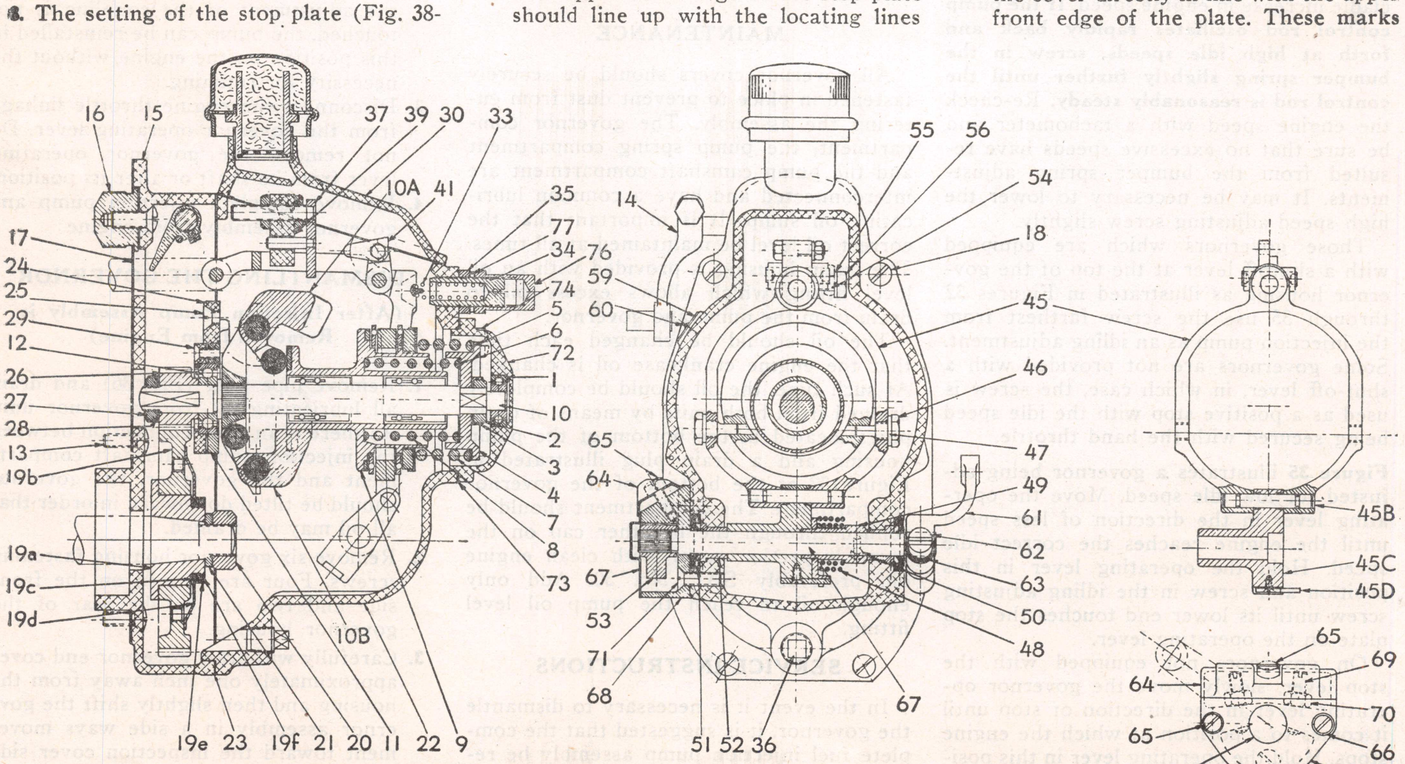


Fig. 37. Cross section of GV type governor assembly.

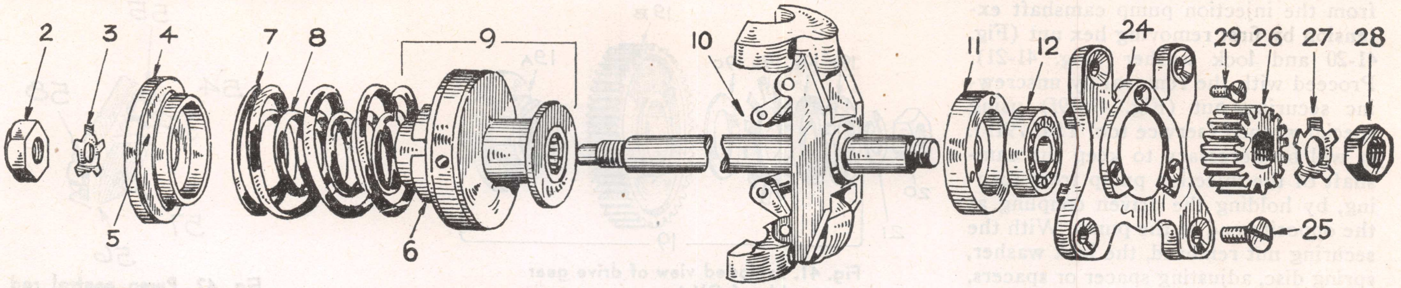


Fig. 39. Exploded view of governor flyweight and sliding sleeve assembly.

should be made for about 1/8" from each inner edge of the housing top and should not extend completely across this surface, in order to prevent the possibility of any oil leakage at this point.

9. The cam nose (Fig. 38-41) has likewise been adjusted by the engine manufacturer, and its position should not be altered. It will be noted that there is a locating line inscribed across the cam nose and extending to the adjacent fulcrum yoke. If replacement of the cam nose or yoke assembly is necessary, its angle should be carefully noted in order that the reassembly may be installed in the same manner.
10. Remove cover plates (Fig. 37-64 & 67) by unscrewing three fastening screws.
11. Using a 3/16" hex socket wrench (service tool TSE 7918), remove set screw (Fig. 38-50).
12. Slide out operating lever shaft (Fig. 38-53).
13. Unscrew four fastening screws holding bearing bridge (Fig. 38-24) to governor end cover and carefully pull out the internal operating parts of the governor as a unit (Fig. 38).
14. Should it be necessary to remove end cap (Fig. 38-72) in order to replace the ball bearing in the cap, unscrew four fastening screws (Fig. 38-74). The ball bearing can be removed by using special puller (service tool TSE 7916).
15. If it is necessary to remove stop flange (Fig. 38-68) in order to replace operating lever shaft oil seal or bearing, the stop adjusting screws (Fig. 38-69) must be loosened and the three flange fastening screws (Fig. 38-71) must be removed. Before disturbing the setting of the stop adjusting screws, a measurement should be recorded in order that they may be reassembled in approximately the same position.
16. Withdraw operating lever spring (Fig. 38-48) and hub as a unit.
17. Unfasten pivot screws (Fig. 38-46) to disengage fulcrum yoke assembly (Fig. 40-45).

CAUTION—Do not remove or alter setting of cam (Fig. 40-41). If, for any reason, the setting of the cam has been disturbed, it should be installed so that the scratch line on top of the cam registers with the cross mark on the fulcrum yoke proper.

18. Remove hex nut (Fig. 39-28) and locking washer (Fig. 39-27) and withdraw driven gear (Fig. 39-26) from flyweight shaft.
19. Slide bearing bridge (Fig. 39-24) from shaft.
20. The ball bearing in the bridge may be removed by unscrewing three fastening screws (Fig. 40-29) which hold the bearing plate.
21. Remove hex nut (Fig. 39-2) and locking washer (Fig. 39-3) from end of shaft.
22. Slide spring seat (Fig. 39-4) from shaft.
23. Remove governor springs (one or two are used, depending on governing speed requirements), **being careful to retain all outer and inner spring spacers** (Fig. 39-5 & 6). The inner spring spacers may either be located on the side next to the spring seat or against the sliding sleeve assembly. For details concerning the use of spacers for the proper spring adjustment, refer to item 5 under "Assembly of the Governor".
24. Disengage sliding sleeve assembly (Fig. 39-9) from flyweight assembly (Fig. 39-10). Do not disengage these two assemblies unless necessary as separating these parts might permit the balls of shaft bearings to drop out. No attempt should be made to disassemble either of these assemblies since their component parts are not serviceable.

    Reference should be made to Figure 39, which clearly indicates the position of the internal parts with respect to one another.
25. The drive gear and friction clutch assembly, (Fig. 41-19) can be removed

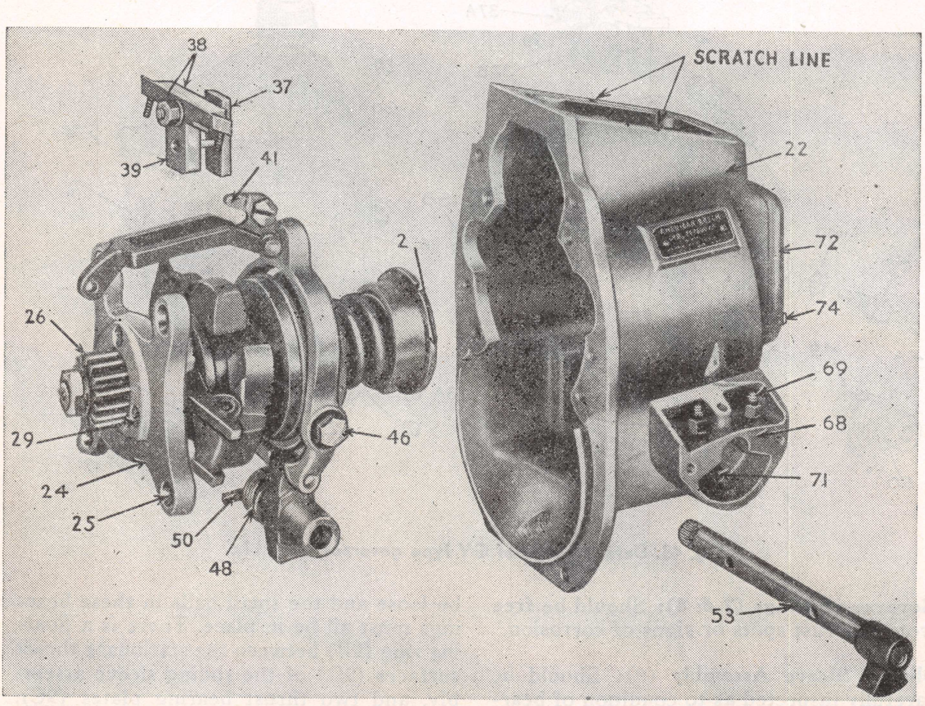


Fig. 38. Dismantling the GV type governor.

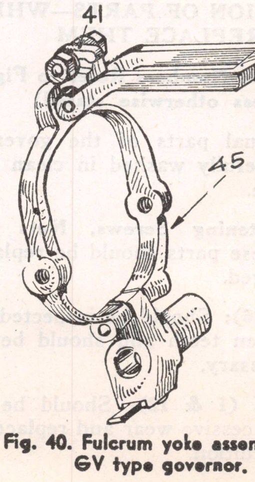


Fig. 40. Fulcrum yoke assembly of GV type governor.

from the injection pump camshaft extension by first removing hex nut (Fig. 41-20 and lock washer (Fig. 41-21). Proceed with the removal by unscrewinc securing nut (Fig. 41-19f) using special wrench (service tool TSE 7919). It will be necessary to keep the camshaft of the injection pump from turning, by holding the driven coupling at the opposite end of the pump. With the securing nut removed, the lock washer, spring disc, adjusting spacer or spacers, and drive gear (Fig. 41-19e, 19d, 19c, 19b) may be removed.

26. Use special puller (service tool TSE 7920) on thread of hub (Fig. 41-19a) to withdraw the hub from the camshaft taper. A puller should never be used in the two threaded holes which are to be found in some driven gears, since it has been found that in pulling against the spring disc (Fig. 41-19d), serious distortion of this spring is liable to occur.

27. It is not necessary to remove the governor housing (Fig. 36-15) to repair the governor or injection pump, even if it is necessary to remove the pump camshaft. The housing should remain tightened to the pump whenever possible. If, for some reason, it is necessary to remove the housing, proceed as follows:

    The governor housing and gasket (Fig. 36-15 & 17) can be removed from the pump by unscrewing four fastening screws (Fig. 36-13) and one screw inside top of housing. The governor housing acts as an end plate for the camshaft of the pump. It is, therefore, necessary to install tappet holders (service tool TSE 7692 for APE. A injection pumps and TSE 7693 for APE. B injection pumps) under the tappet screws of the injection pump to insure that the internal parts of the injection pump do not fall out of position when the camshaft is not held up by the bearing in the governor housing.

28. In type GVA only (not in GVB), there is a linkage arm between the fulcrum yoke extension arm (Fig. 36-45A) and the injection pump control rod. This can be removed by unscrewing fastening screw (Fig. 42-58).

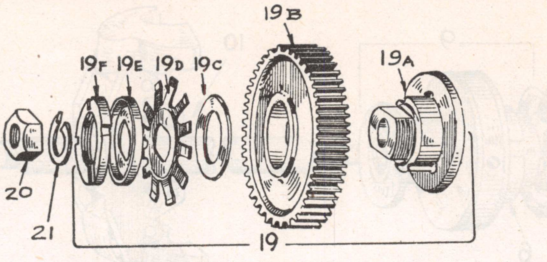


Fig. 41. Exploded view of drive gear assembly of GV type governor.

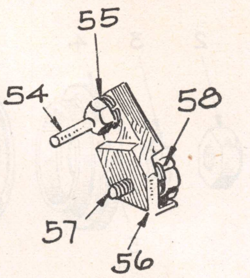


Fig. 42. Pump control rod extension arm assembly of GV type governor.

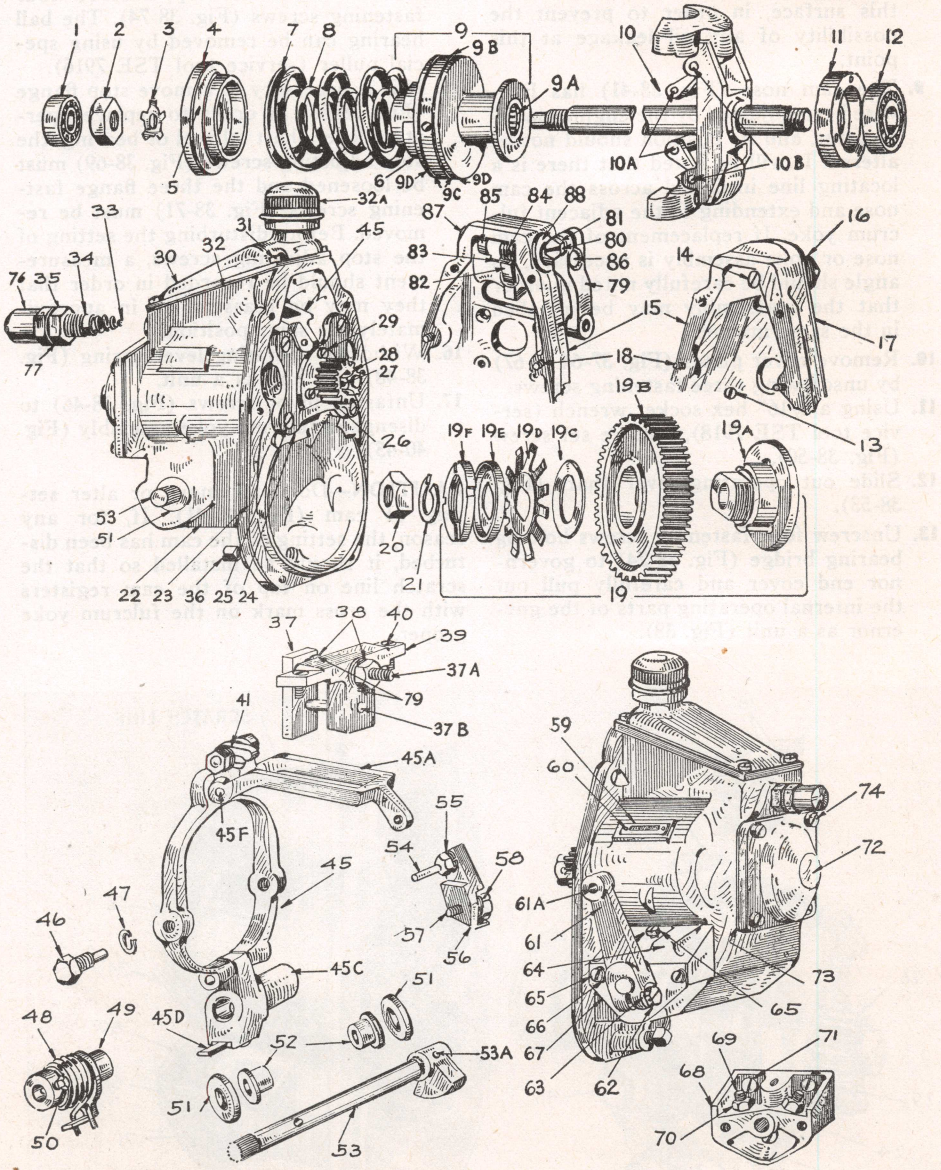


Fig. 43. Detailed view of GV type governor assembly.

EXAMINATION OF PARTS—WHEN TO REPLACE THEM

(All Illustration Numbers Refer to Figure 43 unless otherwise stated)

The individual parts of the governor should be carefully washed in clean fuel oil or gasoline.

Gaskets, Fastening Screws, Nuts and Washers: These parts should be replaced if at all damaged.

Drive Gear (26): Should be inspected for wear or broken teeth and should be replaced if necessary.

Ball Bearings (1 & 12): Should be inspected for excessive wear and replaced if not in A1 condition.

Governor Springs (7 & 8): Should be free from any rust spots or signs of corrosion.

Sliding Sleeve Assembly (9): Should be carefully inspected as to condition of bearings. The two shaft bearings (9A) must not be loose and the small balls in these bearings must all be in place. There is a floating ring (9B) between the stationary thrust surfaces (9D) of the sliding sleeve assembly, and two thrust bearing plates (9C). The total clearance between these parts should not exceed .006". In making a check for the proper clearance, it is recommended that the feeler gauge be inserted between the ring and either one of the bearing plates to get the advantage of a larger contact surface. It is important that the feeler gauge be inserted far enough to go between the balls of the bearing plates and the ring. No attempt should be made to repair the sliding sleeve assembly. If it is not in good condition, the entire assembly should be replaced as a unit.

Flyweight and Shaft Assembly (10): The rollers (10A) must not be appreciably worn or loose on their holding pins. The flyweights should move freely on pivot pins (10B) but they must not be too loose.

Bumper Spring (33): Early types of springs were not provided with a steel, mushroom-shaped button on the end. It is desirable that these early types be replaced, because the button makes a better contact with the fulcrum yoke and eliminates the possibility of the spring catching in the yoke cup.

Fulcrum Yoke Assembly (45): As previously explained, the position of the cam (41) should not be changed, but it should be made certain that it is clamped firmly in place. The cam is in the correct position if the cross line on the top of cam registers with the cross line on the yoke. The cam must not show signs of wear. There must not be excessive play of the linkage arm (45A) and pin (45F) with respect to the yoke (45). There must not be excessive play between the hub (45C) and the yoke (45). Extension piece (45D) must not be distorted and must be firmly staked in place. If the yoke is distorted or if the play between the linkage arm and the yoke and between the hub and the yoke is excessive, the whole assembly must be replaced as a unit.

Operating Lever Shaft Oil Seals and Bearings (51 & 52): Should be inspected for wear or damage and should be replaced if necessary.

Operating Lever and Shaft (53 & 61): The pin (53A) should be tight in place and the stop plate sector should not be loose on its shaft. The hole (61A) in the operating lever should not be excessively worn. Serrations on both the control lever and shaft should be in good condition.

Stop Adjusting Screws & Nuts (69 & 70): If it has been necessary to remove these parts or replace them, this fact should be noted so that they may be re-set in the proper positions after the governor and injection pump assembly is installed again on the engine.

Stop Plate Assembly (37, 38 & 39 & 79): The plate (37) should be examined for any wear which may have been caused by the cam (41). The threaded stud (37A) and the pilot pin (37B) must be firmly fastened to the plate. The adjusting nuts (38) must not be loose. If it appears that these nuts have worked loose, this fact should be noted as the position of the stop plate must then be carefully checked when the governor is reassembled. For details concerning the setting of the stop plate (37), see individual engine builder's requirements.

Drive Gear and Clutch Assembly (19): The drive gear (19B) should be inspected for excessively worn or broken teeth. The surface on the face of the gear which contacts the clutch disc (19D) should be smooth. The hub (19A) should be inserted into the drive gear (19B) and the clearance between the two parts should not be excessive, to the extent that the gear could operate eccentrically. Spring disc (19C), lock washer (19E) and lock nut (19F) should be replaced if damaged or badly distorted.

ASSEMBLY OF THE GOVERNOR

(All Illustration Numbers Refer to Figure 43 unless otherwise stated.)

CAUTION—Do not attempt to assemble governor before reading the following instructions:

1. **After the parts have been carefully cleaned, inspected and replaced when necessary, in accordance with the instructions outlined in the preceding sections, the governor can be reassembled.**
2. **Ordinarily, it will not be necessary to install the governor housing (15) as this part need not be removed to repair the governor or injection pump, even when it is necessary to remove the pump camshaft. However, if for some reason it has become necessary to install a new governor housing, proceed as follows:**

   Press the outer race of the camshaft ball bearing into the housing. No packing seal is required between the pump camshaft and the governor compartment. The end face of the injection pump must be absolutely clean. The governor housing (15) and gasket (17) can be installed and secured by four fastening screws (13) and the screw (14) in the upper part of the governor housing. The camshaft end play of the injection pump should then be carefully checked, and should be within the limits of .004" and .010".
3. **With the housing properly installed, the drive gear and clutch assembly (19) should be mounted on extending camshaft taper. No key is used, although a keyway is provided in the camshaft taper. The clearance between the drive gear hub and the drive gear should be re-checked after the hub has been securely tightened on the camshaft taper. With ample clean lubricating oil between the hub and the drive gear, the latter should rotate freely and easily without binding in any position. If necessary, the gear and its hub may be lapped slightly to provide a nonbinding assembly. Reassemble the component parts of the clutch assembly in the relative positions, as shown in (Fig. 43-19).**

   With the securing nut (19F) firmly tightened, the clutch tension should be carefully checked, as illustrated in Fig. 44. The friction surfaces of the drive gear (19B) and the spring disc (19D) should be well covered with lubricating oil. The gear should rotate with a steady pull of approximately 2¼ to 2¾ pounds feet. A one-foot lever, service tool TSE 7922 or TSE 7928, is used to measure this pull with spring scale TSE 7927. Service tool TSE 7921 is used on governors having a drive gear

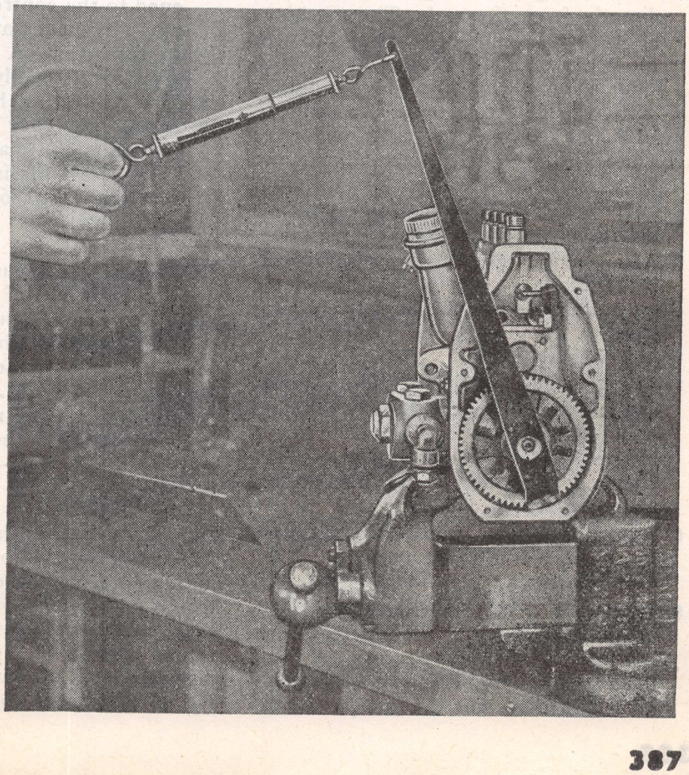


Fig. 44. Method of checking clutch tension of GV type governor.

of 3 15/16" diameter and 61 teeth, and service tool TSE 7928 is used with governors having a drive gear of 3⅝" diameter and 57 teeth.

The drive gear should move through a complete revolution on its hub, with fairly uniform resistance. The gears should not move freely in one spot and rough in another, but should revolve without clutching with the pull of 2¼ or 2¾ foot pounds. If the tension is too great, install another shim (19C), or if the gear moves too freely, remove sufficient shims to give the proper slippage. Three shims thicknesses are available (0.035", 0.049" and 0.065").

4. Slide the sleeve assembly (9) over the shaft of the weight assembly (10). The bearings within the sleeve assembly should be packed with American Bosch special temperature resisting grease No. US 508.
5. Install governor spring or springs (7 and 8) and slide on spring seat (4), making sure that the proper number of spring spacers (5 and 6) are installed in accordance with the adjustments as given in the governor parts list for the particular type involved. Certain types of governors use only one spring, while others use two. Whenever inner spring spacers are necessary, they should be installed at the sliding sleeve assembly end of the spring. If the adjustments as given in the governor parts list call for an innerspring gap, this may be measured with service tool TSE 7924. The prongs of the tool are installed through the two holes in the governor spring seat, with the seat tightened against its shoulder by the securing nut (2). Insert the prongs of the tool until they press against the innerspring, without compressing the spring, and read the gap setting in millimeters directly from the scale. The markings on the scale should be lined up with the outer shoulder of the spring seat. This may be checked by laying a straight edge across these two surfaces. Install or remove a sufficient number of spacers to give the proper adjustment. This adjustment varies for different governor characteristics as required by individual engine builders.
6. After completing the proper spring adjustments. the securing nut (2) should be tightened with the lock washer (3) beneath. Bend over the prongs of this lock washer.
7. Slide bearing plate (11) on the opposite end of the flyweight shaft, together with ball bearing (12) and bearing bridge (24). These three parts are clamped together by means of the clamping screws (29).
8. Assemble driven gear (26) on shaft, firmly tighten in place by hex nut (27), and secure with lock washer (28).
9. Fasten fulcrum yoke assembly (45) to sliding ring (9B) of the sleeve assembly by means of pivot screws (46) and lock washer (47). The cam (41) should be installed so that the line on the top of the cam registers with the locating marks on the fulcrum yoke.
10. Assemble the operating lever spring (48) to the hub (49). The end of the coil spring should straddle the spring plate which is an integral part of the hub. The spring may be drawn into position with a wire loop and should be so assembled that it will be under tension. The hub and the spring assembly should be slid into the fulcrum yoke hub so that the spring also straddles spring plate (45D).
11. If necessary to install new control shaft bushings (52) in the governor end cover (22), they should be carefully pressed into position and reamed with a ⅜" line reamer. New oil seals (51), which have been previously soaked in oil for at least twenty-four hours, should be pressed into position with an application of oil resistant sealing compound on their outer circumference.
12. The internal mechanism, consisting of the shaft and yoke assembly, should now be placed in the governor end cover (22) and fastened in place by four bearing bridge screws (25).
13. Slide the operating lever shaft assembly (53) in place, being careful not to injure the shaft seals (51).
14. Securely fasten hub for spring (49) to the shaft (53) by means of set screw (50), which has a pilot stud fitting into a hole in the operating lever shaft. A 3/16" hex socket wrench (service tool TSE 7918) should be used for tightening the set screw.
15. If the control lever adjusting screws (59) have been moved, they should be re-set to their original position.
16. Secure the cover plate for stop flange (67) with securing screw (65) and lock washer (66).
17. Control linkage pin (54) must be fastened to the control rod of the injection pump by means of lock nut and washer. In case of GVA Governors, extension arm (56) assembly must be installed.
18. Install governor housing gasket (23).
19. Install governor end cover assembly (See Fig. 36), making sure linkage pin (Fig. 36-54) fits into the hole of extension arm (Fig. 36-45A), of the fulcrum assembly.

NOTE—Before securing end cover to the housing by means of fastening screws, (18) make certain that the drive gear does not assume a position where there is danger of the outer face of the gear rubbing on the bearing bridge (24). If the teeth of the gear rub, it will be necessary to re-locate the camshaft in the injection pump by shifting the bearing spacers.

IMPORTANT—On flange-mounted APE. A pumps, the camshaft projection on the flange side should not be more than 1 3/32" measured from the end face of the pump to the narrow end of the taper. If it does, there will be interference with the engine timing gears. The end cover should be properly lined up with the governor housing to remove the possibility of binding the control rod of the injection pump. The countersunk screws which are used to locate the governor end cover should be tightened carefully while moving the governor operating lever back and forth to make sure it does not bind due to misalignment of the governor cover.

20. Secure governor operating lever (61) by means of screw (62) and lock washer (63). The lever should be installed in same position as it was removed. Refer to item 7 on dismantling of the governor.
21. Install bumper spring assembly consisting of spring with button (33) and adjusting screw (34). This should be adjusted to its original position and held with lock nut (35).
22. Inspection cover (30) and gasket (32) should be fastened in space with screws (31).
23. If the governor end cap (72) has been removed, it should be reassembled with gasket (73) in position. The end cap bearing should be re-packed with an American Bosch special temperature resisting grease No. US 508. Secure cap with four screws (74).
24. Install cover plate (64) on governor stop flange with fastening screws (65).

NOTE—All housing and cover screws should be staked.

HOW TO CHANGE GOVERNOR SPRINGS WITHOUT DISMANTLING THE GOVERNOR

(All Illustration Numbers Refer to Figure 45.)

If for any reason it becomes necessary to change the governor springs, either to replace the springs in the governor, or to exchange them for springs providing a different speed governing characteristic, it is not necessary to dismantle the complete governor. Remove the unit from the engine —simply proceed as follows:

1. Remove end plate (72) by unfastening four securing screws.
2. Hold spring seat (4) firmly by special Spanner wrench (service tool TSE 7917), remove hex nut (3) with open end or box wrench.
3. After the hex nut and locking washer have been removed, the spring seat (4) can be withdrawn and the governor springs (and the governor spring spacers, if any are used) can be removed and replaced. To obtain the desired spring adjustment, refer to item 5 under "Assembly of the Governor."
4. After new springs have been installed, the governor should be re-adjusted and tested per instructions given under "Adjusting the Governor on the Engine."

BOSCH VARIABLE SPEED VACUUM GOVERNORS TYPE AEP/MZ

This governor serves the same purpose as the GV type mechanical governor and provides a means for pre-setting and main-

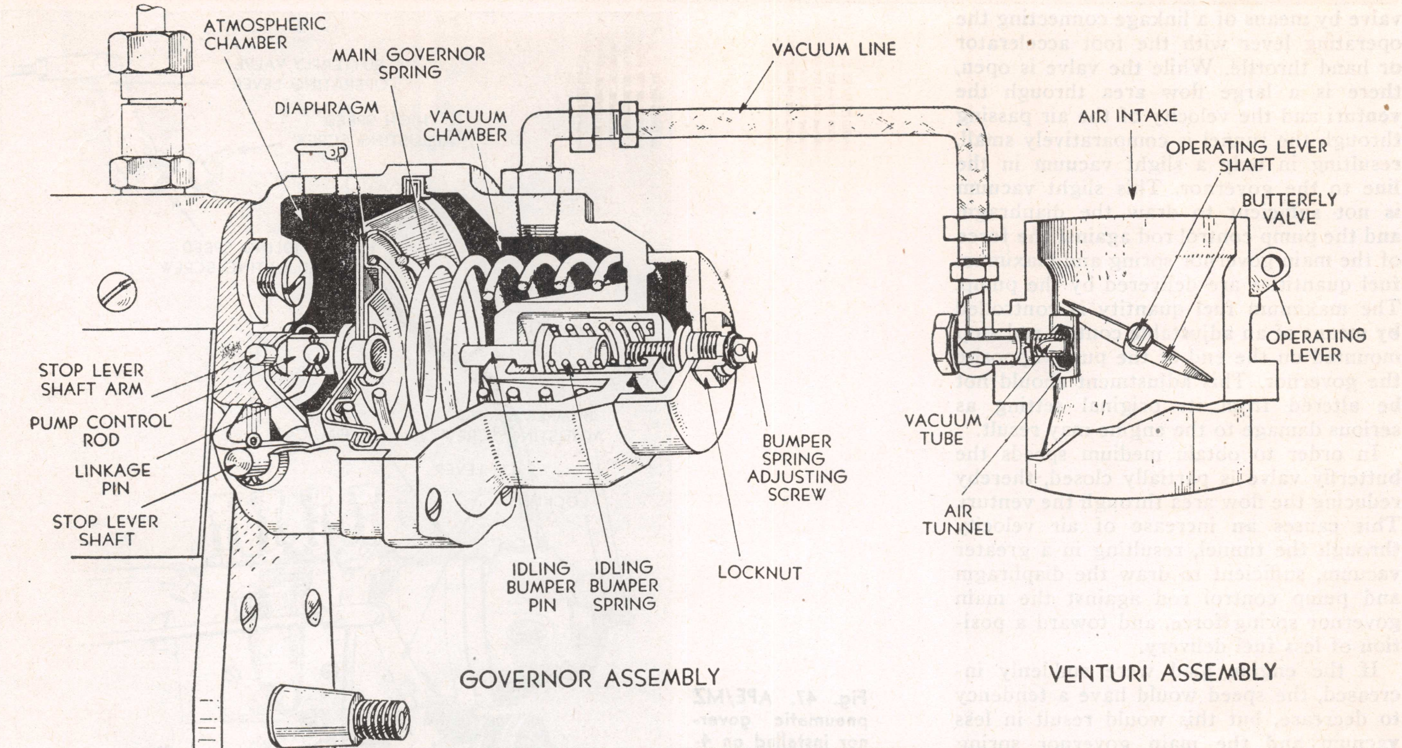

ATMOSPHERIC CHAMBER
MAIN GOVERNOR SPRING
DIAPHRAGM
VACUUM CHAMBER
VACUUM LINE
AIR INTAKE
OPERATING LEVER SHAFT
BUTTERFLY VALVE
OPERATING LEVER
VACUUM TUBE
AIR TUNNEL
STOP LEVER SHAFT ARM
PUMP CONTROL ROD
LINKAGE PIN
STOP LEVER SHAFT
BUMPER SPRING ADJUSTING SCREW
IDLING BUMPER PIN
IDLING BUMPER SPRING
LOCKNUT
GOVERNOR ASSEMBLY
VENTURI ASSEMBLY

Fig. 46. APE/MZ pneumatic governor with venturi assembly.

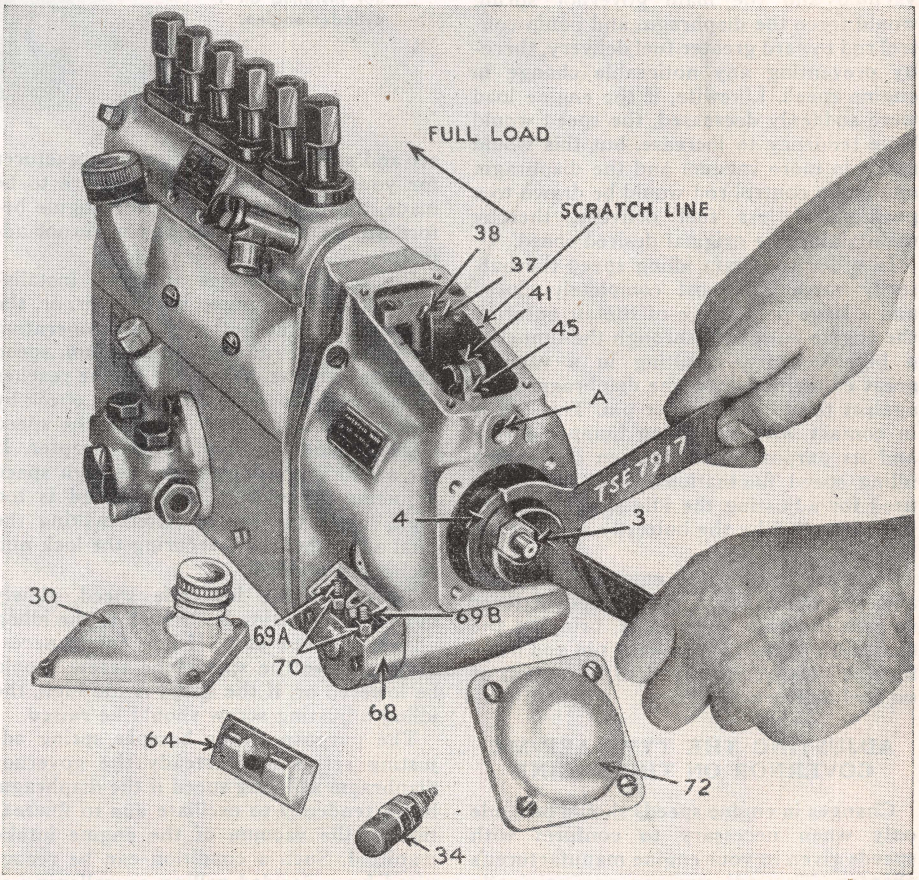

FULL LOAD
SCRATCH LINE
38
37
41
45
A
4
3
TSE7917
30
69A
69B
70
68
64
72
34

Fig. 45. Removing governor springs from GV type governor.

taining within close regulation any desired engine speed within the nominal idling and the nominal maximum speed range, irrespective of engine load. The governor also controls the engine idling speed to prevent stalling and the maximum speed to prevent racing.

OPERATION OF THE GOVERNOR

The American Bosch pneumatic or vacuum governor is a simple governing device operated by a partial vacuum produced by a butterfly valve and venturi assembly located in the engine air intake manifold. The principle underlying the action of the pneumatic governor is that air passing through a tube tends to create a vacuum in another smaller tube entering it at right angles. The amount of vacuum created depends upon the velocity of the air passing through the larger tube.

Diesel engines using a pneumatic governor are equipped with a venturi assembly (Figure 46) in the air intake manifold. The venturi contains a small tunnel covering the opening to the vacuum tube, and a butterfly valve controlling the air entering the engine. The valve is opened and closed by an operating lever and the maximum and minimum valve opening is limited by adjustable stops on the operating lever shaft.

The pneumatic governor attached to the end of the injection pump consists essentially of a housing divided into two air chambers by a flexible diaphragm which is directly connected to the injection pump control rod. The chamber nearer the pump is interconnected with the pump spring compartment and is therefore under atmospheric pressure. The other chamber is connected with the vacuum tube of the venturi and, during engine operation, this chamber is under partial vacuum.

In order to obtain the maximum speed, the engine operator opens the butterfly

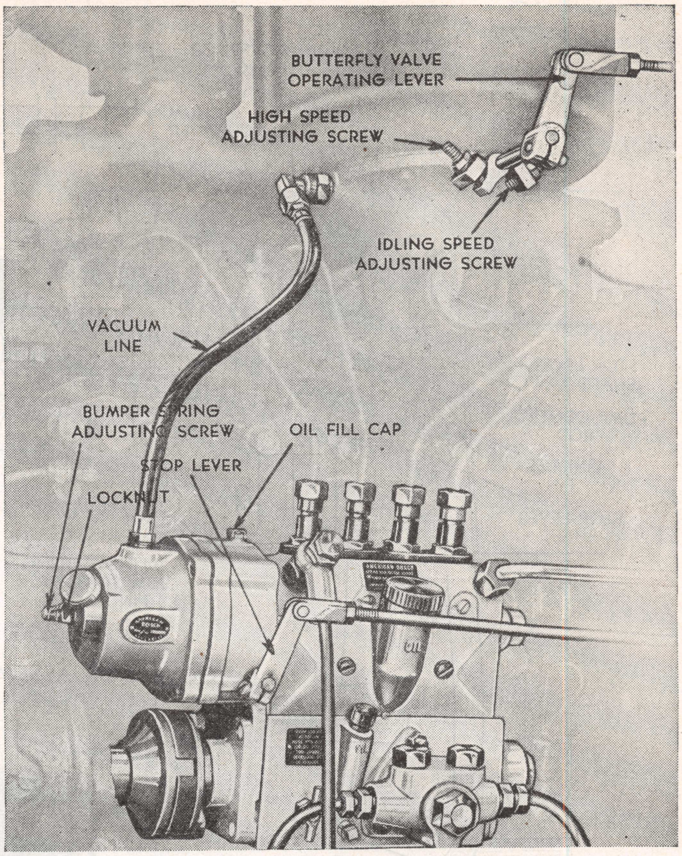

BUTTERFLY VALVE OPERATING LEVER
HIGH SPEED ADJUSTING SCREW
IDLING SPEED ADJUSTING SCREW
VACUUM LINE
BUMPER SPRING ADJUSTING SCREW
OIL FILL CAP
STOP LEVER
LOCKNUT

Fig. 47. APE/MZ pneumatic governor installed on 4-cylinder engine.

valve by means of a linkage connecting the operating lever with the foot accelerator or hand throttle. While the valve is open, there is a large flow area through the venturi and the velocity of the air passing through the tunnel is comparatively small, resulting in only a slight vacuum in the line to the governor. This slight vacuum is not sufficient to draw the diaphragm and the pump control rod against the force of the main governor spring and maximum fuel quantities are delivered by the pump. The maximum fuel quantity is controlled by means of an adjustable control rod stop mounted on the end of the pump opposite the governor. This adjustment should not be altered from its original setting as serious damage to the engine may result.

In order to obtain medium speeds the butterfly valve is partially closed, thereby reducing the flow area through the venturi. This causes an increase of air velocity through the tunnel, resulting in a greater vacuum, sufficient to draw the diaphragm and pump control rod against the main governor spring force, and toward a position of less fuel delivery.

If the engine load were suddenly increased, the speed would have a tendency to decrease, but this would result in less vacuum and the main governor spring would force the diaphragm and pump control rod toward greater fuel delivery, thereby preventing any noticeable change in engine speed. Likewise, if the engine load were suddenly decreased, the speed would have tendency to increase, but this would result in more vacuum and the diaphragm and pump control rod would be drawn to a position of less fuel delivery, thereby maintaining the original desired speed.

In order to obtain idling speed the butterfly valve is almost completely closed and a large percentage of the air entering the engine must pass through the tunnel at a high velocity, resulting in a vacuum great enough to draw the diaphragm back against the idling bumper pin. This pin is in contact with the idling bumper spring and its purpose is to dampen out engine idling speed fluctuations. It is not to be used for adjusting the idle speed, this being controlled by the butterfly valve opening.

In order to stop the engine, a separate shut-off arrangement is provided. A lever rotates the stop lever shaft, bringing the shaft arm against the linkage pin and moving the pump control rod to a position of no fuel delivery.

ADJUSTING THE TYPE AEP/MZ GOVERNOR ON THE ENGINE

Changes in engine speeds should be made only when necessary to conform with speeds given in your engine manufacturer's chapter. The adjustments are originally set and sealed by the engine manufacturer for your protection. If changes are to be made, thoroughly warm up the engine before attempting to make any governor adjustments.

Figure 47 illustrates a typical installation showing the pump with governor, the vacuum line, the butterfly valve operating lever and the minimum-maximum speed adjusting screws. When the engine reaches its maximum speed under no load, check by means of a tachometer whether the speed is as specified in your engine chapter. If the speed is too low, raise the high speed adjusting screw and, if the speed is too high, lower the screw. After making the final adjustment and securing the lock nut, recheck the speed.

To adjust the low idle speed, slowly move the operating lever back to the idling adjusting screw stop. If it is found necessary to raise the speed, the screw should be lowered or, if the speed is too high, the idling adjusting screw should be raised.

The purpose of the bumper spring adjusting screw is to steady the governor diaphragm at idling speed if the diaphragm has a tendency to oscillate due to fluctuation in the vacuum of the engine intake manifold. Such a condition can be recognized by a decided rolling or galloping of the engine at idle. Careful adjustment of the screw will overcome this undesirable condition. Turning the adjusting screw to the left in a counter-clockwise direction will dampen the oscillation of the diaphragm and thereby steady the engine idling speed. Care must be exercised not to turn the adjusting screw too far in this direction, since this will bring about excessively high maximum engine speed.

GOVERNOR MAINTENANCE

Very little attention is required by the American Bosch pneumatic governor. The vacuum line and its connections between the governor and the venturi should be periodically inspected to avoid the possibility of air leaks.

The diaphragm should be kept soft and flexible with a few drops of clean lubricating oil added through the oil cup each time the engine crankcase oil is changed. Excessive quantities of oil in the atmospheric chamber should be avoided.

It is important that your engine chapter be consulted regarding care of the intake air cleaner, for disregard to this maintenance detail may result in erratic governor operation due to an abnormal increase in engine vacuum.

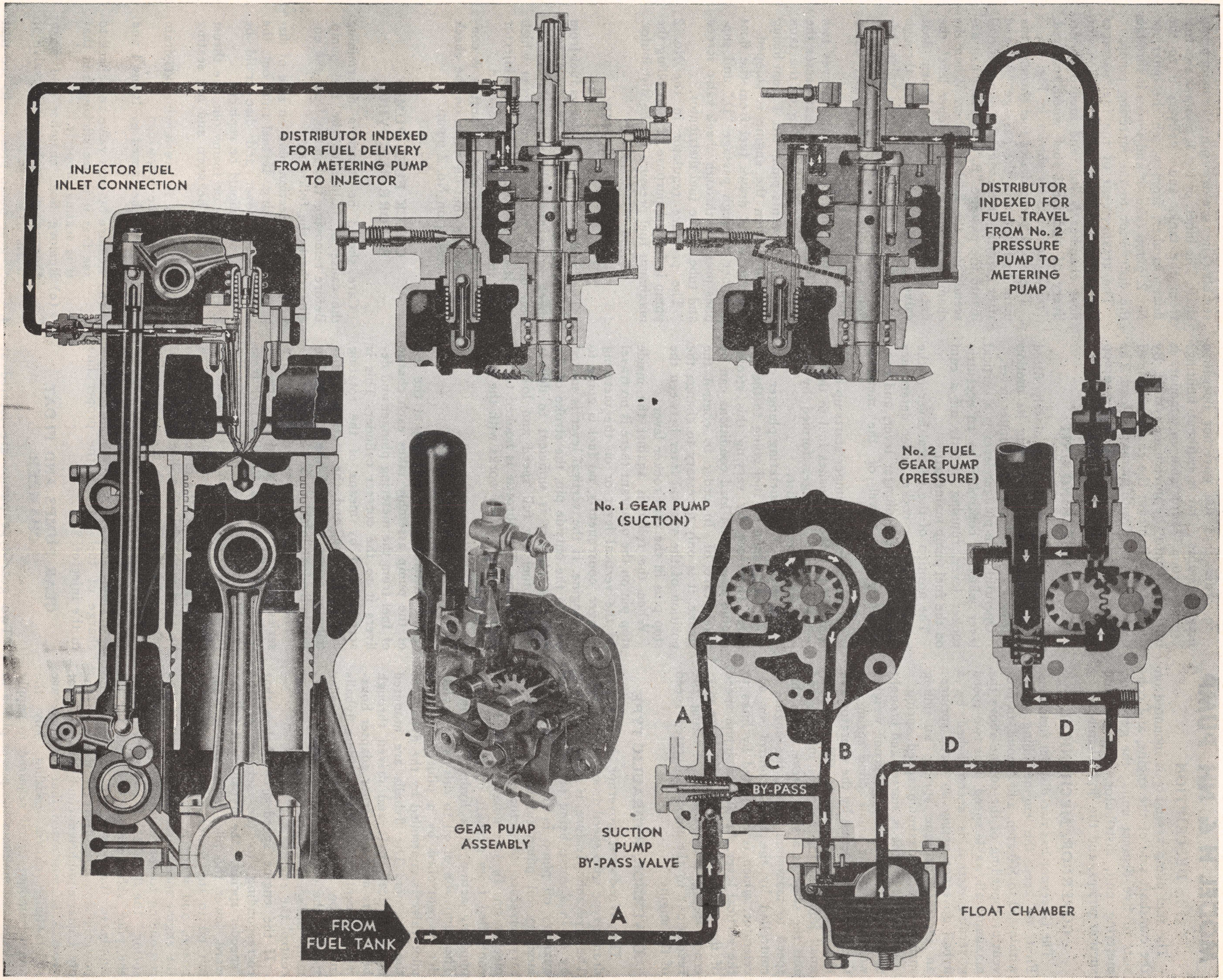

DISTRIBUTOR INDEXED
FOR FUEL DELIVERY
FROM METERING PUMP
TO INJECTOR
INJECTOR FUEL
INLET CONNECTION
DISTRIBUTOR
INDEXED FOR
FUEL TRAVEL
FROM No. 2
PRESSURE
PUMP TO
METERING
PUMP
No. 2 FUEL
GEAR PUMP
(PRESSURE)
No. 1 GEAR PUMP
(SUCTION)
A
C
B
D
D
BY-PASS
GEAR PUMP
ASSEMBLY
SUCTION
PUMP
BY-PASS VALVE
FLOAT CHAMBER
FROM
FUEL TANK
A

Fig. 1: Model H. Fuel flow system. Typical of NH.

MODEL H & NH PUMP

DESCRIPTION

The fuel pump assembly is mounted on the camshaft side of the engine, and consists of five distinct units; the governor, metering unit, distributor, pressure and suction pumps, and the float chamber.

GOVERNOR, MECHANICAL

The Governor has two distinct functions. First, to keep the engine idling speed within 450 to 500 rpm, and second, to prevent overspeeding of the engine above the maximum allowable speed. This two speed governing action is accomplished by a flyball governor acting on three springs: an increased torque spring, an idling spring, and a maximum speed spring.

When the engine is started and brought up to idling speed, the governor weights work against the small idling spring. As the throttle is opened by the operator and the engine speed exceeds 500 rpm, the small idling spring becomes inactive and acts the same as a solid sleeve. From this speed to maximum speed, the engine is controlled by the hand control, or accelerator, which is connected by links to the vertical lever. As the maximum speed of the engine is reached, the large governor spring takes control, limiting the revolutions to the maximum rated speed of the engine.

GOVERNOR, HYDRAULIC TYPE

The Woodward governor is the hydraulic type with speed droop stabilization. The hydraulic feature is brought about by oil in a sump being picked up by an auxiliary oil pump in the governor. The auxiliary oil pump furnishes the necessary pressure to actuate the governor mechanism. In this governor the fuel is controlled from a shaft operated by the opposing action of a hydraulic cylinder. The admission of oil to this power cylinder is controlled by a pilot valve. The pilot valve is controlled by the flyballs of the governor. The flyballs are mounted on a vertical shaft and driven through bevel gears in the governor adapter housing. The centrifugal force of these flyballs in rotation is opposed by a "speeder spring," the compression of which determines the speed at which the governor will control the engine.

If the engine speed drops below that corresponding to the setting of the "speeder spring," the flyballs will fall inward, lower the pilot valve plunger, admit oil to the power cylinder, raise the piston, and increase the fuel supply. If the engine speed increases above that corresponding to the setting of the "speeder spring," the flyballs will fly outward, raise the pilot valve plunger, cut off the oil supply to the power cylinder, drop the power piston, and decrease the fuel supply. Under equilibrium conditions, the pilot valve is so positioned that its ports are substantially closed, passing only the minute amount of oil required to supply leakage and maintain the power piston in a given position.

In order that the governor operation may be stable (that is, without hunting) "speed droop," adjustable in amount, is introduced into the governing system. By speed droop is meant the characteristic of decreasing speed with increasing load. The desired magnitude of this speed droop varies with engine application.

METERING UNIT

The metering pump is a closely fitted reciprocating pump, obtaining its motion through a link from the plunger lever.

Operating the plunger lever is a vertical lever which is controlled by an eccentric rocker lever, running directly off a cam on the fuel pump mainshaft.

The position of the vertical lever in the eccentric of the rocker lever determines the travel of the plunger lever, and consequently the travel of the metering plunger.

As the metering plunger starts up on its controlled stroke it pushes fuel to the injector through passages formed by the rotating distributor disc.

The stroke of the metering plunger controls the amount of fuel going to the engine. Therefore, by varying this stroke, engine speeds and load conditions can be taken care of. In order to control the stroke, it is only necessary to change the position of the vertical lever between the stop pins in the cam rocker lever.

When the roller is against the inside stop pin on the quadrant there is no travel on the vertical lever or on the metering plunger, consequently, no fuel is going to the engine. If the vertical lever is moved over to the outside pin, the stroke of the metering plunger is sufficient to deliver enough fuel for full speed and load to the engine. The throttle is hooked to the eccentric shaft which works with the governor lever.

DISTRIBUTOR

The distributing mechanism at the top of the pump assembly takes each charge of fuel from the metering plunger and delivers it to the correct cylinder. This is accomplished by means of the rotating distributor disc, and the stationary distributor cover, to which the fuel lines to the individual injectors are connected.

The disc and cover are drilled with a series of holes which, when properly indexed, form passages for the fuel from the fuel supply pump to the metering pump. This occurs while the metering plunger is moving down on its suction stroke, and permits the metering pump to be filled with fuel. The disc continues to rotate and lines up with the correct discharge hole in the disc cover just as the metering plunger is driven up by the main fuel pump cam. This forces the metered charge of fuel through the proper line to the injector.

GEAR PUMPS AND FLOAT CHAMBER

Two gear type pumps are located at the extreme rear of the fuel pump assembly. They are driven by the main pump shaft. The inner, or No. 1, pump draws fuel from the tanks and delivers it to the float chamber, from which the outer, or No. 2, pump takes it and forces it through the distributor to the metering pump.

The arrangement of the fuel passages permits recirculation of fuel when the float chamber is full, and immediate delivery of additional fuel when required. This is achieved as shown in Fig. 1.

The No. 1 pump draws fuel through the main fuel line and the passage "A," and after carrying it through the pump, forces it into the passage "B," from which it descends into the float chamber. When the chamber is filled to the proper level, the flat closes the float valve. When float valve is closed, fuel is bypassed through passage "C," and opens bypass valve, admitting fuel to passage "A." This allows fuel to recirculate through No. 1 pump until float valve is open.

The fuel inlet check valve serves two purposes. It prevents fuel that passes the bypass valve from returning to the tank line, and prevents pump No. 1 from losing its prime when the engine is stopped.

Pump No. 2 draws fuel from the float chamber, through passage "D," and supplies pressure through check valve screen and tube to the fuel distributor.

The pressure regulator in the No. 2 pump is for the purpose of controlling the maximum fuel pressure to the distributor.

PRIMING PUMP

The hand priming pump draws fuel from a connection just below the fuel inlet check valve, and delivers it to a connection on the pressure pump, from which point it can be forced to the fuel injector when the priming valve is opened.

The emergency shut-off button is connected to the shut-off valve on the check valve housing on No. 2 pump.

CHECK FUEL PUMP BEFORE REMOVING

Care should be taken in determining the cause of failure of the fuel pump. Before removing fuel pump from the engine, check the following:

1. Remove inspection plug on side of distributor housing. If fuel runs out, the distributor cover and disc could be scored, and should be replaced.
2. If fuel spurts or foams out, the thrust bearing may be worn and not seating properly.
3. If fuel pump is overflowing at drain hole, check the following:
   - (a) This can be caused by Items 1 and 2.
   - (b) Remove by-pass valve and check to see that it is not sticking and that it is seating properly.
   - (c) Remove float chamber and wash thoroughly. Replace float valve if worn.
4. Check gear pump pressure to see that it is not below 60 lbs. at idling speed.

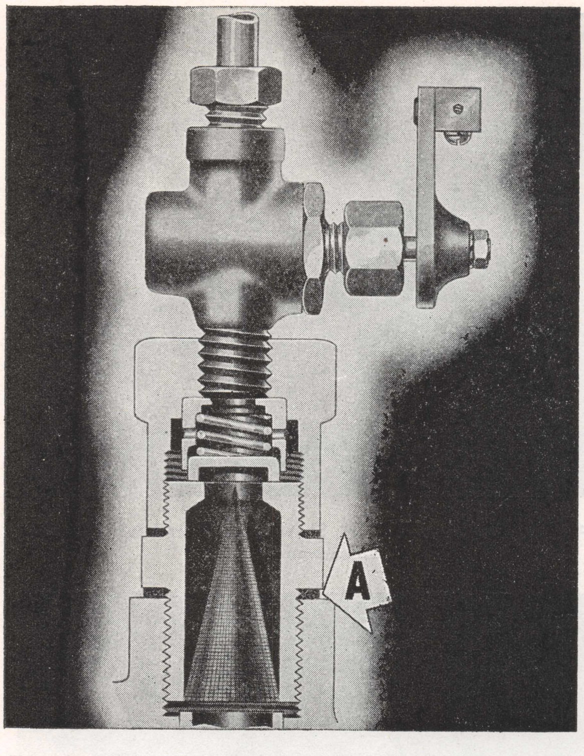


Fig. 8. Model A. Fuel pump screw and check valve assembly.

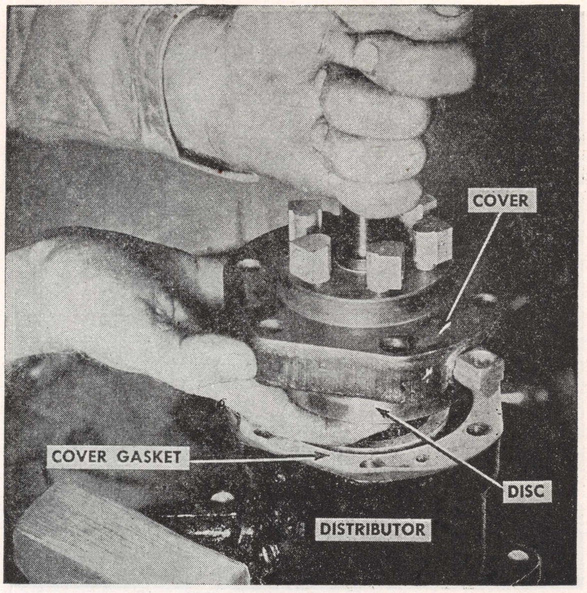


Fig. 9. H and NH. Lifting out distributor disc and cover.

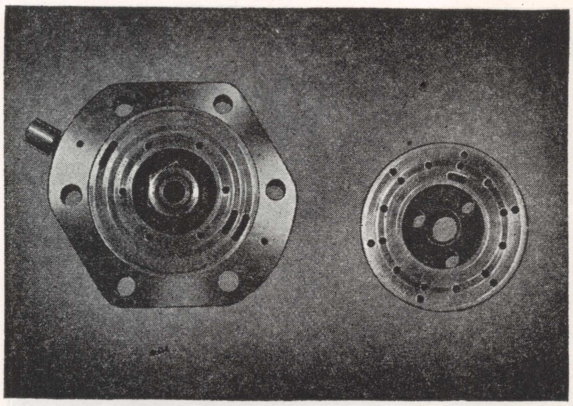


Fig. 10. Model H and NH. Showing worn distributor disc and cover.

This can be caused by:
(a) Worn gear pump.
(b) Pressure regulator worn or stuck.
(c) Defective seal on drive shaft in No. 1 body.

CLEANING FUEL PUMP SCREEN

The small conical screen (Fig. 8), in the fuel pump should be cleaned every 5000 miles, or 250 hours. It should also be cleaned in any instances where the engine refuses to start or gives indications of not developing full power. Cleaning of this screen is performed as follows:

1. Unscrew pressure chamber dome from pressure pump assembly, taking care not to lose copper asbestos gasket on which it seats.
2. Remove fuel supply tube from distributor top to emergency shut-off cock.
3. Unscrew the small hexagonal housing into which shut-off cock is assembled, applying the wrench to the lower of the two hex areas of the housing. Be careful not to mislay the copper gasket for this opening.
4. Place the shut-off cock end of the housing in a vise and unscrew the other half of the housing. The conical screen is located in this part.
5. Wash screen carefully with cleaning solvent and blow out with compressed air in opposite direction of fuel flow.

NOTE—Do not remove the small valves in the shut-off cock part of the housing. If they should accidently be removed, they should be replaced as follows:

1. Clamp shut-off valve half of housing in vise with cup upward.
2. Drop small valve cage into housing with cup end up.
3. Drop small spring into cup.
4. Insert valve with flat face next to spring. This should collapse into cup when pushed down.
5. Reassemble two parts of housing and then proceed with reassembly to pump.
6. Prime pump before attempting to start engine.

FUEL PUMP DISTRIBUTOR DISCS

If fuel with water or dirt in it is used, the fuel distributor cover and disc become scored and unfit for further service. Scored discs cause engine smoking and loss of power. Disc and cover should be exchanged for a new pair if scored, as the specially lapped surfaces cannot be repaired with conventional machining. Discs and covers must always be replaced in pairs.

REMOVAL OF FUEL PUMP DISCS

1. Thoroughly wash outside of pump with cleaning solvent and a brush.
2. Disconnect and remove tachometer shaft cable if used.
3. Disconnect fuel supply tube and fuel lines leading to cylinders at both distributor and cylinder connections and remove them to provide room for taking out discs.
4. Loosen the six cap screws holding distributor cover to distributor, one-half turn at a time, until they can be removed. This procedure is necessary to prevent distortion of distributor disc bearing in the distributor housing.
5. Lift disc cover up far enough to slide hand under distributor disc, and remove disc and cover together as shown in Fig. 9. Fuel between these parts causes them to stick together.
6. Examine disc and cover carefully, and replace if they show scratches or score marks as shown by Fig. 10.

NOTE—Disc and cover must be kept free of dust or dirt. Never place the lapped faces of these parts on any surface except clean paper or cardboard.

INSTALLATION OF FUEL PUMP DISCS

1. Wash disc and cover thoroughly in cleaning solvent and blow out all fuel passages with clean compressed air.

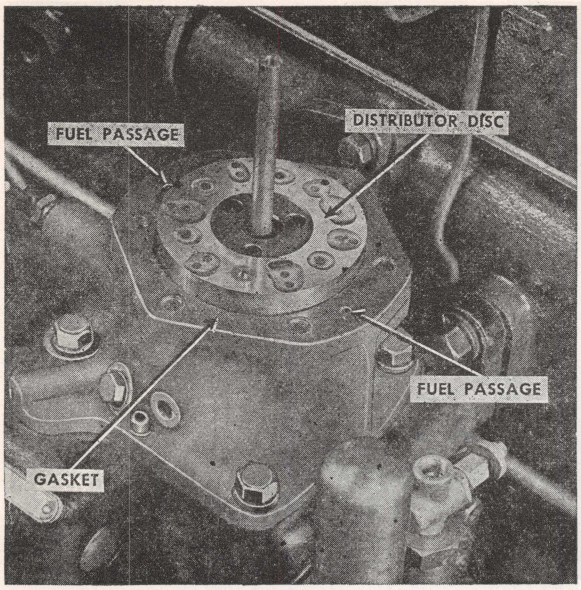


Fig. 11. Model H and NH. Lubricating distributor disc.

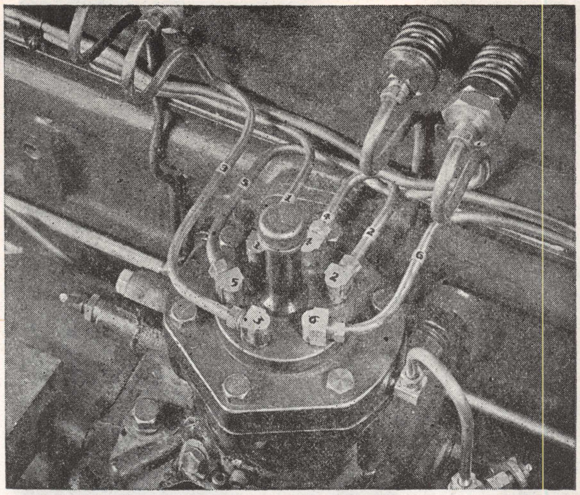
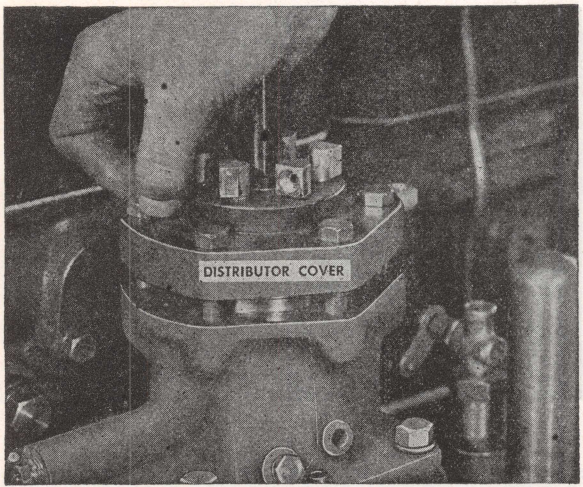


Fig. 13. Model H and NH. Showing numbered fuel lines and connections.



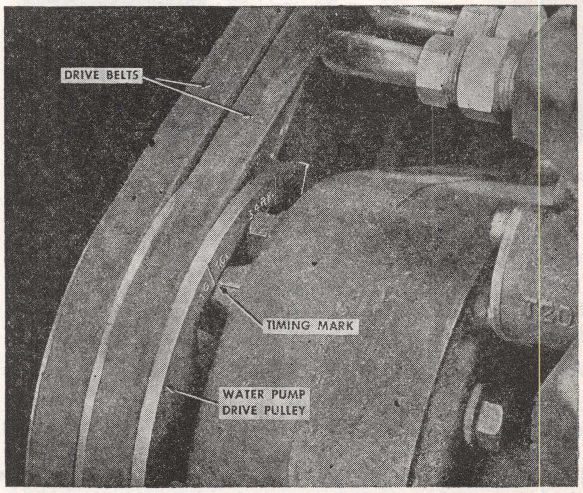
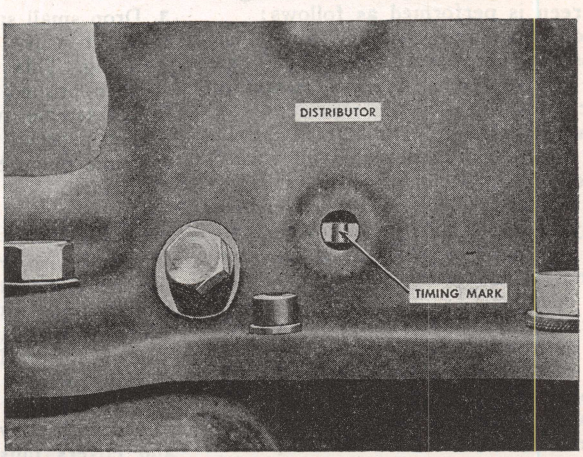


Fig. 14. Model H and NH. Top center timing mark.



2. Place rotating disc in position over the three driving pins. Disc will fit on pins only if installed in correct position.
3. Fill fuel passages on top of distributor disc with clean lubricating oil (Fig. 11), and install gasket and cover. Be sure cover gasket is installed correctly for all fuel passages.
4. Press cover down and start cap screws. (Fig. 12.) These must be turned down ½ turn in rotation until tight to prevent distortion of distributor disc bushing in housing. Tighten screws securely.
5. Replace fuel supply tube and all fuel lines, making sure that they lead to the correct cylinders. Pump connections are numbered to facilitate correct installation. (Fig. 13.)
6. Reinstall tachometer shaft and cable if used.
7. Prime engine before attempting to start.

REMOVAL OF FUEL PUMP ASSEMBLY

Compressor Type: 1. Remove all fuel and lubricating lines leading to fuel pump. Remove tachometer drive cable and controls as used.

Fig. 12. Model H and NH. Installing distributor cover and disc.

Fig. 15. Model H and NH. Distributor collar timing mark.

2. Spot timing marks as shown in Figs. 14 and 15.
3. Uncouple chain from coupling spider drive.
4. Remove cap screws and lockwashers holding pump assembly to cylinder block. The fuel pump is mounted on dowel pins and it may be necessary to use a small bar to remove from dowels.

Less Compressor Type: To remove the less compressor type fuel pump from the engine, proceed in the following manner:

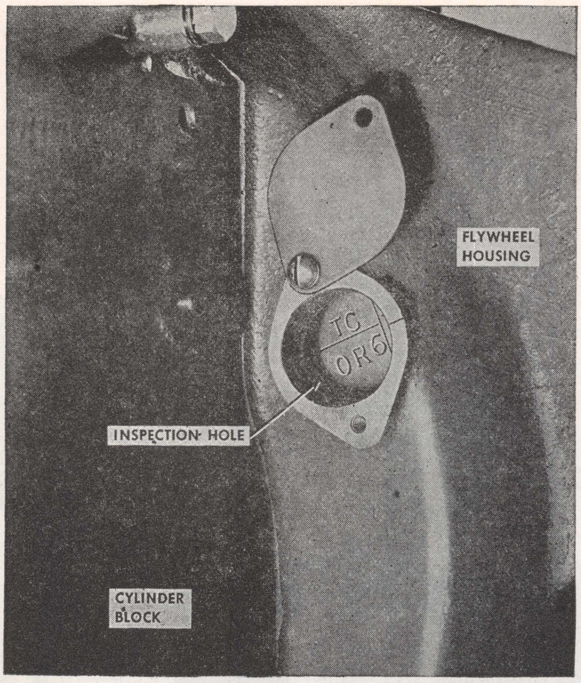


Fig. 16. Model H and NH. Top center mark on flywheel.

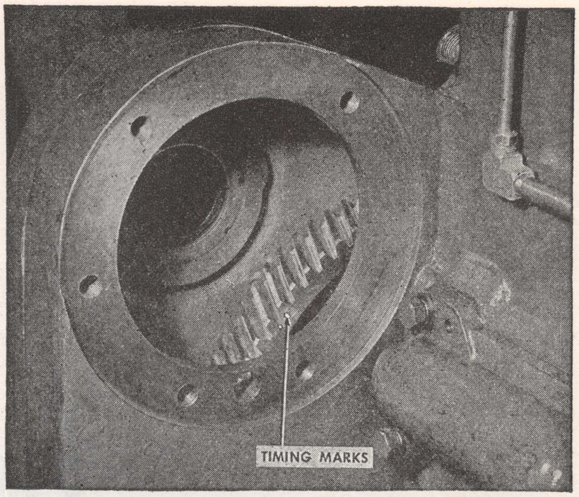


Fig. 18. Model H and NH. Timing marks on camshaft gear.

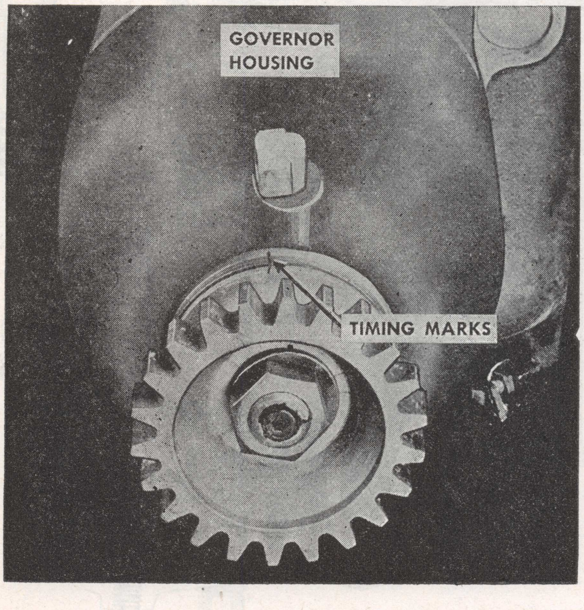


Fig. 17. Model H and NH. Fuel pump timing mark.

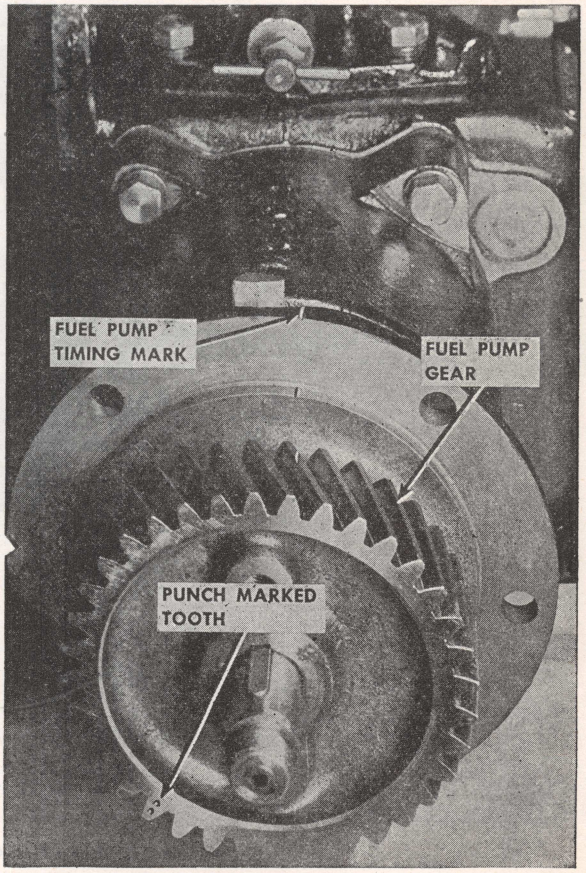


Fig. 19. H and NH. Timing marks on fuel pump gear and housing.

1. Remove all fuel and lubricating lines leading to and from the fuel pump. Remove the throttle and idling control.
2. Loosen water pump clamp ring and rotate water pump body to low point of eccentric to loosen drive belts. Remove the belts from the water pump drive pulley.
3. Remove the nut and lock plate holding the water pump drive pulley to the fuel pump shaft.
4. With a puller, remove the water pump drive pulley from the shaft.
5. Remove the five cap screws holding the fuel pump to the gear case and the four cap screws holding it to the side of the block. With a slightly backward motion, lift the fuel pump from the engine.

Hydraulic Governor Type: To remove the Woodward governor type fuel pump, proceed in the same manner as that described for the less compressor type fuel pump.

INSTALLING FUEL PUMP ON ENGINE

Compressor Type: 1. Turn engine until No. 1 piston comes up on compression stroke. Continue turning until timing mark "TC 1 or 6" (1 or 4 on 4-cylinder engines) appears in inspection hole in the flywheel housing (Fig. 16), and on water pump drive pulley (See Cummins Engine Chapter).

2. Spot timing marks as shown in (Fig. 17).
3. Rotate fuel pump shaft until timing mark on distributor drive collar lines up with inspection hole. (Fig. 15.)
4. Install copper asbestos gasket for oil

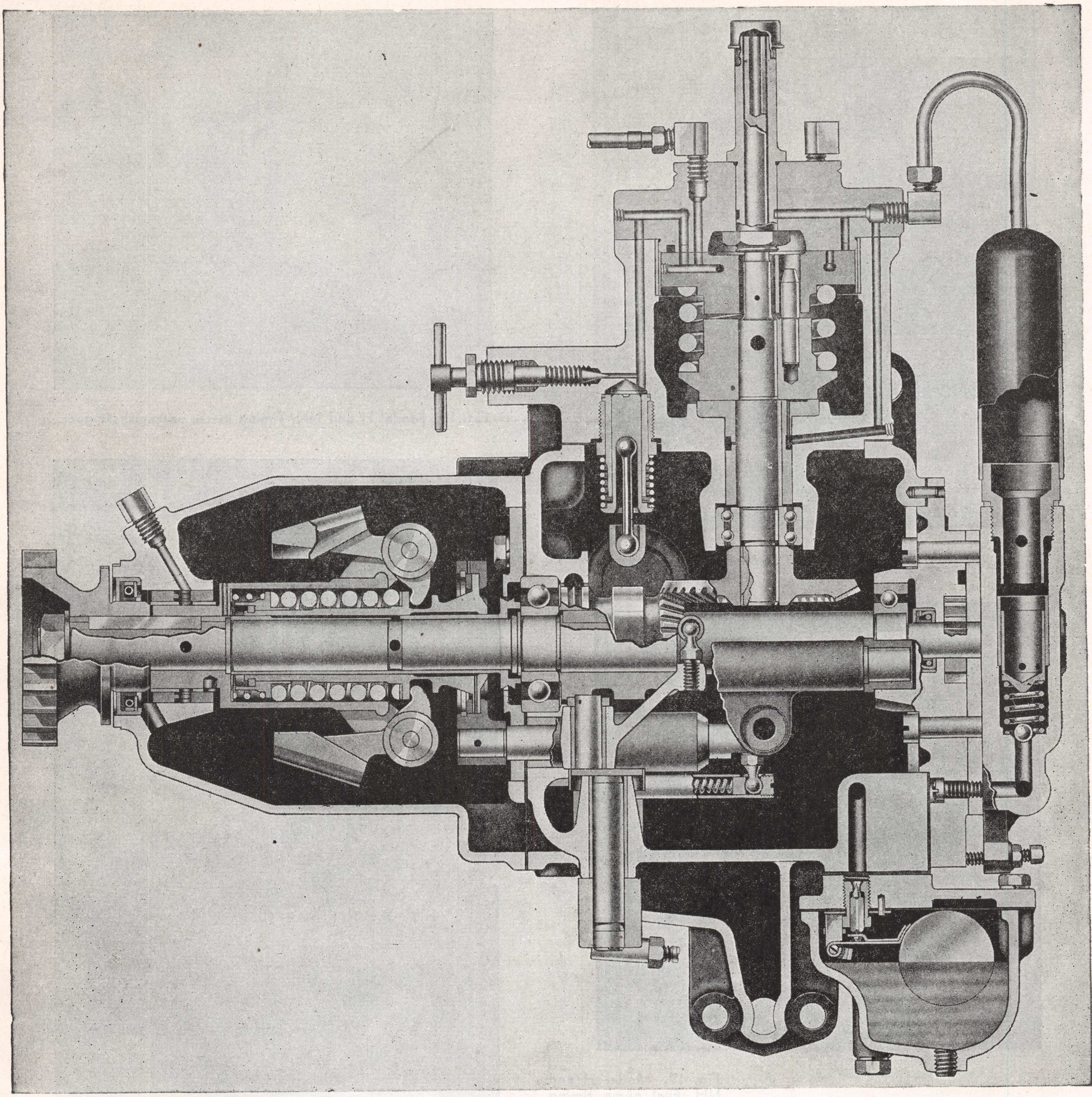


Fig. 20. Model H and NH. Cross section of compressor type fuel pump.

drain hole in pump housing, holding it in place with cup grease.

5. Reattach fuel pump to cylinder block over dowel pins.
6. Reinstall the coupling chain. It may be necessary to advance or retard one of the coupling sprockets slightly, but this will not affect operation.
7. Reattach all fuel and lubricating lines, and prime engine before attempting to start.

NOTE—The above procedure assumes correct timing of the air compressor drive gear. If air compressor was removed from engine, it will be necessary to retime before timing fuel pump.

Less Compressor Type: 1. Rotate the engine until the two punch-marked teeth on the camshaft appear in the fuel pump opening in the gear case. (Fig. 18.)

2. See that the mark TC-1 & 6 (1 & 4 on 4-cylinder engines) is showing in the flywheel housing index hole. (Fig. 16.)
3. Rotate the fuel pump until the small notch in drive collar appears in the inspection hole in the distributor housing.
4. With a piece of chalk or similar substance mark the top surface of each punch-marked tooth on the camshaft gear, and the face of the single punch-marked tooth on the fuel pump gear. (Fig. 19.)

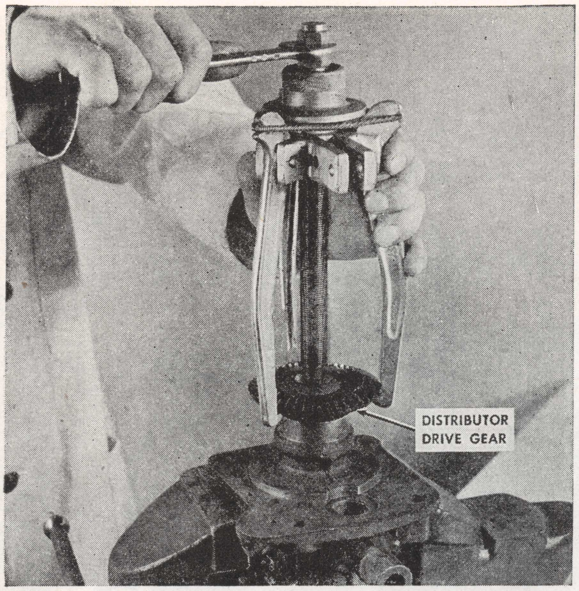


Fig. 21. Model H and NH. Pulling distributor drive gear.

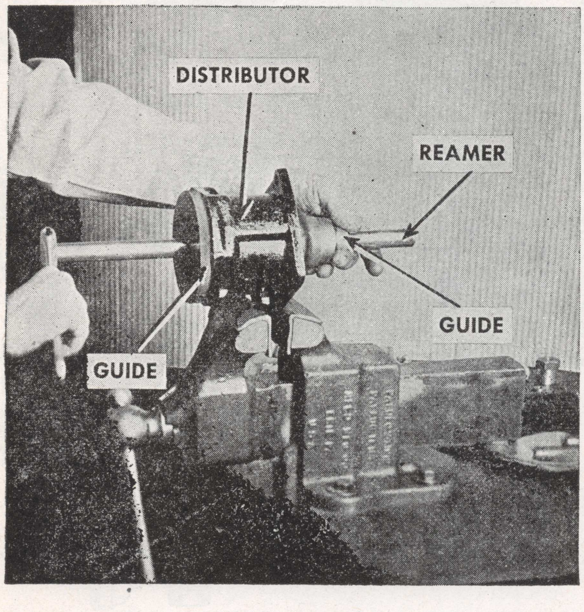


Fig. 22. Model H and NH. Reaming thrust bearing shaft hole.

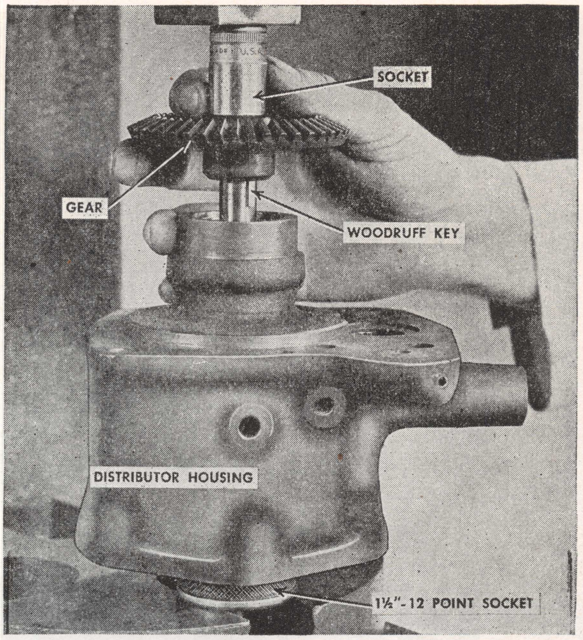


Fig. 24. Model H and NH. Pressing on distributor drive gear.

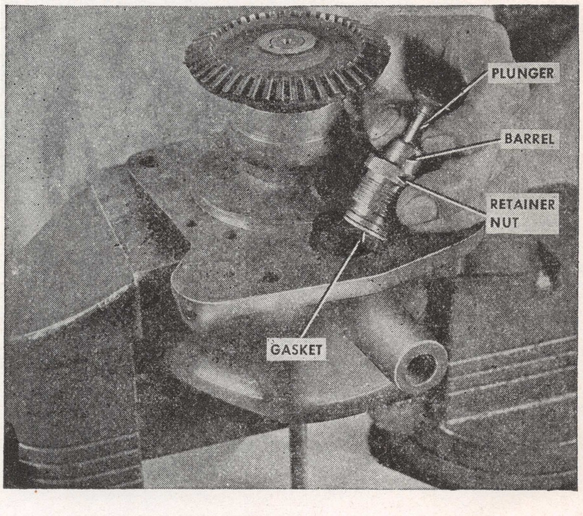


Fig. 25. Model H and NH. Assembling metering pump.

5. Install the copper asbestos gasket for oil drain hole in pump housing holding it in place with cup grease, and lift the fuel pump into place.
6. Using the water pump drive pulley hole as an inspection hole, mesh the fuel pump gear with the camshaft gear. The timing will be correct if the single chalk mark on the fuel pump gear is meshed between the two chalk marks on the camshaft gear.
7. Push the fuel pump tight against the gear case, making sure it is guiding on the trunnion.
8. Install and tighten the five cap screws around the flange.
9. Install and tighten the four cap screws holding the pump to the block.
10. Reattach all fuel and lubricating lines and prime the fuel system before attempting to start the engine.

Hydraulic Governor Type: Proceed in the same manner as described for less compressor type pump.

FUEL PUMP, OVERHAUL

DISASSEMBLY OF DISTRIBUTOR HOUSING

1. Place pump assembly in holding fixture.
2. Remove fuel pump cover and disc.
3. Lift distributor disc spring from housing.
4. Remove cap screws that hold distributor housing to main fuel pump housing.
5. Lift distributor housing, with shaft and gear, from fuel pump housing.
6. Metering plunger barrel can be removed from distributor housing by unscrewing retaining nut.
7. Pull gear from distributor shaft, **Fig. 21**, being careful not to apply too much pressure to outer edge of gear, or warped gear will result. Remove Woodruff key from shaft.
8. Tap lower end of distributor shaft on block of wood, and remove shaft and collar from housing.
9. Remove double ball bearing from lower end of housing.

NOTE—Thrust bearing should not be removed unless known to be defective.

10. Remove priming valve from side of

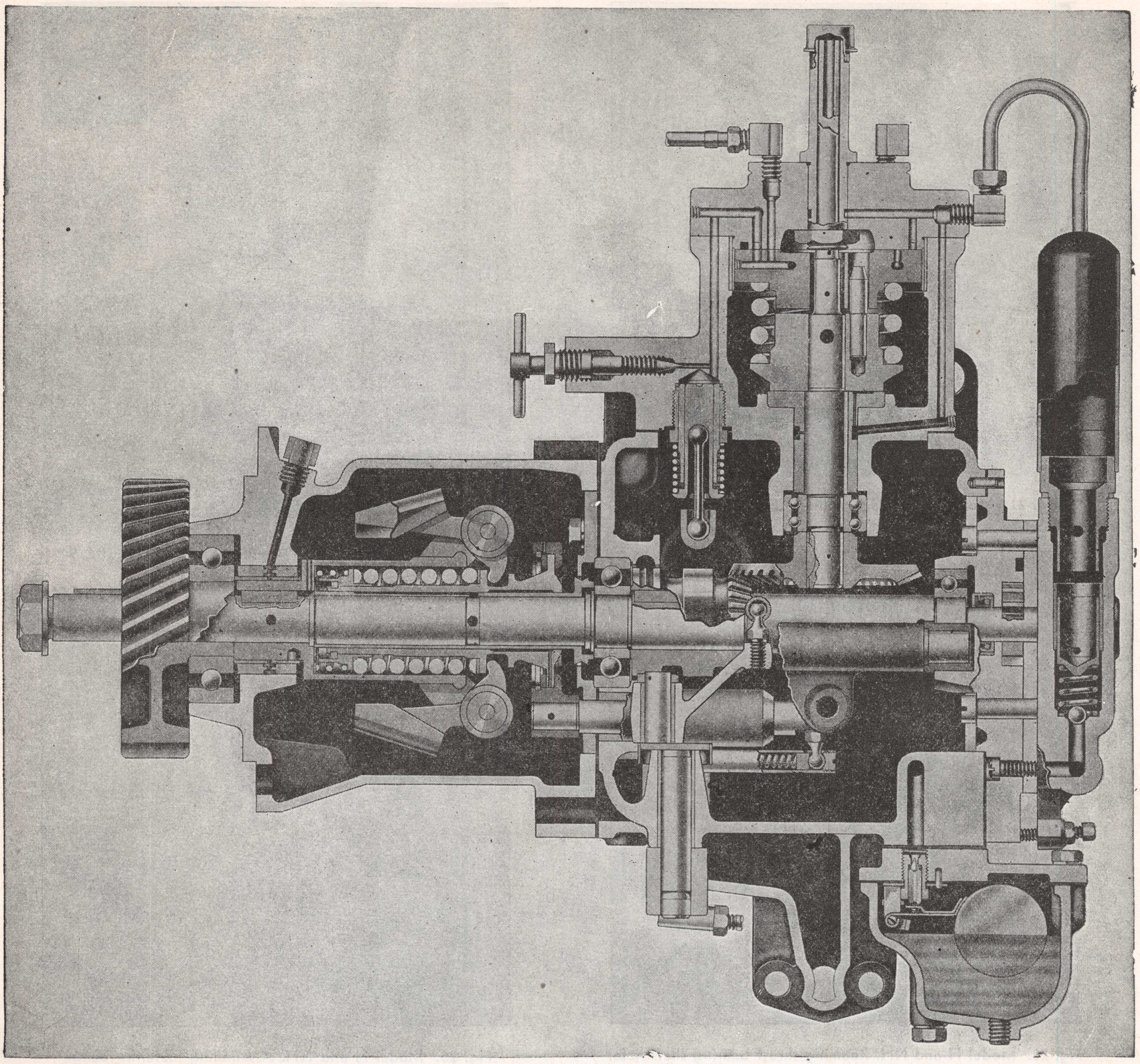


Fig. 23. Model H and NH. Cross section of less compressor type fuel pump.

housing and check the point to see that it has not been broken by overtightening.

11. If priming valve has been broken, make sure all particles have been removed from housing before installing new valve. If valve seat has been damaged, distributor housing must be replaced.
12. Remove distributor check valve screw, spring, and ball.

ASSEMBLY OF DISTRIBUTOR HOUSING

1. Inspect distributor drive collar and shaft. If there are signs of excessive wear, replace with new parts.
2. If collar and shaft are worn excessively in the thrust bearing, fuel will leak by the shaft. This causes low fuel pressure, or causes fuel to fill the main housing and run out overflow.
3. Inspect distributor thrust bearing. If bearing shows excessive wear, replace.
4. To remove thrust bearing, press from housing from bottom side.
5. Wash fuel passages and housing thoroughly.
6. Assemble new bearing to housing. A piece of leather is used between the tool and bearing to prevent damage to bearing face.
7. Ream thrust bearing shaft hole with special line reamer, size .812". (Fig. 22.)
8. Reface thrust bearing with special cutters. A little oil on the face of the thrust bearing when using the cutter will help prevent chattering.
9. Inspect ball bearing on lower end of shaft for wear. Replace if worn.
10. Assemble distributor drive shaft and collar assembly to housing and press gear in place. (Fig. 24.)

NOTE—A 1½"-12 point socket will fit over drive pins in collar for pressing gear in place.

11. Inspect the metering plunger and barrel for wear.
12. If the plunger or barrel is scratched or worn, it will be necessary to replace. Be sure to use a new copper gasket on the end of the barrel when replacing. (Fig. 25.)

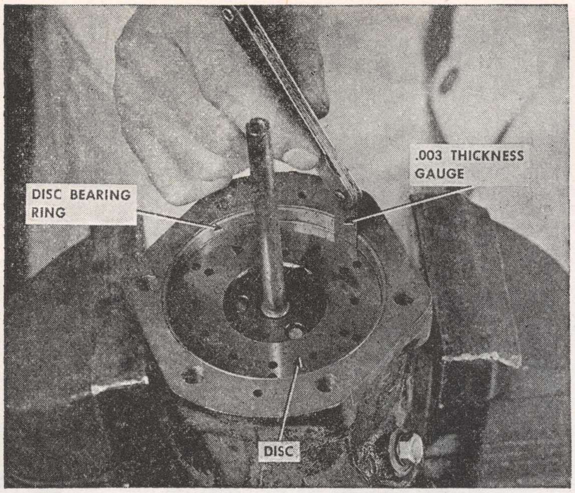


Fig. 26. Model H and NH. Checking distributor disc bearing.

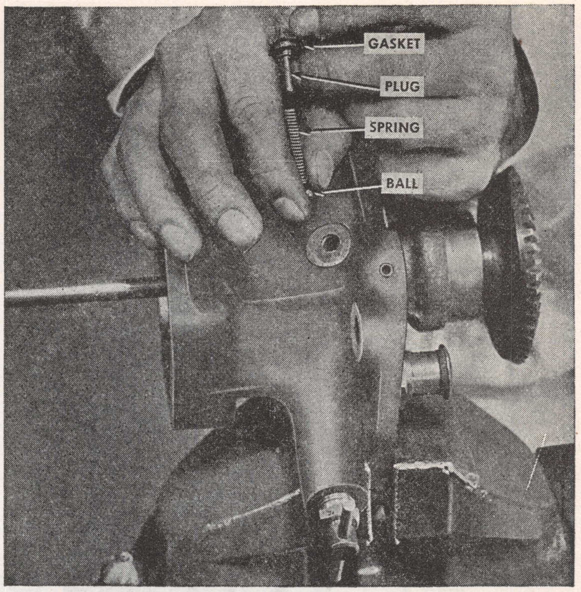


Fig. 29. Model H and N.H. Assembling distributor check valve.

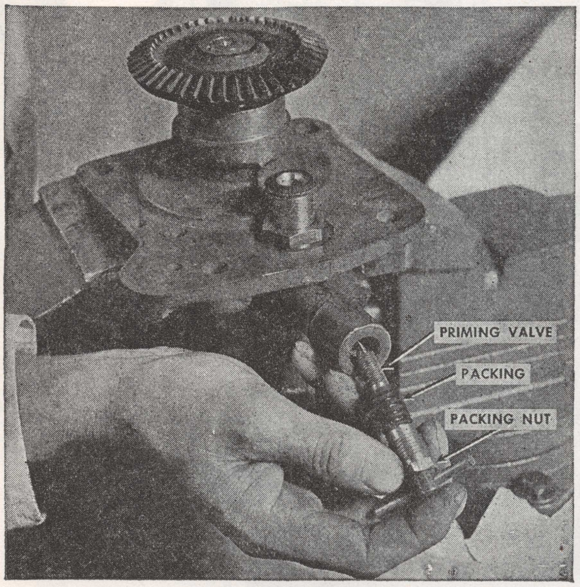


Fig. 28. Model H and NH. Assembling priming valve.

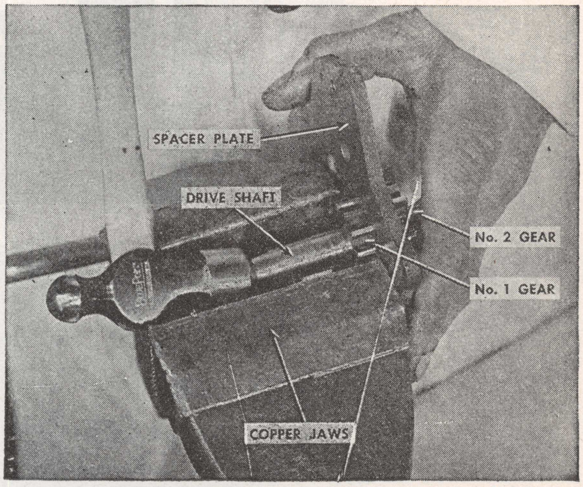


Fig. 30. H and NH. Removing No. 1 pump gear from shaft.

13. **Before assembling the new distributor top and disc, wash all fuel passages** with cleaning solvent and blow out with clean compressed air. Place dis**tributor top on housing and turn drive shaft. Check tachometer drive shaft in top of guide to see that it is running true. It may be necessary to bend shaft** slightly to make it run true.

14. Lubricate both the distributor top and disc faces with clean lubricating oil. Set timing mark on distributor drive collar in line with inspection hole in housing.

15. Place disc thrust spring on collar and locate rotary disc in position on driving pins. (This cannot be put on wrong due to one driving pin being offset.) The distributor top can only be put on **one way to permit the fuel lines to be** connected properly. A new gasket of **proper** design and thickness must be used each time between the distributor **top and housing.**

16. Be sure when placing this gasket on housing that the oil passages are properly indexed.

17. It will be necessary to compress the distributor spring by pushing on the distributor tachometer guide to start the cap screws which hold the distributor top in place.

18. When all cap screws are started by hand, work each one alternately, one-half turn at a time, until the cover is down against the gasket and distributor housing. If the distributor cover is not tightened down evenly, it will likely catch the distributor disc bushing, pushing it down on one side. Should this happen, the seal will break between the distributor top and disc when the engine is started and the flow of fuel to the metering pump will be disrupted.

19. If the distributor disc bushing is distorted it will be necessary to replace. Press a new bushing into the housing.

20. To determine clearance between disc and bearing ring, it will be necessary to place the distributor disc on the drive pins without the thrust spring. If the distributor disc does not rotate freely in the bushing, it will be necessary to use a bearing scraper to relieve the bearing. A smooth bearing must be maintained and held at .003" clearance between the disc and bearing. (Fig. 26.)

21. **Priming Valve:** The priming valve on the front side of the distributor housing is for the purpose of priming the engine and form a passage for the fuel around the distributor top and disc to the injector. This is a needle valve and requires only light pressure on the handle to close. (Fig. 28.)

CAUTION—Never tighten this priming valve with a wrench.

22. Assemble distributor check ball, spring, and screw to housing. (Fig. 29.)

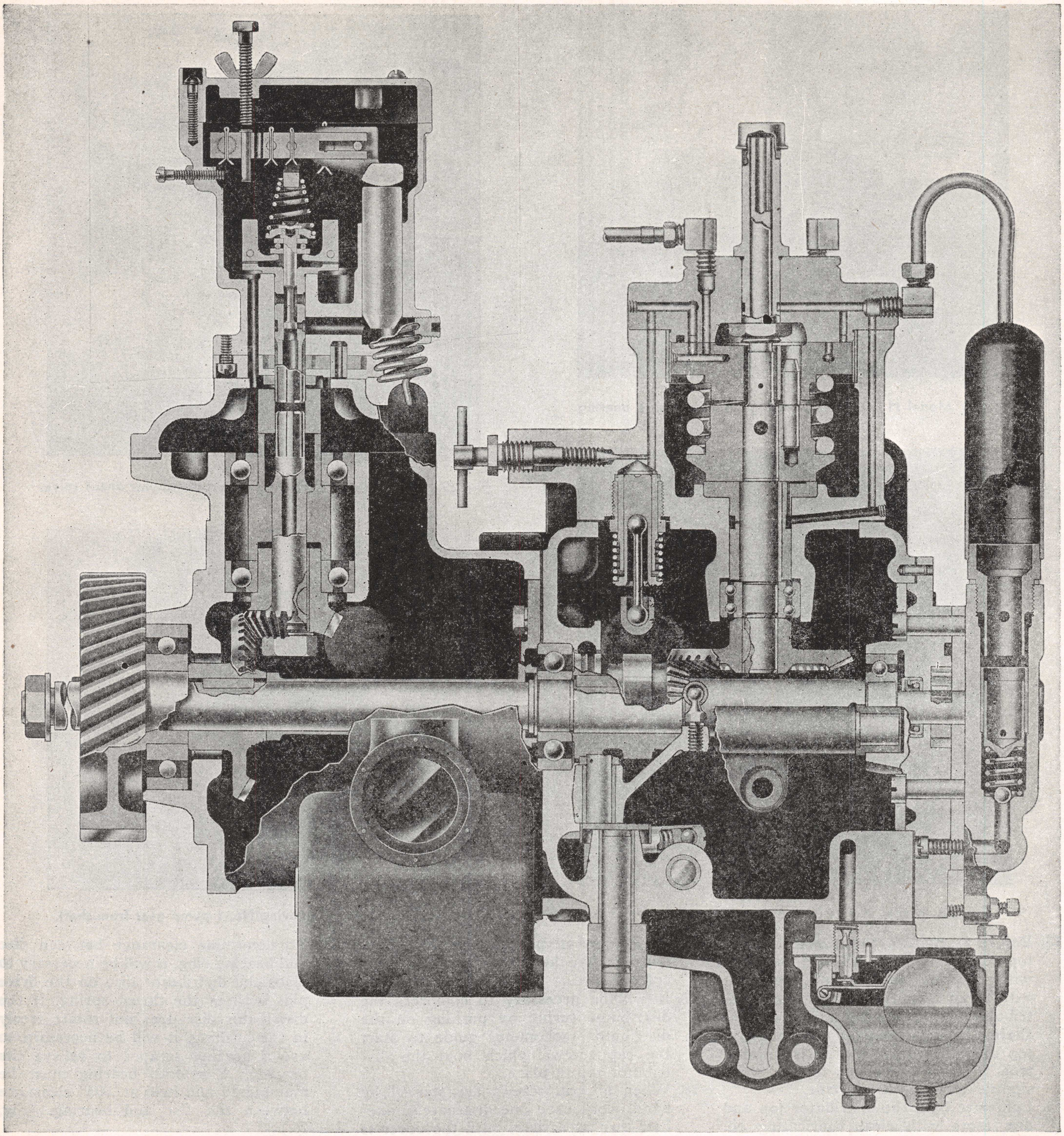


Fig. 27. Model H and NH. Cross section of hydraulic type fuel pump.

NOTE—If this check valve leaks it will cause hard starting.

REMOVAL OF GEAR PUMPS

1. Remove four cap screws holding gear pump bodies to main fuel pump housing. **Do not remove nuts from three bolts on this same face, as these hold the two gear pump bodies together.**
2. Remove cam rocker lever spring retainer, and spring, from side of fuel pump housing. This is the larger of the two hex head screws on the outer side of the housing.
3. Holding to the pressure chamber and the idling control lever, pull the gear pump assembly from the main fuel pump housing.

DISASSEMBLY OF GEAR PUMPS

NOTE—Do not disturb the gear pumps unless pump pressure is below 50 pounds pressure on gauge at idling speed. If necessary, disassemble as follows:

1. Remove nuts from three bolts holding the two pump bodies together. **Tap bolts from bodies with brass drift. The** No. 2 body should slip off, leaving gears on shafts with spacer plate.
2. Remove fillister head screw from front of No. 1 body and slip body from

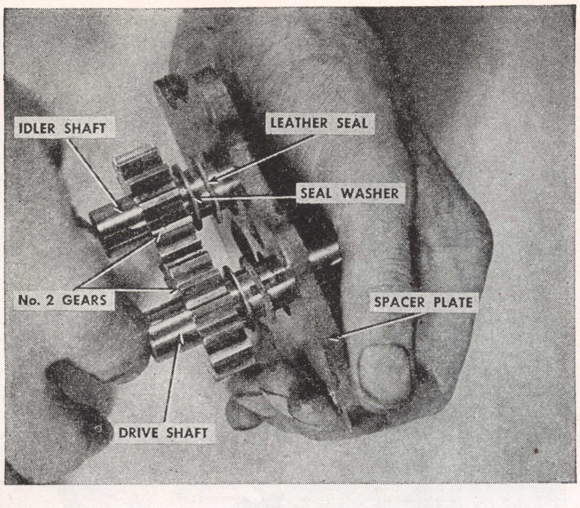


Fig. 31. Model H and NH. Assembling gear seals.

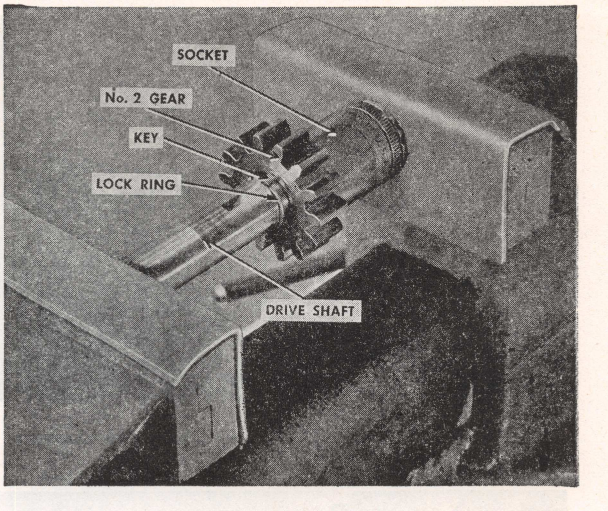


Fig. 32. H and NH. Assembling No. 2 pump gear to shaft.

shaft, leaving gears on shaft with spacer plate.

3. Drive idler shaft from gears, being very careful not to lose oil seal and washer between spacer plate and No. 2 pump gear.
4. Place No. 1 pump drive gear in a vise fitted with copper jaws, gripping gear by the teeth, and tightening vise only enough to hold. (Fig. 30.)
5. Tap lightly on slotted end of shaft to drive out of gear. Pull Woodruff key from shaft.

CAUTION—Any other method of removing this gear will cause small Woodruff key to be driven through spacer plate, making spacer plate unfit for further use.

6. Slide gear and shaft out of spacer plate, being careful not to damage oil seal and washer between gear and spacer plate.
7. Press gear away from lock ring to remove from pump shaft. Remove Woodruff key and lock ring from shaft.
8. Remove idling control lever after taking out cotter pin and washer on end of shaft.
9. Unscrew idler lever shaft from pump body, keeping gasket with shaft.
10. Unscrew pressure chamber and remove chamber and gasket.
11. Remove pressure regulator valve and take out spring and check ball.
12. Remove fuel supply check valve housing by screwing out check valve seat.
13. Place the shut-off cock end of the housing in a vise and unscrew the check valve seat.
14. Remove housing from vise and take out check valve, spring and guide.

ASSEMBLY OF GEAR PUMPS

NOTE—The instructions that follow are for rebuilding the gear pump assembly with new parts. Old parts should be used only if they can be fitted as closely and installed as carefully as described.

1. Caution must be used, when assembling new gears to the spacer plate and shaft, that the shaft seals are assembled properly. These seals are assembled on the No. 2 side of the spacer and with the seal washers working against the No. 2 pump gears. (Fig. 31.)
2. Inspect the drive shaft oil retainer in the No. 1 body to see that it is in good condition. When assembling the No. 1 body on the shaft, precaution must be taken to see that this retainer is not damaged.
3. Assemble No. 2 pump gear, Woodruff key and snap wire as shown in Fig. 32. Press gear over snap wire into recess on gear.
4. Assemble gears to spacer plate. (Fig. 33.)
5. When assembling the No. 1 body, use only .0015" body gasket. Brush a thin coat of shellac on the spacer plate gasket surface only. Assemble gasket in proper position to spacer. Brush thin coat of shellac on gasket, always being careful not to get shellac in gear pockets and fuel passages.
6. With the No. 1 body on the shaft against the gasket and spacer plate, insert the fillister head screw.
7. Shellac gasket to the No. 2 side of the spacer as previously instructed and place body over gears in position.
8. Insert the mounting cap screws through both pump bodies and attach 3/8" nuts to the protruding ends. Draw these nuts up to pull the pump bodies together, at the same time turning the drive shaft to see that the pump gears continue to turn freely. If necessary, tap edges of bodies to free gears. (Fig. 34.)

   Ream the two dowel holes with a standard 3/8" reamer, insert the two threaded dowel bolts and attach nuts. Remove the nuts from the two mounting cap screws and install the pump bodies on the main fuel pump housing.
9. Let shellac dry between gear pump bodies before testing.
10. Reinstall idling lever shaft and assemble idling lever washer and cotter pin.
11. Place pressure regulator spring in housing. If a new spring is used, make sure all burrs are removed from both ends of spring to avoid binding or cocking of regulator valve. (Fig. 35.)
12. Drop check ball into housing.
13. Slide pressure regulator into place with point down toward check ball.
14. Check to be sure regulator is free.

NOTE—If pressure regulator sticks open it will cause drop in fuel pressure. If regulator sticks closed it will cause excessive fuel pressure.

15. Screw pressure chamber into housing making sure that gasket is in good condition.

DISASSEMBLY OF GOVERNOR

Compressor Type: 1. Place fuel pump in holding fixture.

2. Remove hex nut and lockwasher from drive end of main shaft, and remove coupling spider with suitable puller.
3. Remove distributor assembly from top of main housing as explained in previous paragraph.
4. Remove the three cap screws and lockwashers that hold governor housing to main housing, and take off governor housing.
5. Remove gear pumps from rear of main housing in accordance with instructions in previous paragraph.
6. Using an end wrench, disconnect small ball joint screw from governor control rod.
7. Remove the four cap screws from the governor ball bearing shield.
8. Slide governor and main shaft out of main housing.
9. Remove governor weights by first tapping weight pins far enough to one side to permit grinding or filing off riveted heads. Drive pins out, taking care not to damage small ball bearings in weights.

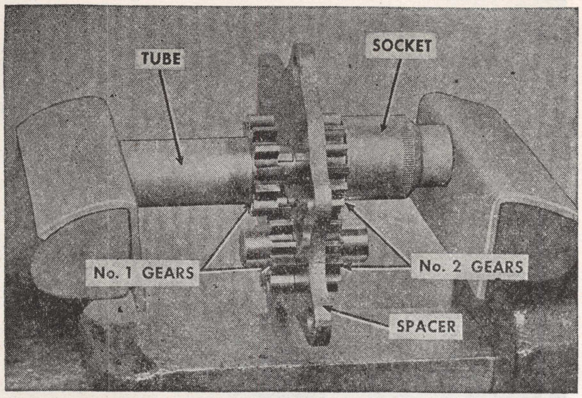


Fig. 33. Model H and NH. Spacer plate in gear assembly.

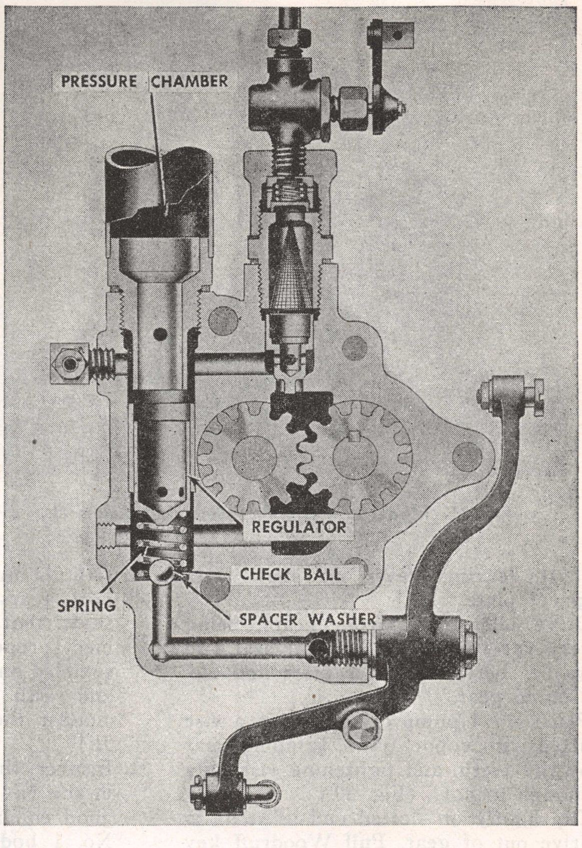


Fig. 35. Model H and NH. No. 2 pressure pump and regulator.

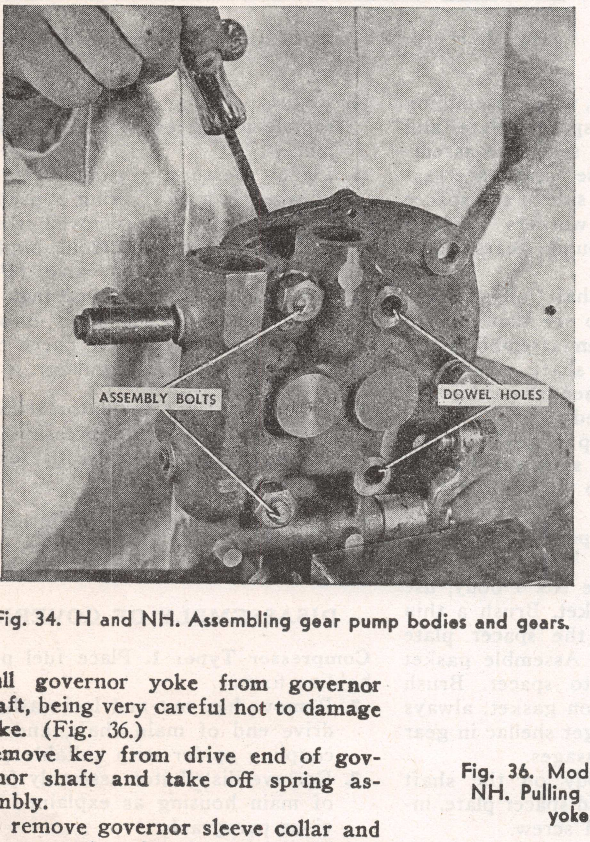


Fig. 34. H and NH. Assembling gear pump bodies and gears.

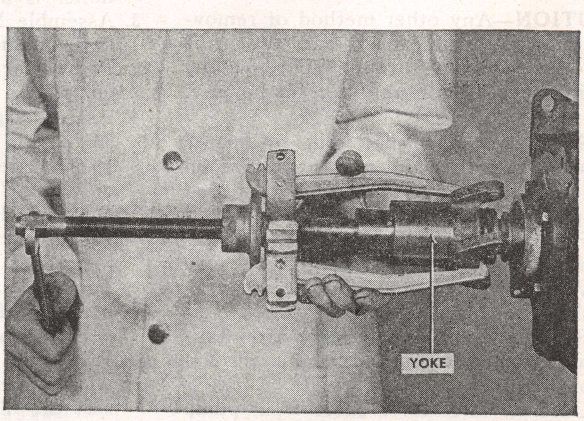


Fig. 36. Model H and NH. Pulling governor yoke.

10. Pull governor yoke from governor shaft, being very careful not to damage yoke. (Fig. 36.)

11. Remove key from drive end of governor shaft and take off spring assembly.

12. To remove governor sleeve collar and thrust washer from spring assembly, first remove snap ring. Thrust washer is prevented from turning by pin in collar.

13. Governor spring can be removed if necessary, by compressing spring and taking out split lock rings in governor sleeve.

Less Compressor Type: Disassembly of less compressor governor is the same as the compressor type with exception of pulling drive gear.

DISASSEMBLY OF HYDRAULIC GOVERNOR DRIVING UNIT

1. Remove control linkage on the side of the pump leading to governor. Remove the four nuts that hold the governor to its adapter plate and lift the governor off.
2. **Remove the four cap screws that hold the adapter plate to the main adapter housing and lift off.**
3. **Loosen the two cap screws that hold the retainer plate over the spindle bearing and turn the plate to one side so as to clear the bearing race.**
4. **Using a heavy screwdriver, or similar tool, pry the spindle up until the drive assembly can be lifted from housing. This may be accomplished by inserting the screwdriver in the inspection hole in the backside of the adapter housing. (Fig. 37.)**
5. **Remove the main drive gear from the front of the drive shaft. Remove the three nuts holding the adapter housing to main fuel pump housing.**
6. **The governor adapter can now be lifted from the main fuel pump housing.**
7. **Remove the four cap screws holding the retainer plate and pull the main shaft from the fuel pump housing.**
8. **If necessary press governor drive gear from shaft.**

NOTE—For disassembly of hydraulic governor, refer to Woodward governor section.

ASSEMBLY OF HYDRAULIC GOVERNOR DRIVE

1. Assemble main shaft assembly. (Fig. 38.)
2. Assemble shaft assembly to main fuel pump housing with a new gasket between bearing shield and main fuel pump housing. Tighten in place with four cap screws and lockwashers.

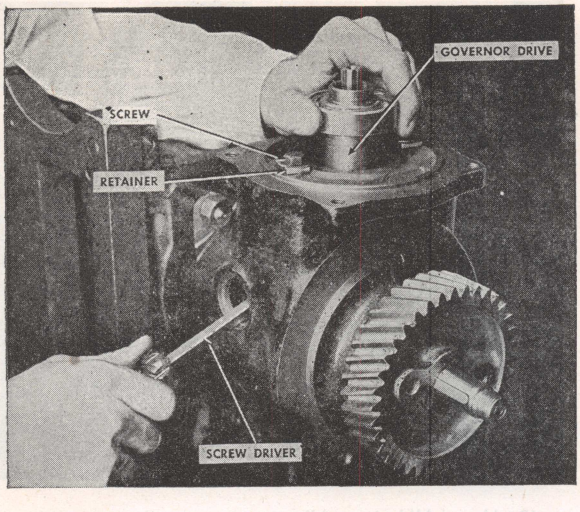


Fig. 37. H and NH. Removing hydraulic governor drive.

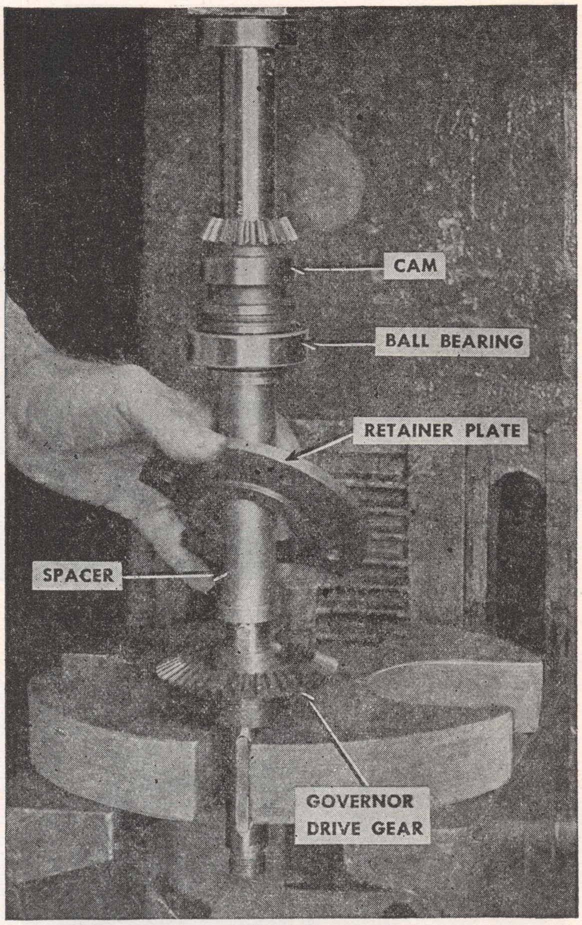


Fig. 38. Model H and NH. Main shaft assembly.

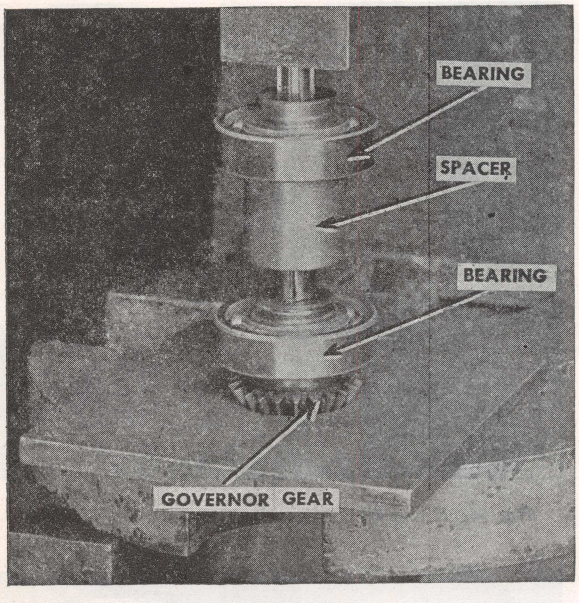


Fig. 39. H and NH. Hydraulic governor drive unit assembly.

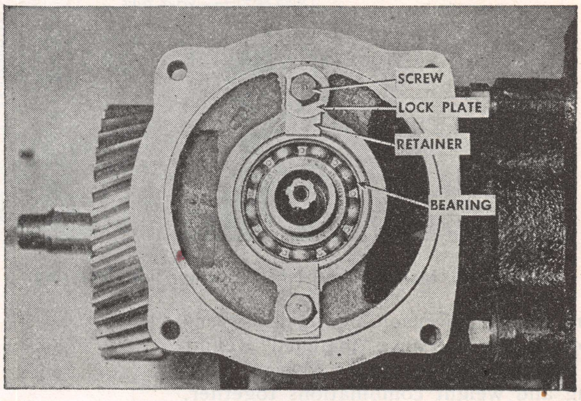


Fig. 40. H and NH. Hydraulic governor drive unit retainer.

3. Assemble governor adapter housing over shaft and tighten in place with lockwashers and nuts.

4. Press driving gear with large ball bearing on shaft over key.

5. Assemble shaft to spacer.

6. Assemble gear to shaft. (Fig. 39.)

7. Assemble unit to adapter housing and secure in place with lockplates and cap screws. (Fig. 40.)

8. Assemble adapter plate to adapter housing and secure in place with four cap screws and lockwashers.

9. Place the spline coupling on the spindle shaft, first making sure that the coupling fits both the spline on the governor shaft and the spline on the spindle shaft. It should be a slip fit. This is important because faulty governor action will result if either a bind or excessive play exists in the coupling.

10. Put the governor base gasket in place.

CAUTION—Be sure it is placed so that it does not cover the oil drain hole.

11. Mount the governor in its correct position making sure that it fits level with the adapter plate. Tighten the hold down nuts with lockwashers evenly and check the governor for freedom of action.

ASSEMBLY OF GOVERNOR

Compressor Type: 1. Inspect fuel pump cam. If worn or rippled, replace cam and shaft as an assembly.

2. Inspect the ball bearings on the main shaft. Replace if worn. The ball bearing next to the fuel pump cam is a shielded bearing and is assembled to shaft with shielded side next to the fuel pump cam. Assemble lock ring as shown by Fig. 41.

3. Assemble governor sleeve tube to main shaft. Assemble lock ring to shaft. Assemble new key to main shaft. (Fig. 42.)

4. Assemble maximum spring to governor sleeve. (Fig. 43.) Assemble governor collar to sleeve making sure it is absolutely free. (Fig. 44.)

NOTE—Before assembling the maximum

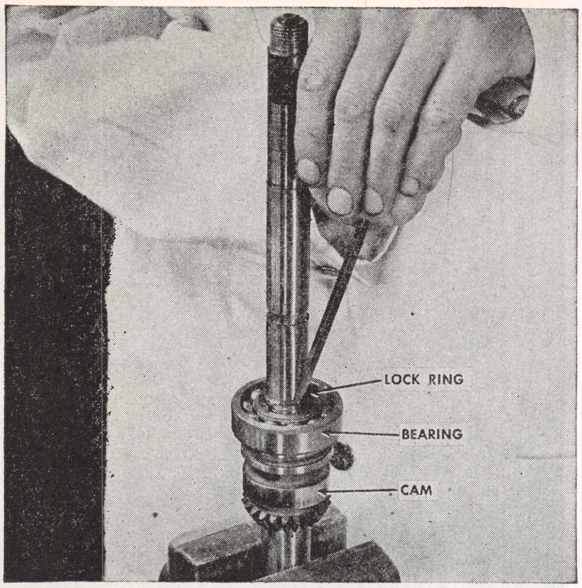

LOCK RING
BEARING
CAM

Fig. 41. Model H and NH. Assembling lock ring.

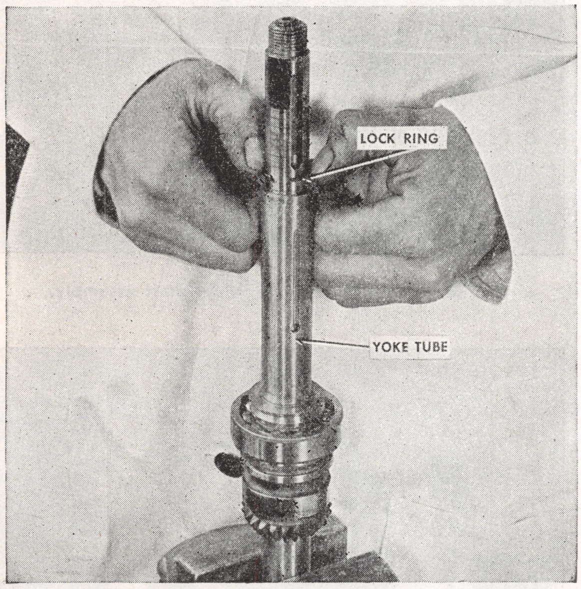

LOCK RING
YOKE TUBE

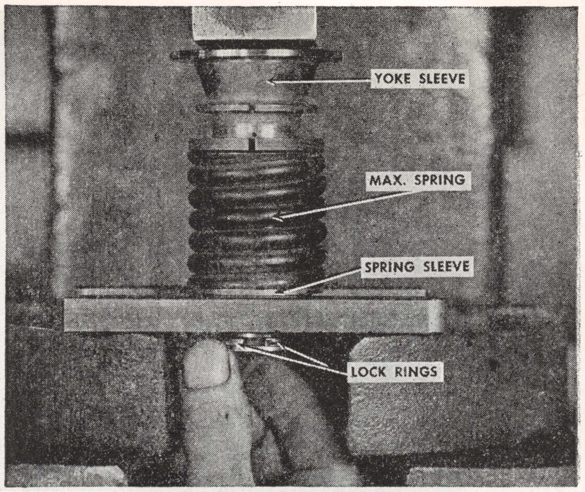
Fig. 42. Model H and NH. Governor tube lock ring.

spring to the governor sleeve, it is very important that you have "matched" weight and spring combinations. Always keep spring and weight combinations together. (Also spacer gaskets when used.)

5. With new gasket for ball bearing shield, assemble governor shaft to main housing.
6. **Lubricate all parts with clean oil and assemble governor sleeve unit over tube on main shaft. Governor sleeve and control rod must be absolutely free on shaft and in housing or poor governor action will result. (Fig. 45.)**

CAUTION—Always have gear pump assembled to main housing when making this check.

7. **Inspect governor weight bushings in the governor yoke.** Wear in these


YOKE SLEEVE
MAX. SPRING
SPRING SLEEVE
LOCK RINGS

43. H and NH. Assembling governor maximum speed spring.

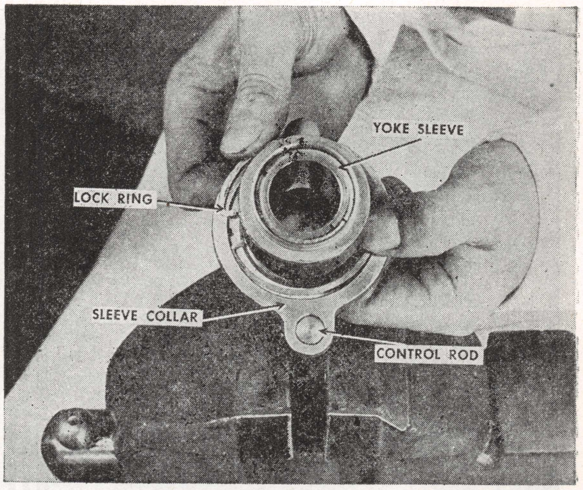

YOKE SLEEVE
LOCK RING
SLEEVE COLLAR
CONTROL ROD

Fig. 44. H and NH. Assembling governor sleeve collar.

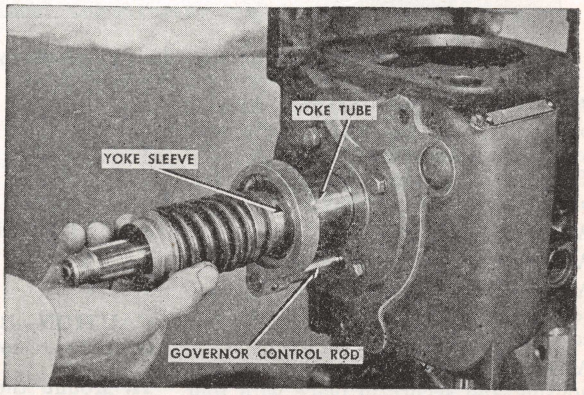

YOKE TUBE
YOKE SLEEVE
GOVERNOR CONTROL ROD

Fig. 45. Model H and NH. Checking governor sleeve and control rod.

bushings can be checked with a new weight pin. If worn, replace with new bushings and ream with special reamer to .256".

8. Place idling spring and increased torque spring in place. Assemble the governor yoke over the key on the main shaft and press in place. (Fig. 46.)
9. Inspect the working radius on the governor weights for wear. If flattened or worn, replace, using new weights bearing same number as was stamped on worn weights. This assures same governed speed. Inspect the small ball bearings in the weights. If pitted or worn, install new bearings with shielded side out. Attach weight assemblies to governor yoke with new weight pins. When weights are prop-

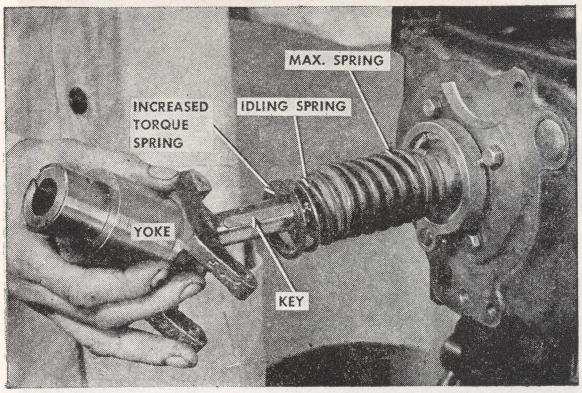


Fig. 46. Model H and NH. Assembling governor yoke.

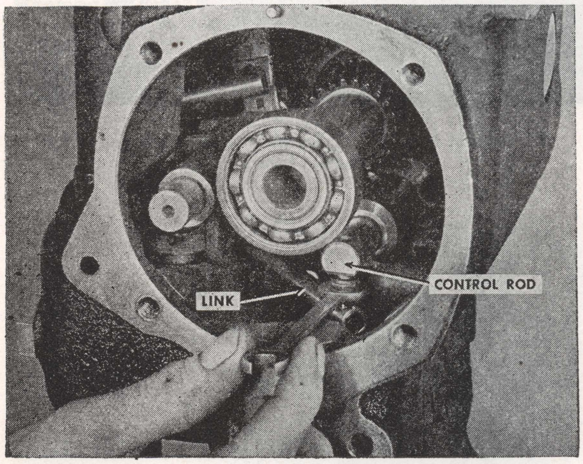


Fig. 47. Model H and NH. Assembling governor link.

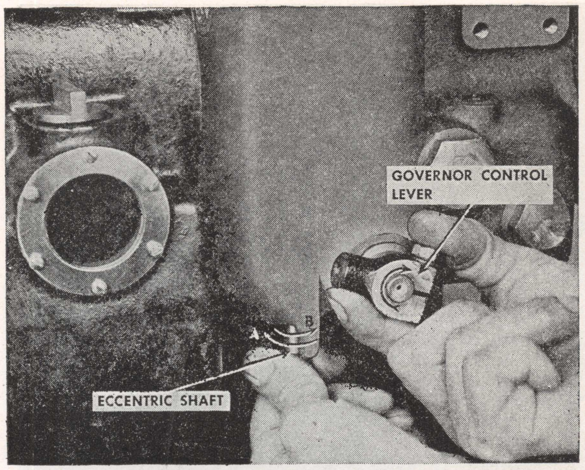


Fig. 48. H and NH. Setting control lever and eccentric shaft.

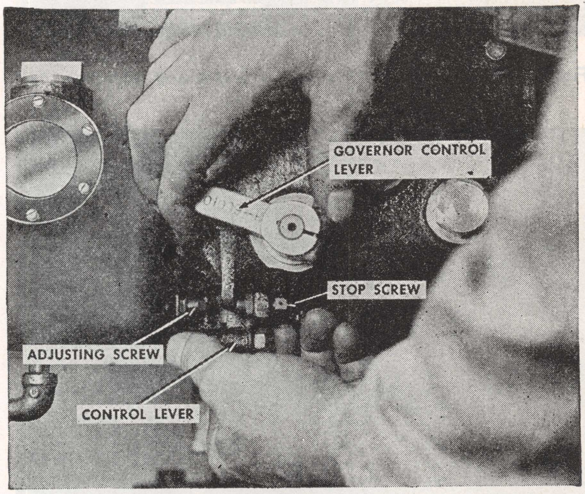


Fig. 49. Model H and NH. Assembling constant speed fuel pump control lever.

erly assembled, the working radius must not ride on the governor sleeve, and the turning fins must be free in the slot in the governor sleeve.

10. **Peen each end of the governor weight pin sufficiently to hold in place.**
11. **Assemble governor link as shown in Fig. 47.**
12. **Refer to** FINAL ASSEMBLY AND ADJUSTMENTS, **before assembling governor housing.**

REASSEMBLY OF HYDRAULIC GOVERNOR CONTROL LINKAGE

Constant Speed Governor—Hydraulic: 1. Install all parts as explained in INSTALLATION OF HYDRAULIC GOVERNOR CONTROL SHAFT.

2. **Turn governor control lever in direction of arrow with fingers to stop.** (Fig. 48.)
3. **Turn eccentric shaft in direction of arrow "A" with fingers to stop.**
4. With lever and shaft in this position, assemble control lever. (Fig. 49.)
5. Turn stop screw into lever until it **just touches stop on housing and lock in place with jam nut.**
6. **Turn control lever in a right hand** rotation to stop.
7. **Turn adjusting screw to stop on housing.**

CAUTION—This **screw** must be given three more **complete turns** on standard H fuel pumps and **six more** complete turns on supercharged H fuel pumps.

8. Lock adjusting screw in place with jam nut and seal.
9. Assemble terminal lever to terminal shaft. (Fig. 50.)

NOTE—The lever must be free to turn on shaft.

10. Assemble control link and spring.
11. With wrench turn governor control lever in a clockwise rotation to stop.

CAUTION—Do not force levers.

12. Hold control lever in this position and make sure control lever is in stop position. Turn terminal shaft in a counter clockwise rotation to stop.
13. Tighten lockscrew securely.

NOTE—If all steps have been followed closely the fuel pump is set for the proper governor action and fuel delivery.

Hydraulic Governor—Variable Speed: 1. Install all parts as explained in INSTALLATION OF HYDRAULIC GOVERNOR CONTROL SHAFT.

2. Turn governor control lever in direction of arrow with fingers to stop. (Fig. 48.)
3. Turn eccentric shaft in direction of arrow "B" with pliers, to stop.
4. With lever and shaft in this position, assemble control lever to eccentric shaft, with stop fin on housing in the middle of stop ears on control lever. (Fig. 51.)
5. Turn stop screw into lever until it just touches stop fin on fuel pump housing.

CAUTION—From this point the adjusting screw on standard H fuel pumps must be given three more complete turns, and on supercharged H fuel pumps, six complete turns.

6. Lock with jam nut and seal.
7. Holding control lever in wide open position, turn adjusting screw into stop fin on housing, and lock in place with jam nut.

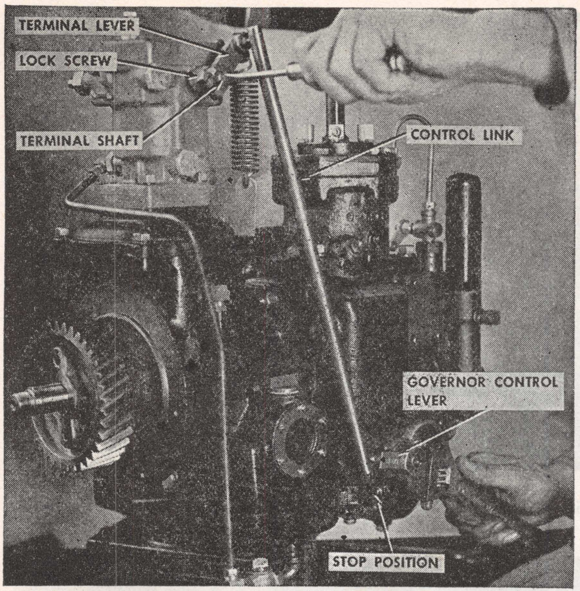
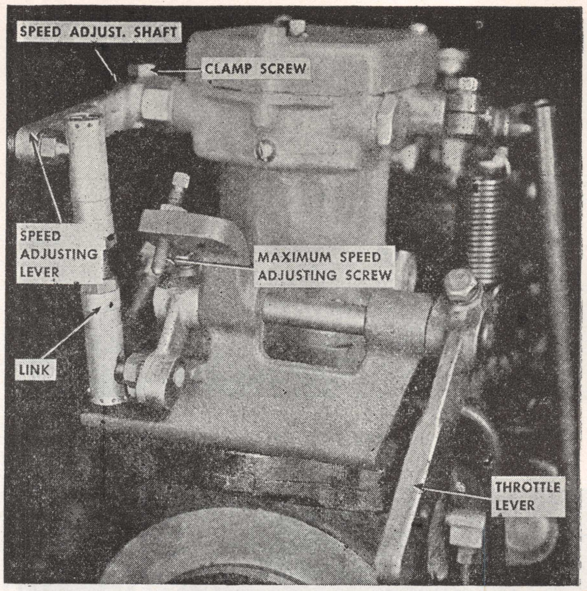

TERMINAL LEVER
LOCK SCREW
TERMINAL SHAFT
CONTROL LINK
GOVERNOR CONTROL LEVER
STOP POSITION

Fig. 50. H and NH. Setting control levers and governor shaft.


SPEED ADJUST. SHAFT
CLAMP SCREW
SPEED ADJUSTING LEVER
MAXIMUM SPEED ADJUSTING SCREW
LINK
THROTTLE LEVER

52. Model H and NH. Variable speed fuel pump throttle control levers.

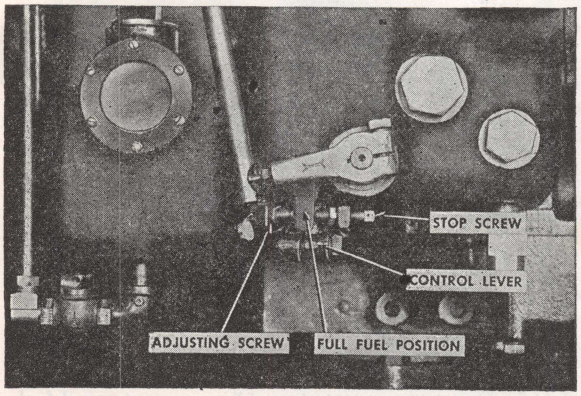

STOP SCREW
CONTROL LEVER
ADJUSTING SCREW
FULL FUEL POSITION

Fig. 51. Model H and NH. Variable speed fuel pump control lever.

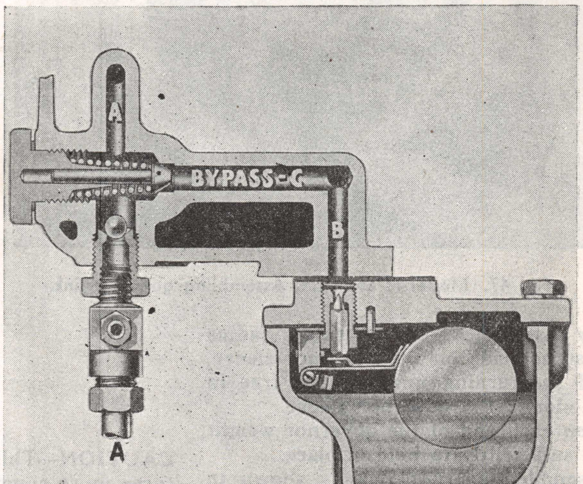

A
BY-PASS-C
B
A

Fig. 53. H and NH. Fuel pump float chamber and by-pass.

NOTE—This will lock the fuel pump control lever in full fuel position.

8. From this point follow steps 10-11-12 and 13 described under HYDRAULIC GOVERNOR CONSTANT SPEED.
9. Assemble all control linkage as shown in Fig. 52.
10. When speed adjusting lever is assembled to governor speed adjusting shaft, be sure shaft remains in neutral position.
11. Tighten clamp screws in levers securely.
12. The maximum speed adjusting screw controls the maximum speed of the engine and must be adjusted when installed on the engine and while engine is running.

NOTE—If you do not have sufficient adjustment it will be necessary to turn the speed adjusting shaft slightly in a counterclockwise rotation. Do not allow maximum speed adjusting screw to project from lever too far.

DISASSEMBLY OF FLOAT CHAMBER

1. Remove two cap screws holding float chamber to fuel pump housing.
2. Remove two cap screws holding top plate to float chamber.
3. Remove nut and washer from float bearing pin and remove pin. This allows float, float stop, and float valve to come free.
4. With small wrench, remove float valve seat from top plate. Be careful not to lose gasket under seat.
5. If necessary, remove check valve seat at main fuel inlet, being careful not to lose ball check.

ASSEMBLY OF FLOAT CHAMBER

1. Reinstall check valve and seat at main fuel inlet, if removed. (Fig. 53.)
2. Place small dowel pin in float chamber top plate, making sure that it is tight enough that it will not drop out.
3. Place gasket in position on top plate.
4. Place float bearing bracket in position on dowel pin.
5. Install float valve seat with new gasket and tighten securely.
6. Make sure that float valve is free of burrs and in good condition; drop into place.
7. Place float in position and insert bearing pin.

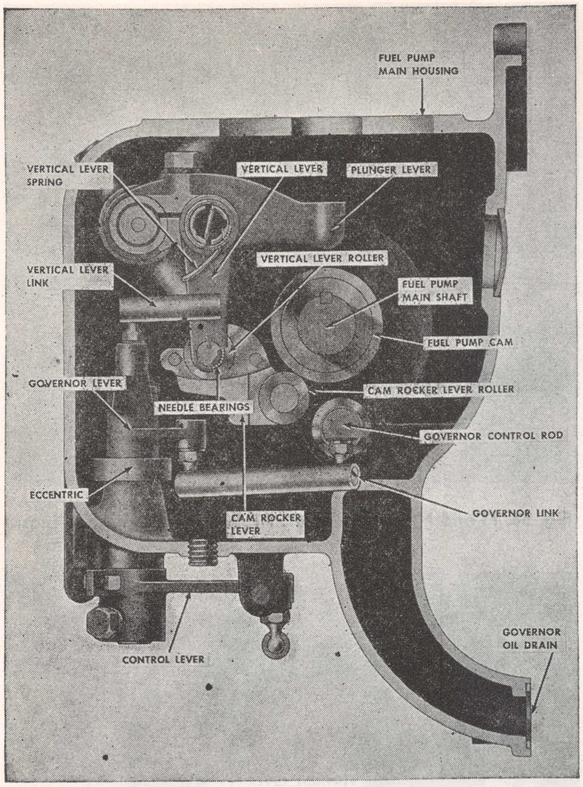


Fig. 54. Model H and NH. Cross section of standard fuel pump main housing.

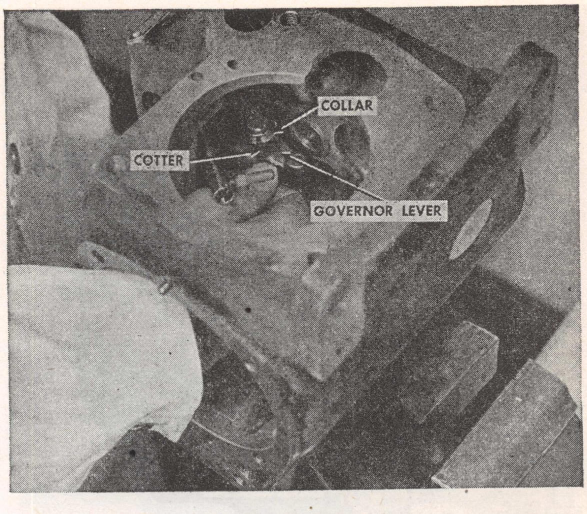


Fig. 55. H and NH. Assembling governor lever collar and pin.

8. Place float stop in position, and assemble lockwasher and nut to bearing pin.
9. Make sure float and valve are absolutely free and that float contacts head of valve, holding it firmly on seat in closed position, otherwise fuel will overflow at bottom of pump.
10. Assemble float chamber to top plate, making sure that float has adequate clearance in chamber.
11. Assemble chamber with new gasket to fuel pump housing and bolt securely in place.
12. Install and tighten drain plug, or recheck tightness if it was not removed.
13. Assemble bypass valve, spring and retainer.

DISASSEMBLY OF PARTS IN MAIN HOUSING

Remove distributor, gear pumps, governor, and float chamber, as described in preceding paragraphs.

Vertical Lever: 1. Use small wrench to remove ball joints from the vertical lever.
2. Insert socket wrench through hole in top of housing to loosen cap screws which hold the plunger lever shaft and plunger lever pin in place.
3. Using small punch, drive through expansion plug on one end of plunger lever shaft until opposite expansion plug falls out. Then drive the shaft out from the opposite end, being careful not to damage bushings.
4. Lift vertical lever assembly from housing.
5. Remove vertical lever spring and cap screw.

WARNING—Place parts on clean paper or cloth only.

6. Push pin from plunger lever, making sure not to lose any of the 56 needle bearings in which it is mounted.
7. Using a small punch, drive pin from vertical lever roller, making sure not to lose any of the 22 needle bearings in which it is mounted.

Cam Rocker Lever: Remove cam rocker lever from housing and disassemble further as follows:

1. Mount lever firmly in a vise having copper jaws.
2. Remove rivet pin with small punch.
3. Using small brass rod as driver, remove roller pin.

CAUTION—It will not be necessary to remove stop pins as they never encounter wear. Removal of these pins will result in serious damage to pump and engine.

Governor Lever and Eccentric Shaft: 1. Remove small governor link from governor control rod with small wrench.
2. Remove cotter pin from collar with a pair of diagonal cutters, and remove collar.
3. Loosen cap screw at bottom of throttle lever hub and take throttle lever from lower end of eccentric shaft.
4. Turn eccentric shaft until governor lever can be lifted from shaft.
5. Lift eccentric shaft from housing.

Hydraulic Governor Control Shaft: On the hydraulic governor (fuel type pump), the governor control rod is situated in the side of the main housing. If it becomes worn it may be removed as follows:

1. Proceed to step 5 under GOVERNOR LEVER AND ECCENTRIC SHAFT.
2. Loosen the cap screw in the governor control lever and remove the lever and rod.
3. Remove the Woodruff key from the shaft.
4. Remove the control lever thrust washer.
5. The shaft must be pulled out from inside the fuel pump housing.

ASSEMBLY AND INSTALLATION OF PARTS IN MAIN HOUSING

Eccentric Shaft and Governor Lever: 1. Inspect eccentric shaft bushing in main housing. Replace if worn, and ream with a standard 9/16" reamer.
2. Inspect governor lever bushing for wear. Replace if worn and ream with standard ½" reamer.
3. Inspect the ball joints in the vertical lever and governor lever link for wear. Replace if pitted or worn. If ball joints are pitted or worn, bad governor action will result.
4. Install governor lever assembled with the vertical lever and governor lever links to the eccentric shaft.
5. Install collar over governor lever and insert new cotter pin. Make sure that there is no more than .002" thrust on governor lever when assembly is completed. (Fig. 55.)

Hydraulic Governor Control Shaft: 1. Inspect control shaft bushing, if worn replace and ream with ½" standard reamer. (Fig. 56).
2. Install shaft in bushing.
3. Inspect oil retainer carefully. If its condition is at all questionable replace and assemble over shaft and seat with a driving mandrel.
4. Install thrust washer on shaft and insert Woodruff key.
5. Hold the shaft firmly in place from inside the housing and tap the control lever on to the shaft, making sure the keyway is in line with the key.
6. Tighten the lever cap screw. Make sure shaft operates freely.

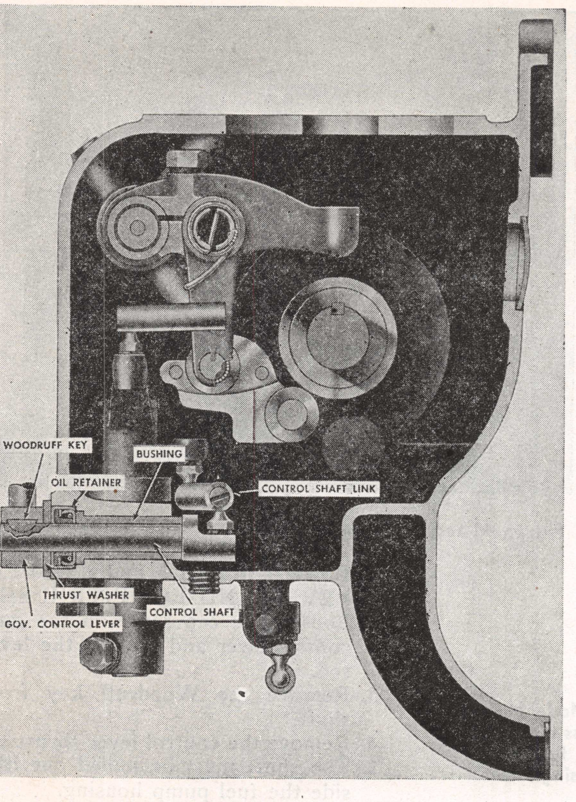


Fig. 56. Model H and NH. Cross section of hydraulic type fuel pump main housing.

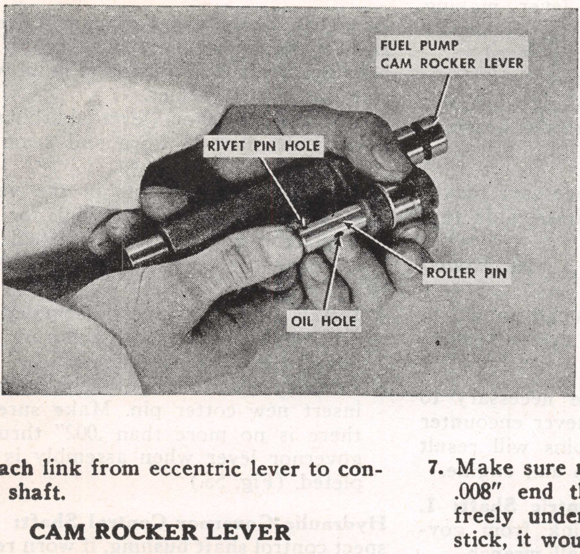


Fig. 57. Model H and NH. Cam rocker level.

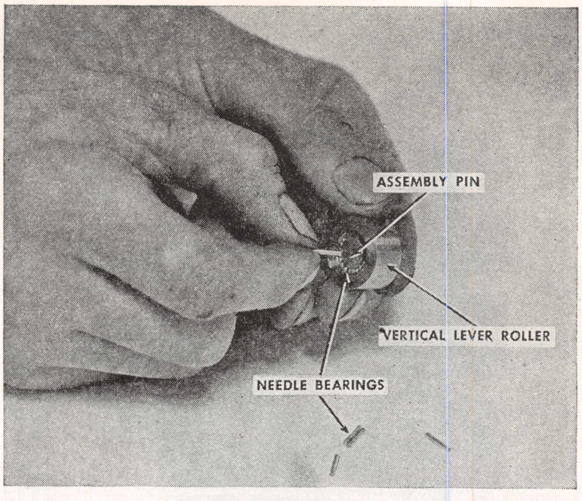


Fig. 58. H and NH. Vertical lever roller and needle bearings.

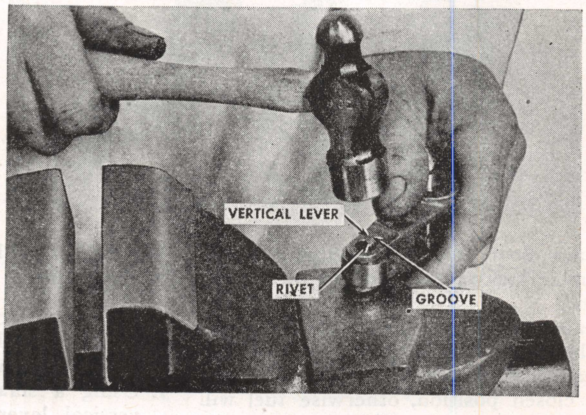


Fig. 59. Model H and NH. Assembling vertical lever and roller.

7. Attach link from eccentric lever to control shaft.

CAM ROCKER LEVER

1. **Inspect cam rocker lever for wear on ground radius where vertical lever roller operates. If lever is rough, it will cause bad governor action, and it must be replaced.**
2. **Inspect roller pin for wear; replace if worn.**
3. **Inspect roller and replace if worn.**
4. **Start roller pin into lever, making sure oil hole in pin is open.**
5. **Assemble roller in place and tap pin through roller, making sure lubricating hole in pin indexes with hole in lever. (Fig. 57.)**
6. **Pin the roller pin in place.**
7. **Make sure roller is free and has .006"-.008" end thrust to allow it to turn freely under tension. If roller should stick, it would cause serious damage.**
8. **Inspect cam rocker lever bushings in main housing and No. 1 gear pump body. Replace if worn. When replacing main housing bushing be sure oil hole is lined up properly for lubrication. Ream with 13/16" bottom reamer. Ream bushing in No. 1 gear pump body with ⅝" bottom reamer.**
9. **Reinstall cam rocker lever assembly in housing.**
10. **At this time it is best to assemble the gear pressure pump to the main housing.**
11. **Be sure to use proper gasket between main housing and gear pump. Bolt gear pump in position to body. Check cam rocker lever to see that it rocks freely and that it has at least .006" end thrust. If lever is not free, it may be necessary to scrape the bushings slightly so that it will work freely. If this lever does not work freely, it will affect the metering pump fuel delivery.**

VERTICAL LEVER

1. **Inspect vertical lever, pin, roller, and roller pin.**
2. **If pitted or worn, replace. If parts are worn or pitted, poor governor action will be encountered. It is always best to replace needle bearings if pins and lever are found to be corrugated or pitted.**
3. **Spread clean cloth on work bench and on it place the parts of the vertical lever to be assembled. Place roller on index finger and put piece of ⅜" rod, 7/16" long, in hole. Fill hole with 22 long needle bearings as shown in Fig. 58. Place roller in position and push roller pin through. This will cause small plug to fall out on opposite side. Lock in place by riveting copper rivet into grooves on both sides of vertical lever. (Fig. 59.)**
4. **When assembling plunger lever pin, use ⅝" inside diameter copper tubing with slot for needle bearings to pass through.**

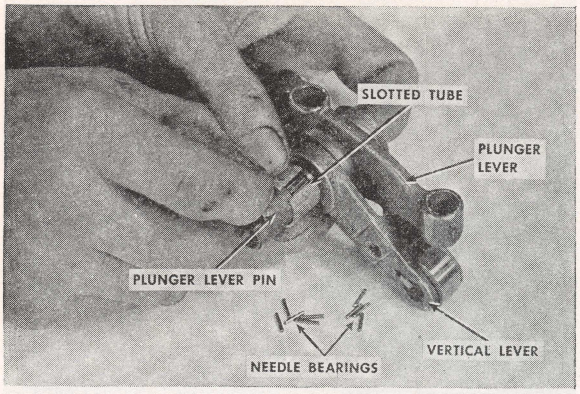

SLOTTED TUBE
PLUNGER LEVER
PLUNGER LEVER PIN
NEEDLE BEARINGS
VERTICAL LEVER

Fig. 60. Model H and NH. Assembling plunger lever pin and needle bearings.

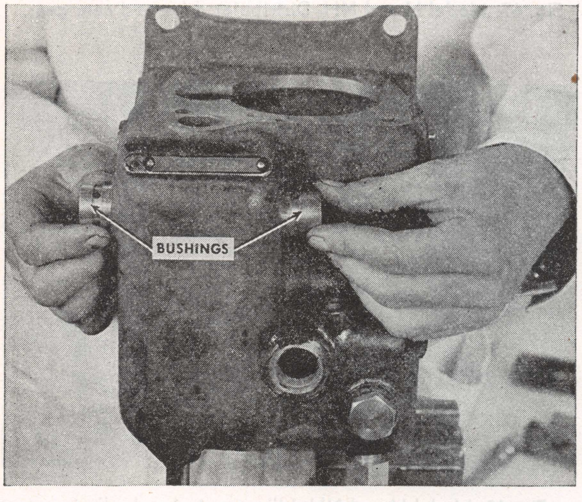


Fig. 61. H and NH. Assembling plunger lever shaft bushings.

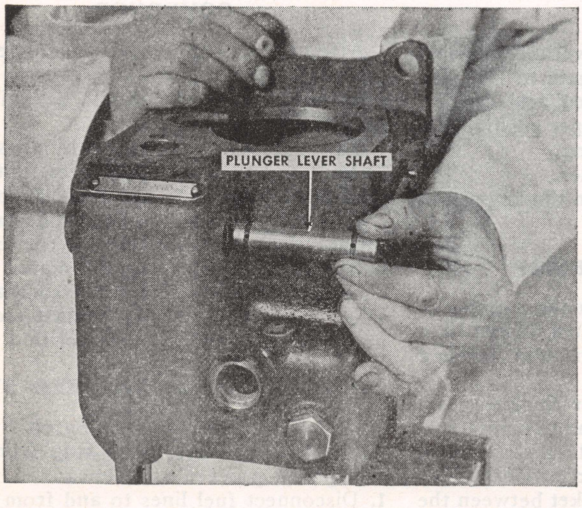

PLUNGER LEVER SHAFT

Fig. 62. H and NH. Assembling plunger lever shaft.

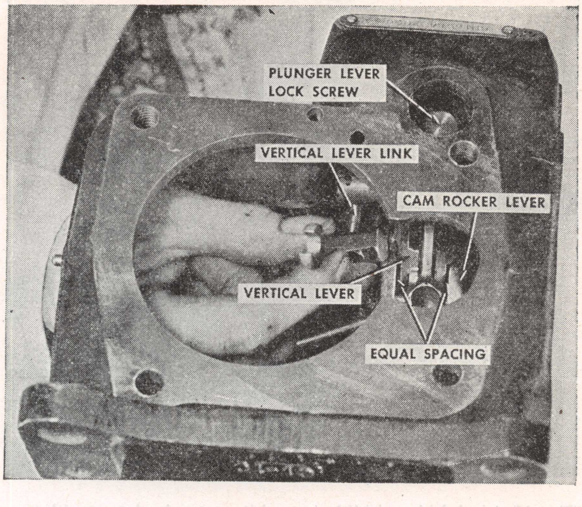

PLUNGER LEVER LOCK SCREW
VERTICAL LEVER LINK
CAM ROCKER LEVER
VERTICAL LEVER
EQUAL SPACING

Fig. 63. Model H and NH. Spacing vertical lever in cam rocker lever race.

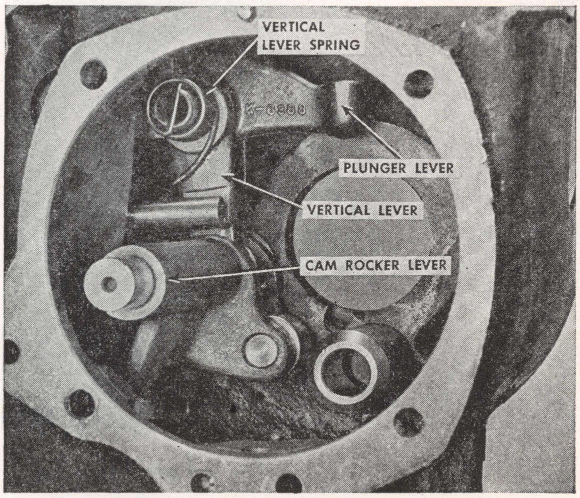

VERTICAL LEVER SPRING
PLUNGER LEVER
VERTICAL LEVER
CAM ROCKER LEVER

Fig. 64. Model H and NH. Vertical lever spring in position.

(Fig. 60.) Place plunger lever between arms of vertical lever in position. Tap plunger lever pin through vertical lever and plunger lever, leaving the needle bearing race open on one side. Place the slotted tubing over the pin and insert 28 short needle bearings. Tap the plunger lever shaft through far enough to allow the opposite bearing race to be filled with the same number of needle bearings. Tap plunger into position and turn groove in pin to match the cap screw hole in the plunger lever. Run cap screw down loosely to hold the pin in place.

5. Inspect plunger lever shaft bushings in main housing for wear. If worn, replace in proper position to match up with oil holes in housing as shown in (Fig. 61). Ream with ¾" standard reamer.

6. Place vertical lever in position in housing. Insert plunger lever shaft as shown in Fig. 62. It is necessary that the vertical lever and roller be spaced in the center of the cam rocker lever race when it is in proper working position as shown in Fig. 63. To space the vertical lever, it may be necessary to shift the plunger lever shaft bushings one way or the other. With socket wrench tighten shaft lockscrew. Insert new expansion plugs on each end of plunger lever shaft. With large flat end punches, wedge in place. Check position of vertical lever and roller in cam rocker lever race to see that it has not shifted while inserting expansion plugs. Check to see that plunger and vertical lever work freely. Place vertical lever spring in position as shown in Fig. 64.

7. Assemble vertical lever link with new lockwasher to vertical lever.

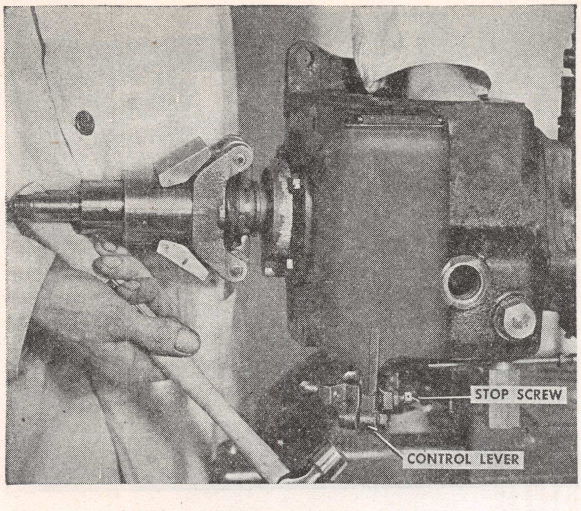


Fig. 65. Model H and NH. Assembling standard control lever.

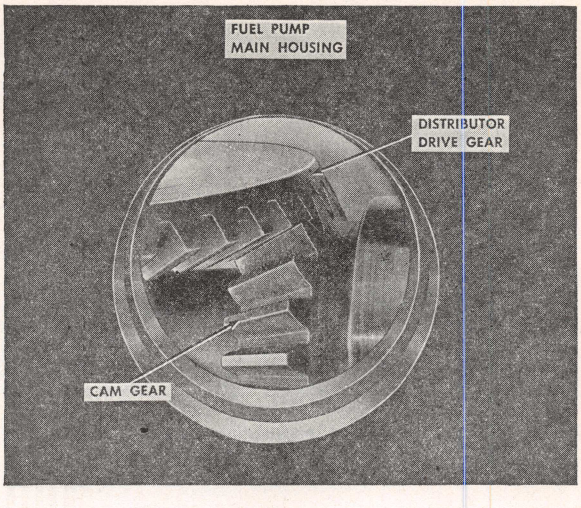


Fig. 67. Model H and NH. Distributor drive and cam gear.

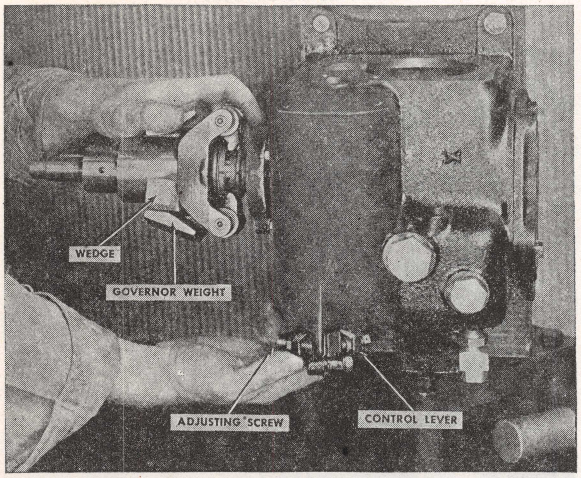


Fig. 66. Model H and NH. Setting fuel adjusting screw.

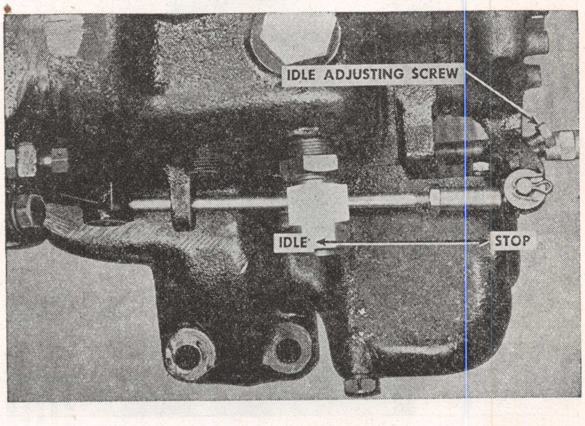


Fig. 68. Model H and NH. Idling control and adjustment.

FINAL ASSEMBLY AND ADJUSTMENTS

With Compressor and Less Compressor: 1. Assemble gear pressure pump to main housing.

2. Assemble cam rocker lever spring, gasket and spring retainer.
3. Holding down on the top end of the eccentric shaft, assemble control lever to eccentric shaft in stop position. (Fig. 65.)
4. Turn stop screw in to the stop on housing, and lock in place with jam nut.
5. If new control lever or eccentric has been installed, it will be necessary to drill new pin hole in lever and shaft.
6. To set the maximum fuel setting stop, to avoid any stress on the governor and fuel control mechanism, proceed as follows: With small wooden wedge under governor weights, compress the idling spring. (Fig 66.)
7. With hand control opened to maximum fuel position, turn adjusting screw into stop on housing and give screw three more complete turns from that point, and lock in place with jam nut.
8. Inspect bushing in governor housing. If worn, replace and ream to 1⅝". Inspect oil seal. If damaged, replace.
9. With new gasket in proper position, assemble governor housing.
10. Assemble coupling spider.
11. Assemble copper plug in the keyway of the drive spider.

TIMING FUEL PUMP

1. Set timing marks on coupling spider or drive gear as shown in Figs. 17 and 19.
2. Set timing mark in distributor housing as shown in Fig. 15.
3. With a gasket of proper thickness, assemble distributor housing to main housing. Be sure to assemble the metering plunger, spring, and link, properly.
4. The thickness of the gasket between the distributor housing and the main housing determines the back lash of the distributor drive gear.
5. The distributor drive gear back lash is .004". This can be checked by rocking the main shaft gear by hand. Check by turning the distributor gear one complete turn and checking at various positions. (Fig. 67.)

ADJUSTMENT OF IDLING GOVERNOR

After fuel pump is installed on engine and engine running, the low speed or idling governor stop screw, should be adjusted. (Fig. 68.)

This adjustment is made by loosening locknut and turning idling screw until engine idles at between 450 and 500 rpm.

If more adjustment is required than the screw permits, readjustment of the linkage to the idling control may be made. Make sure this adjustment is made so that the idling lever holds screw against stop on pump body when in idling position.

REMOVAL OF OVERSPEED STOP

NOTE—To identify parts, consult Fig. 69. To remove the overspeed stop from the fuel pump, proceed as follows:

1. Disconnect fuel lines to and from overspeed stop.
2. Remove the cap screws and lockwashers from the cover plate and lift cover from body.
3. Remove pawl spring.
4. Remove pawl spring from shaft.
5. Remove the four fillister head screws from the housing and pull unit from fuel pump housing.

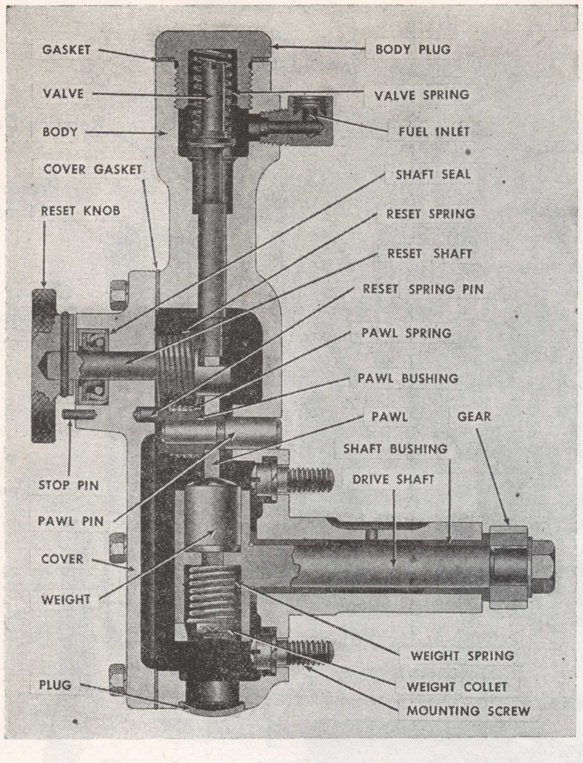

GASKET
BODY PLUG
VALVE
VALVE SPRING
BODY
FUEL INLET
COVER GASKET
SHAFT SEAL
RESET KNOB
RESET SPRING
RESET SHAFT
RESET SPRING PIN
PAWL SPRING
PAWL BUSHING
PAWL
GEAR
SHAFT BUSHING
STOP PIN
DRIVE SHAFT
PAWL PIN
COVER
WEIGHT
WEIGHT SPRING
WEIGHT COLLET
PLUG
MOUNTING SCREW

Fig. 69. Model H and NH. Cross section of overspeed stop.

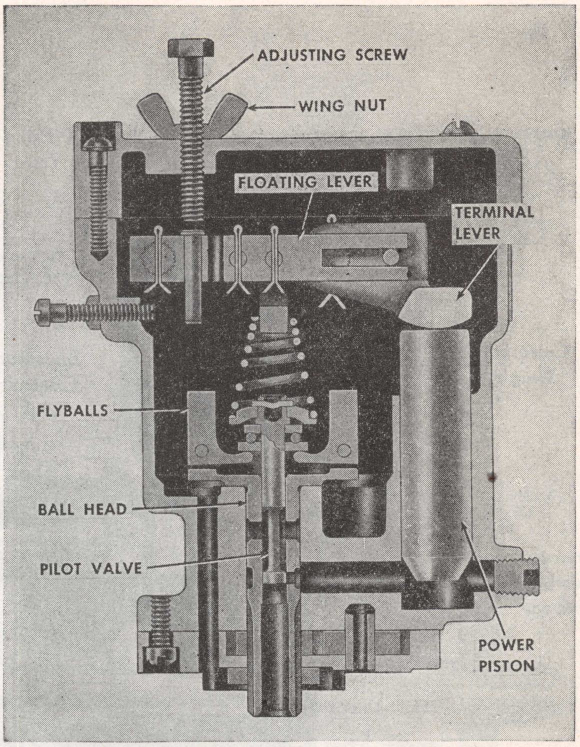

ADJUSTING SCREW
WING NUT
FLOATING LEVER
TERMINAL LEVER
FLYBALLS
BALL HEAD
PILOT VALVE
POWER PISTON

Fig. 70. Model H and NH. Side cross sectional view of Woodward governor.

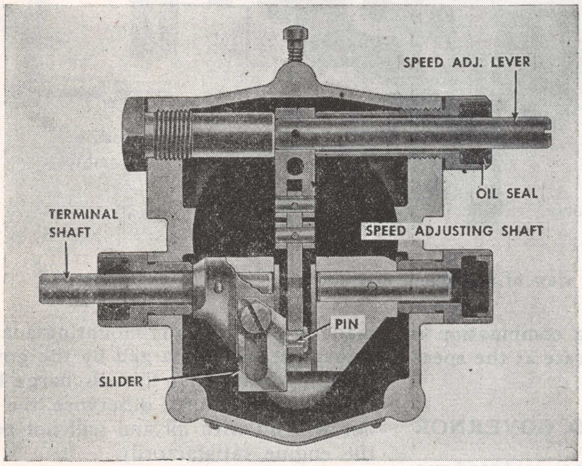

SPEED ADJ. LEVER
OIL SEAL
TERMINAL SHAFT
SPEED ADJUSTING SHAFT
PIN
SLIDER

Fig. 72. Model H and NH. Top cross sectional view of Woodward governor.

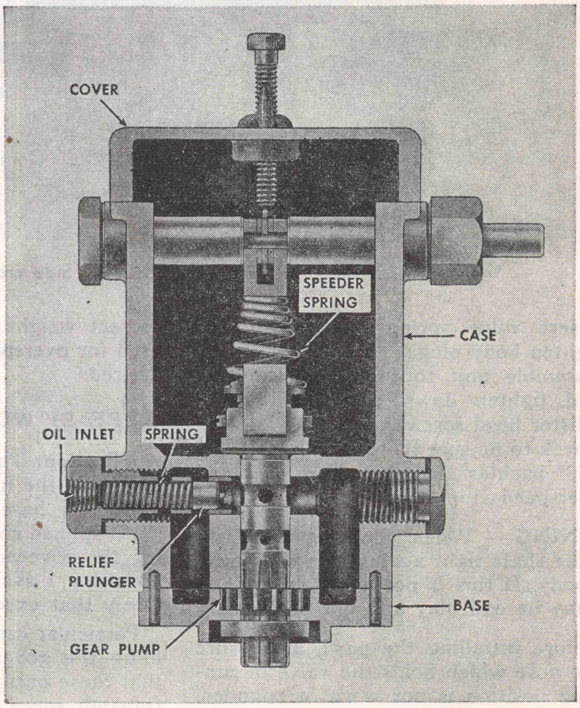

COVER
SPEEDER SPRING
CASE
OIL INLET
SPRING
RELIEF PLUNGER
BASE
GEAR PUMP

Fig. 71. Model H and NH. End cross sectional view of Woodward governor.

SERVICE AND REPAIR OF OVERSPEED STOP

NOTE—To identify parts, consult Fig. 69.

Disassembly: 1. Remove body plug.

2. Lift valve spring, and valve from body.
3. Remove nut and lockplate from end of drive shaft, and pull gear.
4. Remove Woodruff key from shaft.
5. Pull shaft from body.
6. Uncotter weight spring collet and screw collet from weight shaft.
7. Remove weight and spring.

Assembly: 1. Insert weight in shaft; assemble spring and spacers (if used) and install spring collet and cotter key.

NOTE—Turn collet down flush with end of weight shaft before installing cotter pin. It will be necessary that you use correct weight and spring combinations for speeds you wish the overspeed stop to operate.

2. Examine drive shaft bushings in body. If they show signs of wear, replace them and ream with 9/16" reamer.
3. Install drive shaft in body and check to see that it has .002" running clearance.
4. Install Woodruff key in shaft and install drive gear. Lock gear with lockplate and nut.

NOTE—Shaft must have .004" end play.

5. Inspect valve and valve seat. If either shows signs of wear or pitting they should be seated to a true seat before installing.

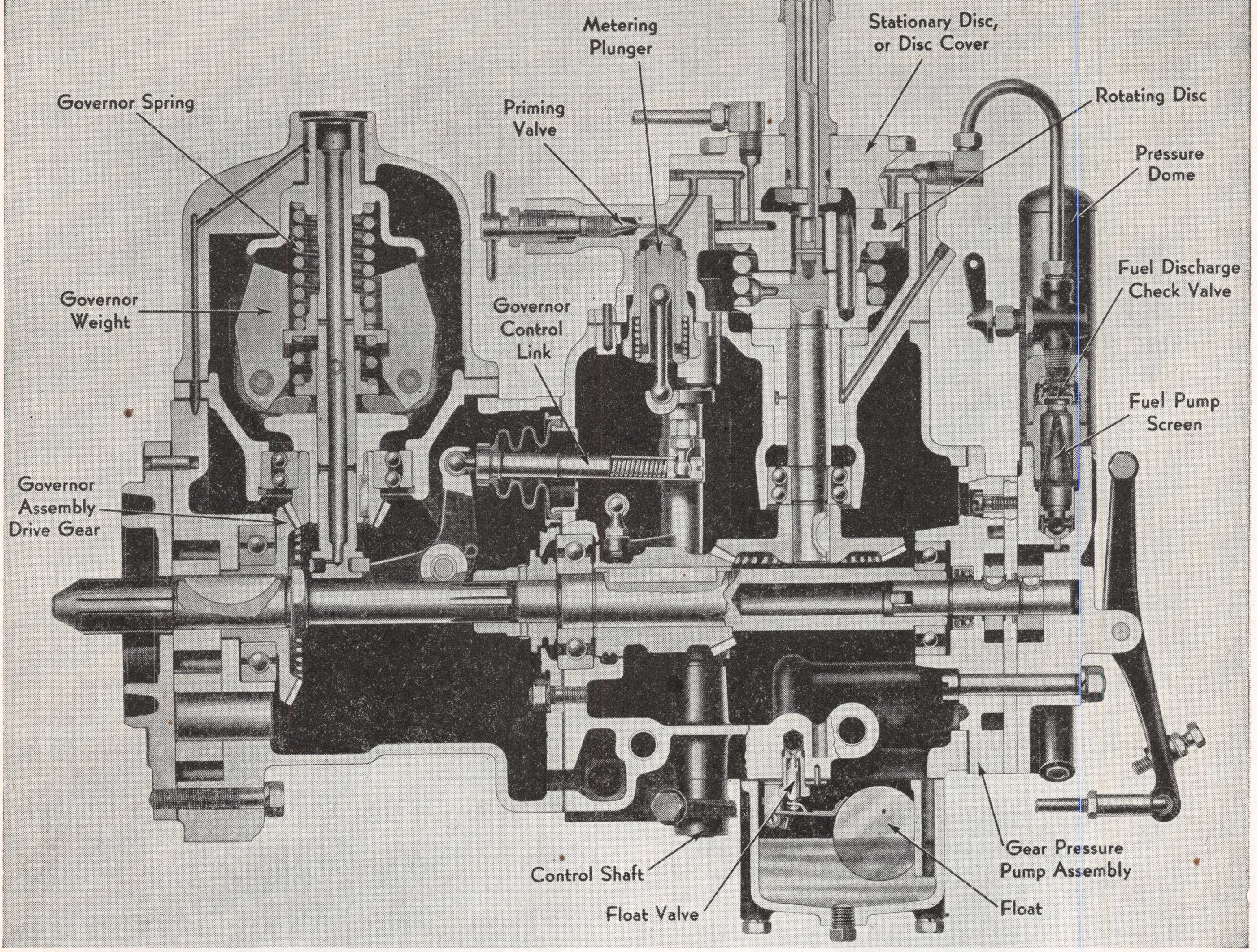


Fig. 73. Model A. Side cross sectional view of fuel pump assembly.

6. Insert valve spring and install and tighten body plug.
7. Assemble unit to fuel pump housing and tighten down evenly with four fillister head screws.
8. Check to be sure there is at least .002"-.003" backlash between drive gear and overspeed stop gear.

WARNING — When checking backlash, hold the shaft tight against the overspeed stop body. If this is not done, the motion felt may be end play and not backlash.

9. Before installing the pawl, make sure the nose which holds the valve in running position is not worn or rounded. Should this condition exist, trouble would result.
10. Assemble pawl to shaft, and install spring.
11. Assemble cover to body and turn reset knob in clockwise rotation to set valve in running position.
12. Reconnect fuel lines to fittings.
13. Start engine.

CAUTION—It is very important that the correct weight and spring combination is used for overspeed to operate at the speed desired.

TYPE S1 WOODWARD GOVERNOR

Application: The governor is mounted vertically on the fuel pump with a gasket between its base and the adapter pad. A 9/16" splined coupling is provided for driving the governor. This part should fit the governor drive shaft freely, but not so freely that excessive backlash exists.

Particular care should be used in assembling the governor drive parts to insure that these parts will run smoothly and not transmit speed irregularities, such as may be caused by shaft run-out, or improper backlash, etc. The ballhead in the governor, being very sensitive, will pick up these impulses and governor performances will be erratic.

A supply line is provided between the governor and the governor oil sump. This should be so installed as to insure a continuous flow of oil for use as may be required by the governor. Provisions are made in the drive and mounting adapter to return the oil discharged by the governor. It is important that this discharge be free from back-pressure; otherwise, the governor will fill with oil and will not regulate the engine satisfactorily.

The terminal shaft rotates through 30 degrees for full travel and extends from the side of the governor case. Not less than two-thirds of the available terminal shaft travel should be used to regulate the fuel between idling and full load.

Installation and Adjustment: When the governor is installed, particular care should be exercised to see that it is mounted squarely, and that the splined drive shaft is in exact alignment with the coupling sleeve on the drive from the engine. The hold-down nuts should be securely and evenly tightened. The line between the governor lubricating oil sump and governor should be installed. The linkage connections to the speed adjusting shaft should be assembled. When making up the linkage connections between the terminal shaft and fuel system, care should be taken to insure that

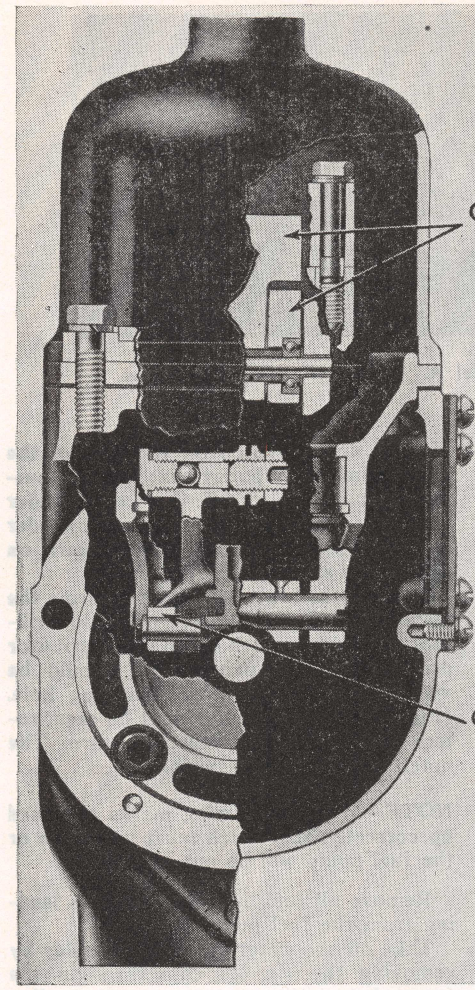


Fig. 74. Model A. Cutaway view of fuel pump.

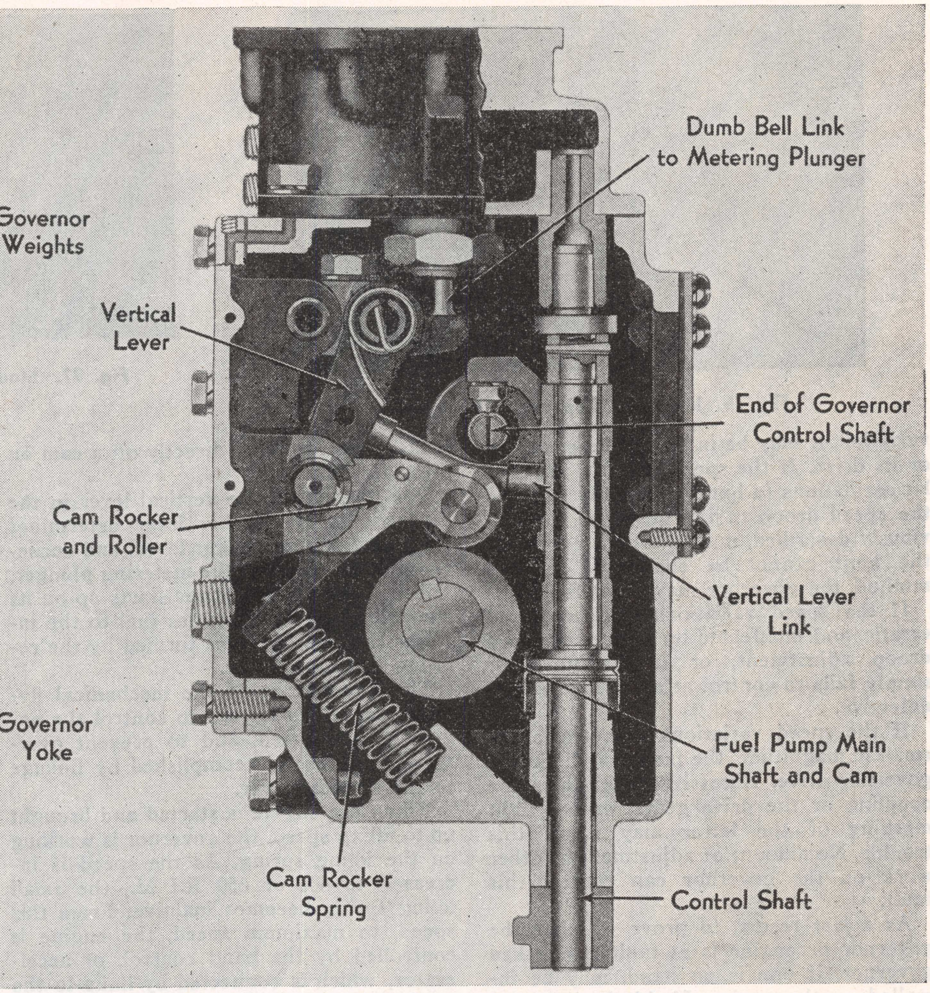


Fig. 75. Model A. Center cross sectional view of fuel pump.

when the terminal shaft of the governor is in the off position, the fuel system will also be shut off.

After checking the foregoing carefully, as far as the governor is concerned, the engine may now be started. After the governor begins to receive oil pressure it will start to open the fuel, and continue in this direction until the engine fires. After the engine is running, it will control the speed at the point for which the governor speed adjustment is set.

If the governor allows the engine to hunt, shut down the engine and remove governor cover. Loosen the lockscrew which holds slider and move the slider away from the center of the governor, about one-eighth inch. This increases the speed droop setting. Tighten the lockscrew and replace the cover. Start the engine and observe if the engine is still hunting. If it is, repeat the procedure outlined above until hunting stops.

Lubrication: The governor is lubricated by oil introduced into the governor housing past the power piston, and pilot valve plunger. The oil is broken up into a fine mist by the rotation of the governor flyballs. The oil collects in the bottom of the governor case, and is discharged through the base, by a drain hole.

Speed Lever Adjustment: Rotation of the speed adjusting shaft causes the speed adjusting lever to raise or lower the floating lever. Since the terminal lever is stationary when the load is steady, the floating lever pivots on pin and increases or decreases the compression on speeder spring. Increasing this compression causes the speed to rise; decreasing it causes the speed to drop. Rotating the speed adjusting shaft sufficiently far in the decrease speed direction causes the floating lever to pick up speeder spring and lift the pilot valve plunger. This opens the area under the power piston to the drain and enables the fuel return spring to shut off the fuel completely, thus shutting down the engine. If the governor is to be used for constant speed service, speed adjustment may be made by adjusting screw. Wing nut is provided which may be preset to limit the speed adjustment setting which can be made, and thus limit the maximum operating engine speed. If lever type speed adjustment is used, to give a variable speed range, adjusting screw may be preset to give the desired minimum engine speed.

Speed Droop Adjustment: When the slider is pushed toward the center of the governor as far as it will go, the speed droop adjusting lever pin is near the axis of the terminal lever. Consequently, as the power piston moves, there will be but a slight up and down movement of the floating lever. This, in turn, results in a minimum change of loading on the speeder spring, or minimum speed droop. As the slider is moved away from the center of the governor speed droop adjusting lever, the pin moves away from the axis of the terminal shaft. Consequently, the movement of the power piston, through the floating lever, causes a greater change of loading on the speeder spring, or increased droop.

Governor Service: Governor faults usually show up in speed variations of the engine, but this does not mean that all such speed variations indicate governor faults. Therefore, when improper speed variations appear, the following procedure should be carried out:

1. Check the load to be sure that the speed changes observed are not the result of load fluctuations.
2. If the load is uniform, carefully check the engine to be sure that all cylinders are firing properly.
3. See that the governor is installed so that no bind exists in the governor or in the fuel mechanism on the engine.

If neither load nor engine irregularities are found to be the cause of the speed

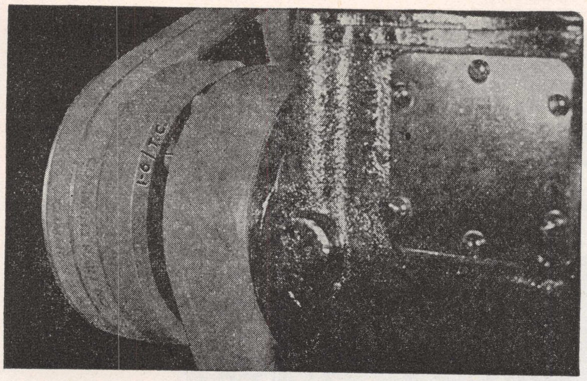


Fig. 76. Model A. Top center timing mark.

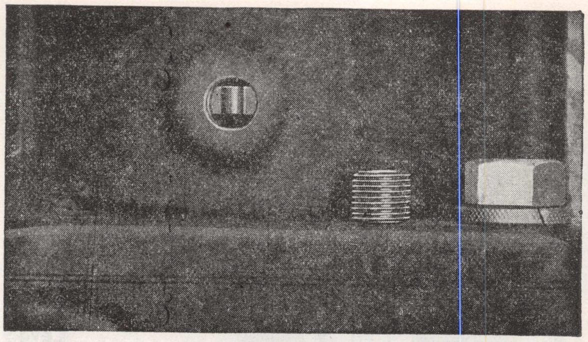


Fig. 77. Model A. Distributor collar timing mark.

variation, it may be in either the governor or its drive. If the speed changes in regular oscillations (a hunt), gradually increase the speed droop of the governor, as previously described, until the hunt ceases. If the hunt cannot be eliminated by this method, the governor may be at fault.

If the speed variations are large and erratic, and unaffected by change of speed droop adjustment, or if the governor simply fails to control at all, it is probably defective.

If the speed variations are erratic but small in magnitude, the fault may lie in the governor drive. Excessive backlash in the coupling or the drive gears, or too tight meshing of the latter may cause this trouble. No amount of adjustment or other work on the governor can correct this fault.

As a last resort, to prove whether the governor or engine is at fault, a checked governor, if one is on hand, may be installed on the engine. If this is done, see that the checked governors bear the same designation as the one removed. The designation is important because of right and left-hand rotation, and the possibility of there being different flyballs in the governors.

If it is concluded that the governor is defective, it should be removed from the engine and returned to Cummins Engine Company.

MODEL A FUEL PUMP

MECHANICAL PRINCIPLES

The fuel is first delivered to the float chamber by the suction, or No. 1 pump. Fuel level in the float chamber is maintained by the proper action of the float and by-pass valve.

The fuel is picked up from the float chamber by the pressure, or No. 2 pump, and is delivered to the distributor head under constant pressure. From this point, it is delivered to the metering plunger (which is on its down stroke) by the indexing of transfer passages in the distributor top and disc.

The metering pump is merely a closely fitted reciprocating pump, obtaining its motion, through a link, from the plunger lever.

Operating the plunger lever is a vertical lever which is controlled by an eccentric rocker lever, running directly off a cam on the mainshaft.

The position of the vertical lever in the eccentric of the rocker lever determines the travel of the plunger lever, and consequently the travel of the metering plunger.

As the metering plunger starts up on its controlled stroke, it pushes fuel to the injector through passages formed by the rotating distributor disc.

The governor is of the mechanical flyball type. Its duties are to control the engine at idle speed, and to prevent overspeeding. This is accomplished by linkage to the vertical lever.

When the engine is started and brought up to idling speed, the governor is working on the idling spring. As the speed is increased to 600 or 650 R.P.M., the small idling spring becomes inactive. From this speed, to maximum speed, the engine is controlled by the hand control, or accelerator, which is connected by links to the vertical lever. As the maximum speed of the engine is reached, the large governor spring becomes active and the governor takes control, limiting the revolutions to the maximum rated speed of the engine.

The amount of travel of the metering plunger controls the amount of fuel going to the engine. Therefore, by varying the travel of the metering plunger, various engine speeds and load conditions can be taken care of. In order to vary and control the travel, it is only necessary to change the position of the vertical lever in the quadrant of the rocker lever between the stop pins.

When the roller is against the outside stop pin on the quadrant there is no travel on the vertical lever, or on the metering plunger. Consequently, no fuel is going to the engine. If the vertical lever is moved over to the inside pin, the travel on the metering plunger is sufficient to give full speed and load to the engine. The throttle is hooked to the eccentric shaft which works with the fuel pump governor lever.

FUEL PUMP, OVERHAUL

TO REMOVE FUEL PUMP FROM ENGINE

Time Fuel Pump to Engine: It is necessary to turn the engine by hand until the fuel rocker lever starts to push the injector plunger down. Watch on the face of the water pump drive pulley next to gear housing for numbers 1 & 6 T. C. on six-cylinder engines (numbers 1 & 4 on four-cylinder engines). Match this mark with mark on gear cover as shown in Fig. 76.

Remove the lower ⅛" pipe plug from the inspection hole in the side of the distributor housing. A notch cut in the distributor drive collar and painted red should be visible through the inspection plug hole. (Fig. 77.) If the notch cannot be seen, rotate the engine one complete turn. The notch should now be visible.

NOTE—When the timing marks are lined up correctly, this notch must be visible or the fuel pump will be out of time.

Remove all fuel lines and controls leading from the fuel pump.

Take off the water pump drive pulley by removing the six ⅜" capscrews on the front of the pulley and then tap the pulley off its hub with a soft hammer.

Remove the four ⅜" capscrews on the gear case cover directly behind the water pump drive pulley.

Remove the oil line and adapter plate connected to the lower side of the lubricating oil pump.

Take out the two ½" capscrews holding the fuel pump to the engine and then slide the entire fuel pump assembly out and toward the rear of the engine.

REMOVING DISTRIBUTOR

Remove small goose neck fuel line leading from gear pressure pump to the distributor top.

Remove the five capscrews holding the distributor housing in place. Remove distributor housing assembly.

REMOVAL OF GEAR PRESSURE PUMP

Remove the five capscrews holding the gear pump to the fuel pump housing (do not remove nuts). Remove pump by tapping slightly with block of wood.

REMOVING GOVERNOR

Remove the small plate on the side of the lubricating pump housing. With a ⅝"

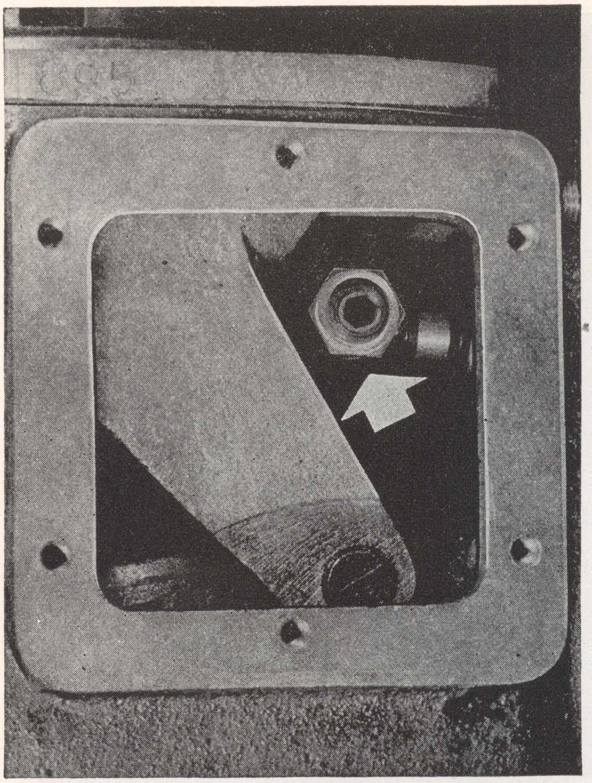


Fig. 78. Model A. Arrow indicates governor link adjusting screw.

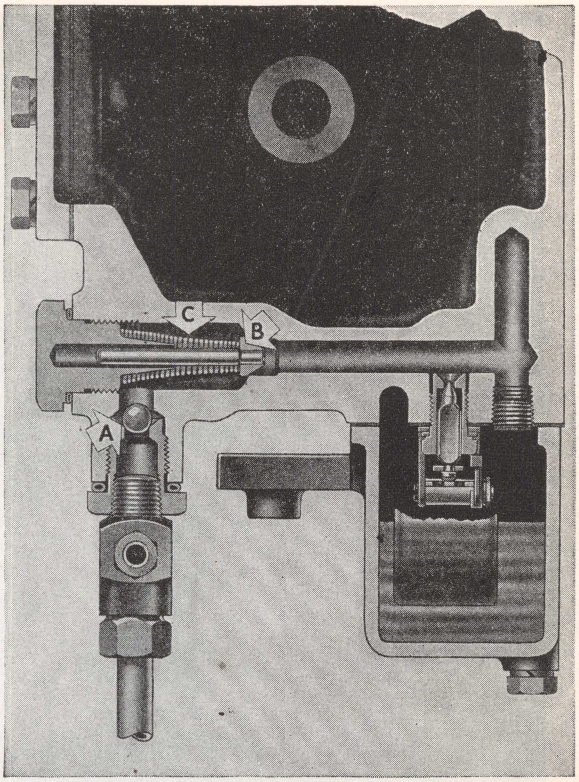


Fig. 79. Model A. Sectional view of fuel inlet check valve and by-pass valve assembly.

socket wrench loosen jam nut and back out Allenhead adjusting screw approximately six turns. (Fig. 78.) This will allow the governor link to float free so that the governor assembly can be removed.

Take out the four capscrews that hold the dome housing in place and remove. You will now be able to lift the complete governor assembly from the lubricating oil pump housing.

Remove the three nuts which will allow lubricating pump main housing to be removed.

FUEL INLET CHECK VALVE

Inspect ball and seat for dirt and wear. If worn, replace, and check to see that ball is seating well as shown by "A", Fig. 79.

BY-PASS VALVE ASSEMBLY

Remove by-pass valve guide, spring and valves and wash all fuel passages thoroughly. Inspect by-pass valve (B, Fig. 79) and spring (C, Fig. 79) for wear. If valve is worn, replace. If spring is stretched out or cut off, replace. Free length of by-pass valve spring is 1 25/32" new.

Always replace valve guide gaskets.

FLOAT CHAMBER

Remove and clean float chamber. Remove small nut and lock washer from float bearing pin and remove pin. Remove stop bracket and float valve. (Fig. 80.) If worn, replace float valve and seat. In assembling these parts, be sure the float does not rub on side of float chamber. If the float sticks closed, it will cause the engine to starve for fuel. If it should stick open, it will cause fuel to run out the tell-tale hole in the main fuel pump housing.

REPAIR OF DISTRIBUTOR

Care should be taken in determining the cause of failure to the distributor. Before removing from the engine, check inspection holes. If fuel pours out of the top inspection hole, the distributor cover and disc could be scored, and should be replaced. If the fuel spurts or foams out, it could be that the drive collar and thrust bearing are not seating properly.

To repair, remove cover and disc. (Fig. 81.) (Caution: Remove capscrews one-half turn at a time.) Pull distributor drive gear, remove Woodruff key and tap end of distributor shaft with lead hammer. Remove shaft. If thrust bearing indicates excessive leak, consult your nearest Cummins dealer. If collar and shaft assembly is loose in the thrust bearing, fuel will leak excessively by the shaft and bearing, causing fuel to fill up in the main housing and run out the tell-tale or trouble hole in the side of the main housing.

If the metering plunger is stuck in the barrel, screw out clamp nut holding metering plunger barrel. If the plunger and barrel are scratched and worn, it will be necessary to replace them. Be sure to use a small copper gasket on the end of the barrel when replacing. (Fig. 82.)

Before assembling the new distributor top and disc, wash all fuel passages with clean fuel oil or kerosene and blow out with clean compressed air. Lubricate both the distributor top and disc faces with clean lubricating oil. Place the rotary disc on thrust spring, over the driving collar. (This cannot be put on wrong due to one driving pin being off-set.) The distributor top can only be put on one way to permit the fuel lines to be connected properly. A gasket of proper design and thickness must be used each time between the distributor housing and distributor cover.

It will be necessary to compress the distributor spring by pushing on the distributor tachometer guide to start the capscrews which hold the distributor top in place. (Fig. 83.) When all capscrews are started by hand, work each one alternately, one-half turn at a time, until the cover is down against the gasket and distributor housing. If the distributor top is allowed to cock, it will likely catch the distributor disc bushing, pushing it down on one side. Should this happen, the seal will break between the distributor top and disc when the engine is started and the flow of fuel to the metering pump will be disrupted. In this case, consult your nearest Cummins dealer.

The priming valve on the front side of the distributor housing is for the purpose of priming the engine and forms a by-pass for the fuel around the distributor top and disc to the injectors. This is a needle valve and does not require much pressure on the handle to close. **Never tighten this priming**

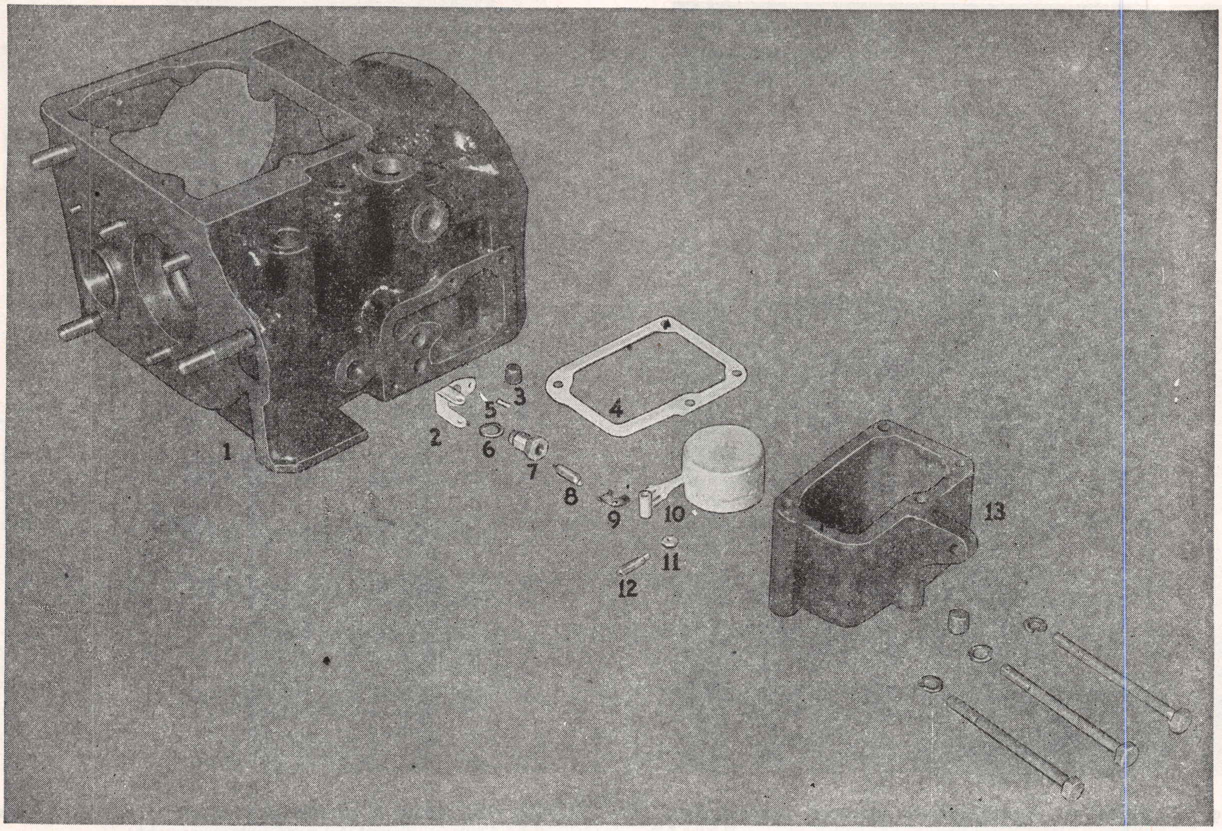


Fig. 80. Model A. Float Chamber Assembly.

1—Main housing. 2—Bearing bracket. 3—Pipe plug. 4—Float chamber gasket. 5—Bracket locating pin. 6—Valve seat gasket. 7—Valve seat. 8—Valve. 9—Float stop. 10—Float. 11—Bearing pin nut. 12—Bearing pin. 13—Float chamber.

valve with a wrench. If the priming valve is tightened too tightly, the tip is likely to break off and crack the distributor housing.

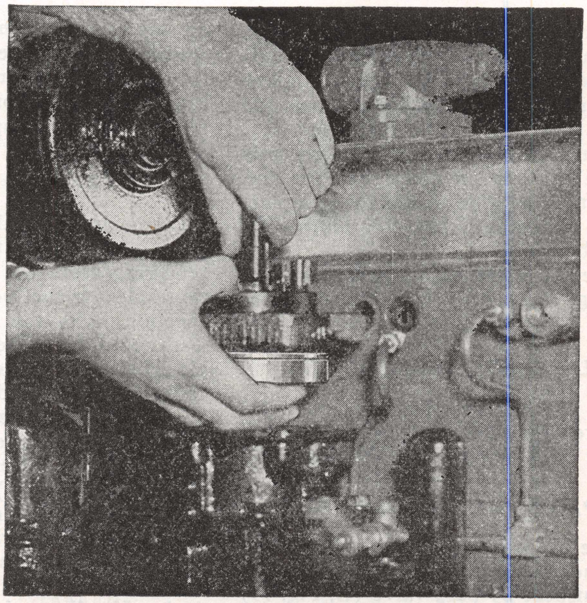


Fig. 81. Model A. Removing distributor cover and disc.

GEAR PRESSURE AND SUCTION PUMP

Gear pump should not be dismantled unless it has low pressure at idling speed of engine. If this should become necessary, proceed as follows:

Remove pressure chamber, shut off cock, pressure regulator, spring and check ball. Remove nuts and bolts from gear pump body. If the body is scored or badly worn, it must be replaced. When disassembling the No. 1 pump, it will be necessary to remove the fillister head screw on the front side of the body. Tap the end of the drive shaft lightly to remove the gears and spacer of the No. 1 and 2 pumps. Inspect the No. 1 body and gears and if found scored or worn badly, replace with new parts.

Before attempting to remove the gears from the shaft, it will be necessary that **you use a strip of copper over the jaws of the vise.** Clamp No. 1 drive gear in vise. Tap on the drive end of the drive shaft **lightly,** holding the spacer plate against the No. 2 gear so that the key from the No. 1 gear will not damage the spacer plate or oil seal. Remove the small Woodruff key from the shaft before removing from the spacer plate. Since there are no keys in the idler shaft, it can be pressed out through the gears.

Caution must be used, when assembling new gears to the spacer plate and shaft, that the shaft seals are assembled properly. These seals are assembled on the No. 2 side of the spacer plate, with the leather part of the seal in the spacer and the copper washers working against the No. 2 pump gears.

When assembling the gear pump, use only .0015" body gasket. Shellac both sides of the gasket, using a thin clear shellac. Be sure shellac is kept away from the gears and fuel passages.

Inspect the drive shaft oil retainer in the No. 1 body to see that it is in good condition. When assembling the No. 1 body on the shaft, precaution must be taken to see that you do not damage this retainer. With the No. 1 body on the shaft, place the proper gasket against the spacer plate and insert the fillister head screw.

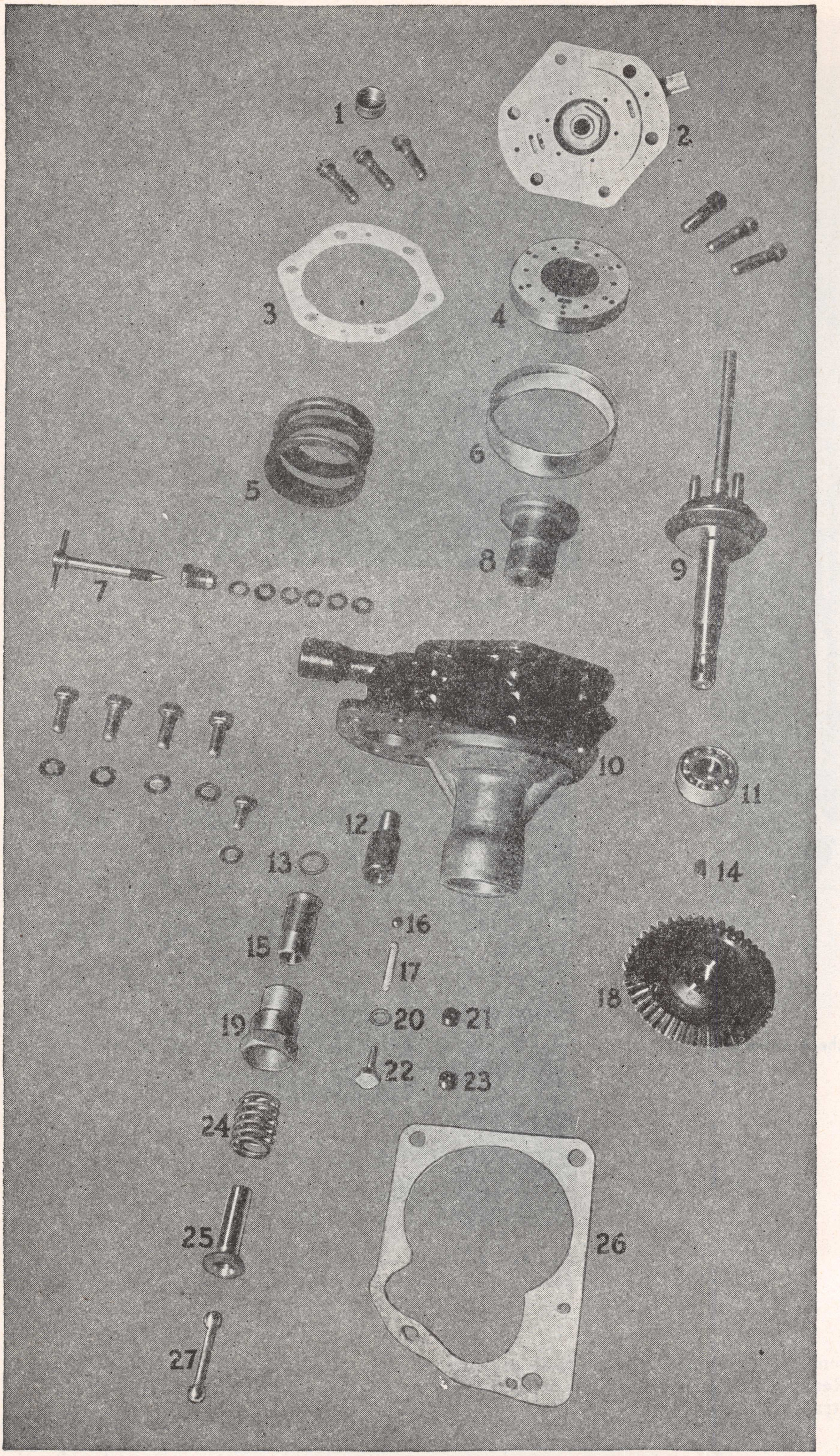


Fig. 82. Model A. Distributor Assembly.

1—Tachometer dust cap. 2—Distributor cover. 3—Distributor cover gasket 4—Distributor disc. 5—Disc spring. 6—Disc bearing. 7—Priming valve. 8—Distributor shaft bearing. 9—Distributor shaft and collar. 10—Distributor housing 11—Ball bearing. 12—Eccentric crank bushing. 13—Plunger barrel gasket. 14—Woodruff key. 15—Plunger barrel. 16—Check valve ball. 17—Check valve spring. 18—Distributor drive gear. 19—Plunger barrel clamp nut. 20—Check valve guide gasket. 21—Pipe plug. 22—Check valve guide. 23—Pipe plug. 24—Plunger spring. 25—Plunger. 26—Housing gasket. 27—Plunger link.

Assemble the No. 2 body in position. Insert two bolts in the holes that are used to hold the gear pump to the main housing; with nuts, pull the bodies together. Drive the two dowel bolts for the gear pump through the bolt holes and tighten down with nuts.

Let shellac dry between gear pump bodies before testing. Assemble the check valve and check valve housing as shown in Fig. 84.

If the pressure regulator is stuck in the sleeve, remove and polish with fine emery cloth. Be sure that the check ball beneath the pressure regulator is in place.

If when testing the pressure pump, the fuel pressure is below 130 pounds at maximum speed, use spacer washers below the regulator spring in pressure chamber. One 1/64" washer will raise pressure approximately ten pounds.

FUEL PUMP LEVER SUPPORT PLATE

Remove the seven small capscrews holding the lever support plate in place. Remove the inspection plate on the opposite side of the pump and disconnect the link from the eccentric governor lever. Remove lever support plate. If radius in cam rocker lever is worn or pitted, replace. If radius is worn, bad governor action will result.

In assembling cam rocker lever roller and floating bushing, be sure that the oil hole in the pin indexes with the oil channel in the cam rocker lever. Tap rivet through pin and lever and peen.

Inspect the cam rocker lever bushings for wear.

Tap bushing in support plate, with flat side of bushing indexing with flat side of support plate. Ream with ½" straight reamer. Remove bushings and assemble cam rocker lever in place. Cam rocker lever must work freely when assembled. Press on snap rings in grooves at the end of lever shaft.

VERTICAL LEVER

Take clean cloth, spread it out on work bench, and on it place the parts of the vertical lever assembly. Place roller on index finger and put piece of ⅜" rod, 7/16" long, in hole. Fill hole with 22 long needle bearings. Place roller in position and push roller pin through. This will cause small plug to fall out on opposite side. Lock in place by riveting copper pin into grooves on both sides of vertical lever.

When assembling plunger lever pin use ⅝" inside diameter copper tubing with slot for needle bearings to pass through. Place plunger lever between arms of vertical lever in position as shown in Fig. 85. Tap plunger lever pin through vertical lever and plunger lever, leaving the needle bearing race open on one side. Place the slotted tubing over the pin and insert 28 short needle bearings. Tap the plunger lever pin through far enough to allow the other bearing race to be filled with the same number of needle bearings. Tap plunger lever into position and turn groove in pin to match the capscrew hole in the

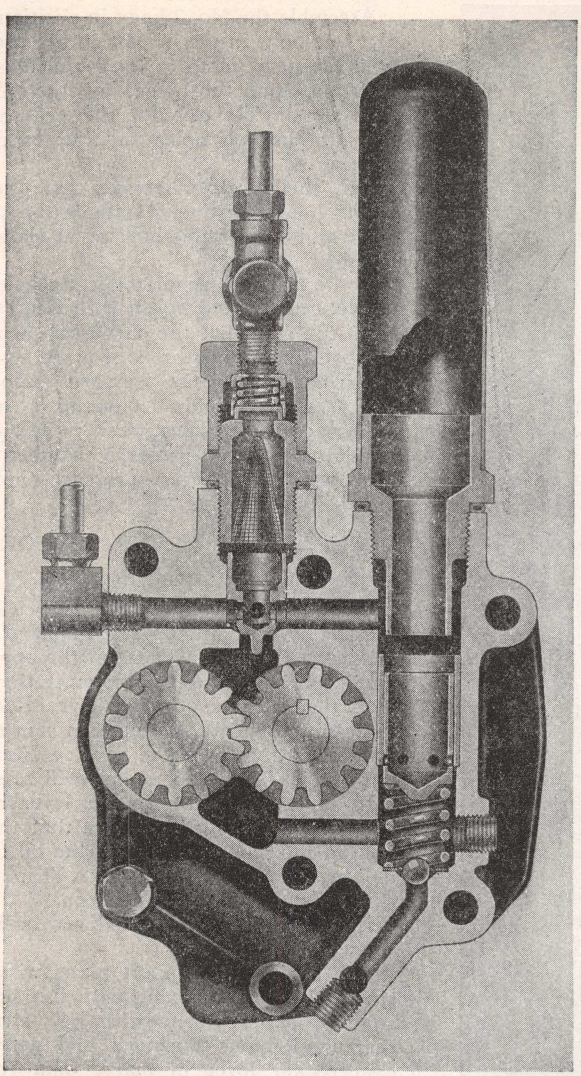


Fig. 84. Model A. Cross sectional view of check valve and housing.

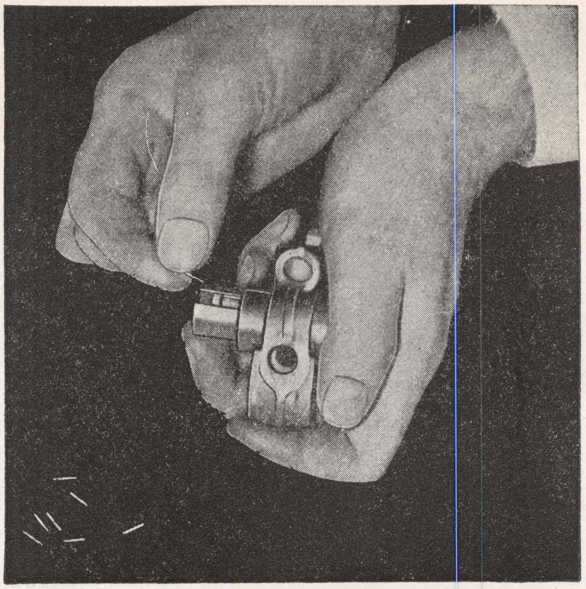


Fig. 85. Model A. Assemble plunger lever between arms of vertical lever as shown.

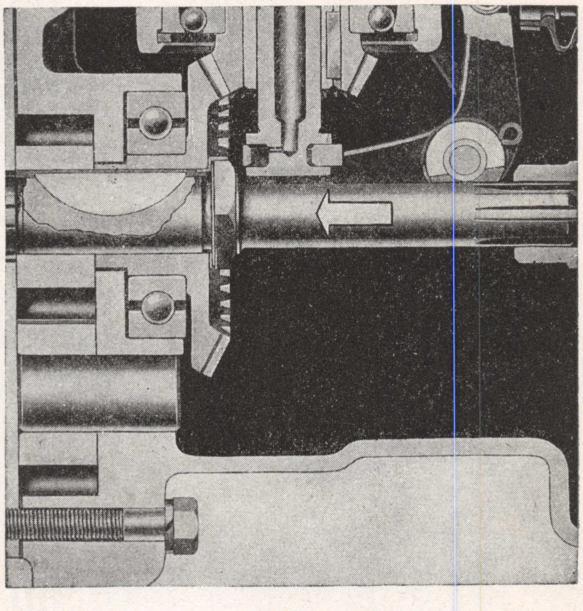


Fig. 86. Model A. Press lubricating oil pump shaft from governor drive gear and oil pump drive gear in direction indicated by arrow.

plunger lever. Run capscrew down loosely to hold the pin in place.

If ball joints in short link are not worn or slack, attach long end of link to vertical lever. (Bad action will result if ball joints are worn or loose.)

Place vertical lever assembly in position on support plate. Tap plunger lever shaft through holes in support plate and plunger lever. Be sure needle bearings are showing evenly on either side. Tighten capscrew down snugly.

To check oil travel in this assembly, place lubricating oil on each side of cam rocker lever roller. Blow air through intake hole in support plate. If correctly assembled, oil will bubble out around roller.

HAND CONTROL ECCENTRIC

The bushings in the main housing for the eccentric lever and governor lever have very little wear and it should seldom be necessary to replace them. To replace the bushings in the governor lever, it will be necessary to remove the taper pin in the upper half of the eccentric crank to remove from the hand control eccentric. Ream all eccentric bushings with a 9/16" straight reamer.

REPAIR OF MAIN SHAFT ASSEMBLY

In the main shaft on the gear pump drive end is a small pin for driving the fuel gear pressure pump. Inspect and replace if worn.

Carefully inspect cam on the main shaft. If scored or rippled it should be replaced.

The spline coupling on the end of the main shaft has very little wear. Replace if worn in excess of .005 or .006.

LUBRICATING OIL PUMP ASSEMBLY

It should seldom be necessary to disassemble the lubricating oil pump. Many oil pressure troubles are blamed on the pump when, in reality, the fault is elsewhere. Before going into the lubricating pump, make sure that it is causing the trouble.

The lubricating oil pump is of the gear type and consists of two helical cut gears, running in a cast iron case. It is built into the front end of the lubricating pump housing and is driven by the fuel pump shaft.

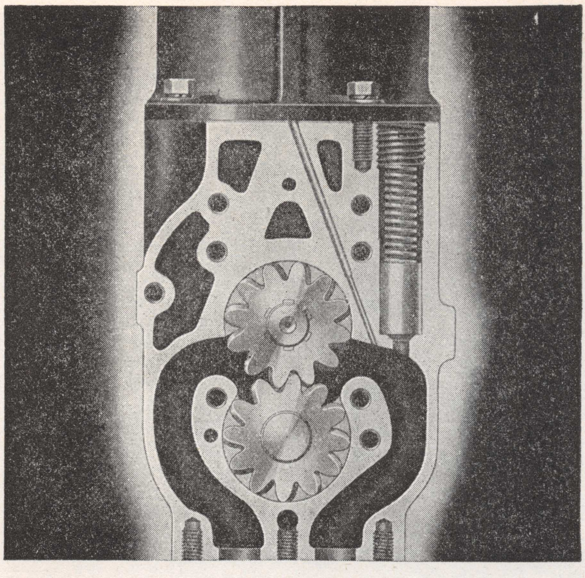


Fig. 87. Model A. Lubricating oil pump assembly.

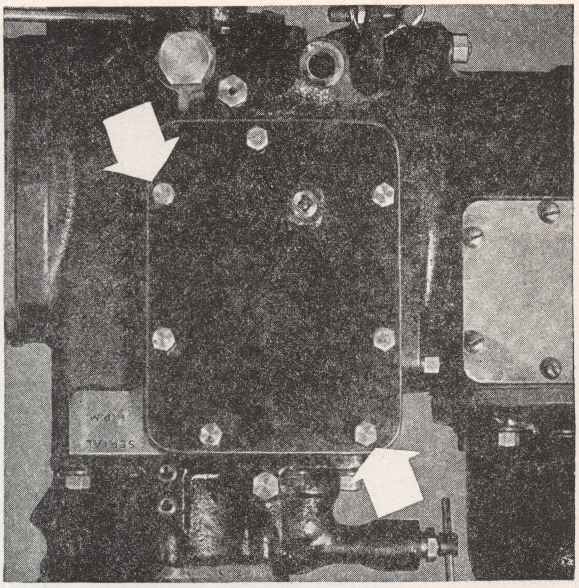


Fig. 89. Model A. Support plate assembly. Arrows indicate position of dowel holes.

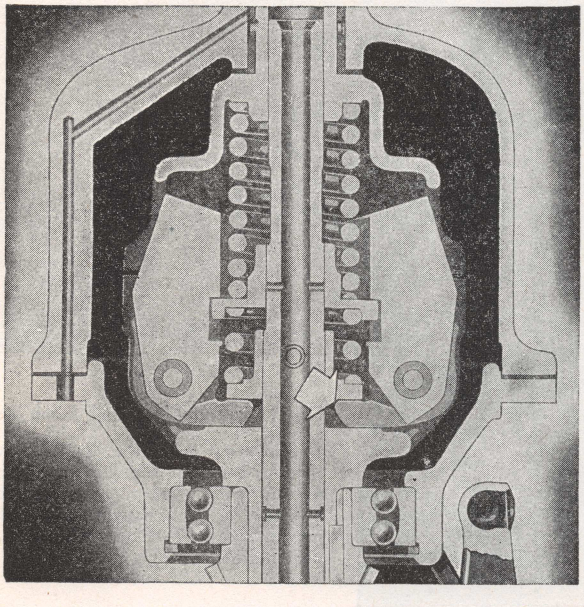


Fig. 88. Model A. Cross sectional view of governor unit.

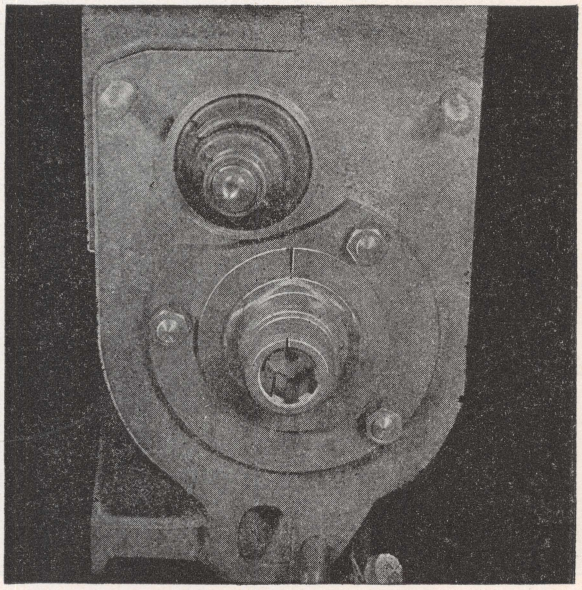


Fig. 90. Model A. Showing timing mark for main shaft and distributor drive.

The pump may be inspected by removing the four Allenhead capscrews in the face plate on the front of the governor drive housing, the capscrew on the back of this flange and remove the plate.

To remove lubricating pump drive gear, it will first be necessary to remove lubricating pump housing from fuel pump main housing. Take off nut and lock plate from face of governor drive gear, and press shaft from gears in direction of arrow, Fig. 86.

If the body of the pump should be badly scored or worn, it should be replaced.

The lubricating oil pump has .001 to .002 clearance when new. If the lubricating oil pump is disassembled, fill the pump with clean oil when reassembling, so that it will not run dry for the first few seconds of operation.

The oil pressure regulating valve is located directly under the governor weight housing. Over a period of time, the oil pressure regulator will wear on one side, due to the by-pass hole in the end of the housing. When this wear occurs, the regulator has a tendency to stick and should be replaced. (Fig. 87.)

GOVERNOR UNIT

Governor will function properly unless maximum weights are worn on the radius shown by arrow, Fig. 88. Should sludging occur, it will cause a slow action on acceleration.

To check weights and springs, remove dome housing. Remove capscrews from yoke cap. Remove maximum spring, spring sleeve and the idling spring. Grind or file one side of weight pin and drive out with drift pin. Inspect governor weight pin bushings in governor yoke and bronze bushing in governor weights for wear. Replace if worn. Check small weights for wear on radius; also support sleeve against which the radius of weights work. On both sides of each governor weight there is a small thrust washer which keeps the governor weight from binding on the side of the yoke. Be sure to replace. When replacing parts, be sure that the marks on the governor yoke cap correspond with the marks on the weight yoke.

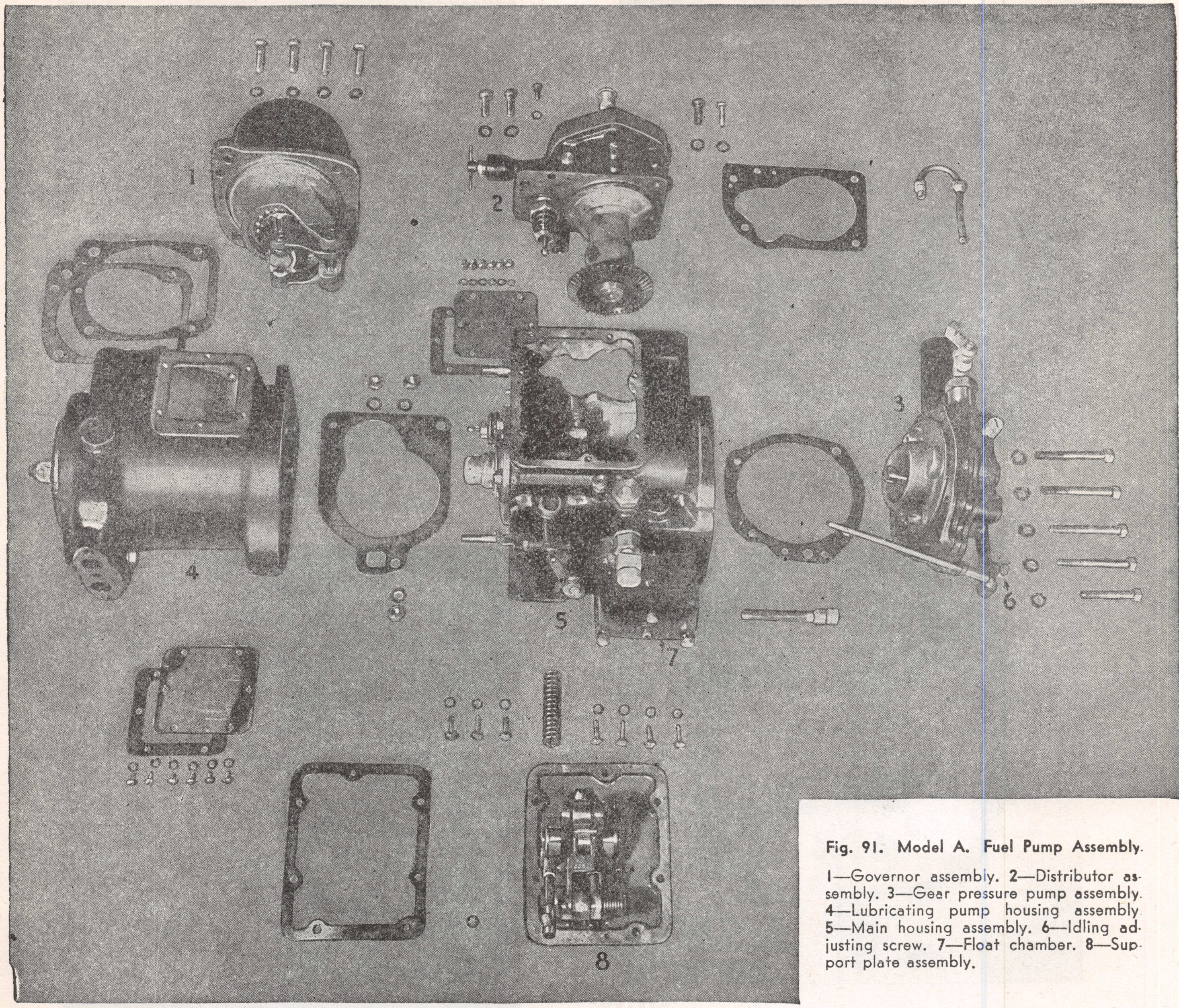


Fig. 91. Model A. Fuel Pump Assembly.

1—Governor assembly. 2—Distributor assembly. 3—Gear pressure pump assembly. 4—Lubricating pump housing assembly. 5—Main housing assembly. 6—Idling adjusting screw. 7—Float chamber. 8—Support plate assembly.

If it becomes necessary to replace the large ball bearing on the lower end of the governor shaft, it will be necessary to pull the pinion.

GENERAL ASSEMBLY

Assemble the main shaft assembly, with a new gasket, through the main housing and tighten in place with lock washers and nuts.

Place cam rocker lever spring in recess in main housing.

Place the support plate against the opening, in position against cam lever spring and start capscrews on bottom side of support plate. Do not screw in tightly. Assemble all capscrews as shown in Fig. 89. The two holes indicated by arrows are dowel holes and the plate should be tapped in position so that the capscrews can be screwed into these holes without being forced. This will line up the cam rocker lever roller with the cam on the main shaft. After all capscrews are started, tighten down evenly.

With new gasket, assemble the fuel gear pump to the fuel pump main housing. Be sure the slot on the gear pump drive shaft indexes with the drive pin in the main shaft. This can be done by turning the main shaft and holding a pressure against the gear pump until slot and pin match. Assemble capscrews and tighten in place.

When placing distributor in position on fuel pump, use gaskets of various thicknesses to adjust the distributor drive gear lash. (Note: In removing the distributor housing for repair, it is always best to save the original gaskets.) Back lash can be checked by looking through the inspection hole in the back side of the fuel pump housing.

When placing distributor in position, stick plunger link in metering plunger barrel with cup grease. This will keep the link from dropping into the main fuel pump housing.

Be sure the mark on the spline coupling on the main shaft is turned straight up with the mark on the bearing shield. This is the timing-mark for the main shaft and distributor drive. (Fig. 90.)

Connect fuel supply line from gear pump to distributor cover.

Check rubber boot on governor link. If not in good condition, replace.

Place gasket over studs with the drain hole in the gasket indexed with the hole in lower side of main fuel pump housing. The lubricating pump main shaft has a top center mark on the spline on the end of the shaft. This mark indexes with the mark on the top center of the coupling on main

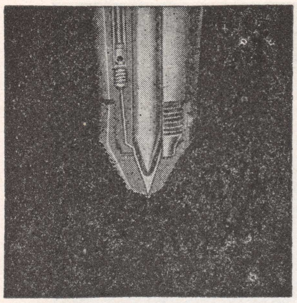


Fig. 92. Models A, H, NH. Intake of fuel.

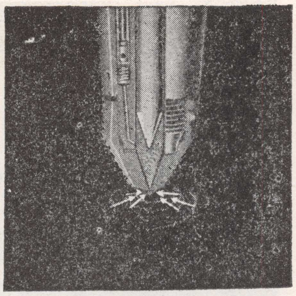


Fig. 93. Models A, H, NH. Preheated fuel.

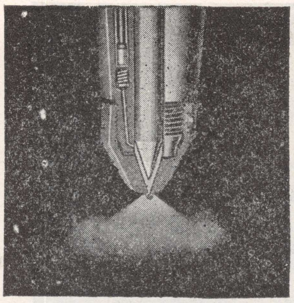


Fig. 94. Models A, H, NH. Injecting fuel.

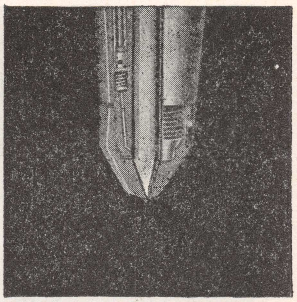


Fig. 95. Models A, H, NH. Injection complete.

shaft of the fuel pump. Start the lubricating pump housing by pressing on with hand and then tighten with nuts.

Replace the gasket on the bottom of governor ball bearing cage. These gaskets are of varying thicknesses and must be used in the proper combinations to adjust the governor drive gear lash. Be sure governor lever ball socket hole is open to engage the long link from the main fuel pump housing. Be sure link does not bind on bottom of governor lever, when replacing governor assembly in position. Take small screw driver and pry link into position. Move governor control lever with hand, forcing long link socket into position in governor lever. When in place, tighten Allen set screw in against ball socket snugly. Use ⅝" socket wrench to tighten lock nut.

ADJUSTING OF IDLING GOVERNOR

After the fuel pump is installed on the engine and the engine is running, it will be necessary to adjust the idling speed of the engine.

This can be accomplished by the adjusting screw shown by arrow 6, Fig. 91. Desired idling speed is between 450 and 500 R.P.M.

NOTE—Make sure the idling control is held in position so that the idling adjusting screw is firmly against its stop.

SERVICE HINTS

BY-PASS AND FUEL PUMP VALVE

1. By-pass valve sticking closed will cause overflow of fuel in main housing.
2. By-pass valve sticking open or not seating will cause engine to starve for fuel.
3. Fuel inlet check valve leaking will cause:
   a. Engine to starve for fuel.
   b. Priming pump to not function.
   c. Excessive cranking of engine when starting.

FLOAT CHAMBER

1. Float valve sticking closed will cause engine to starve for fuel.
2. Float valve sticking open or leaking will cause overflow of fuel in fuel pump main housing.

GEAR PRESSURE PUMP

1. Clean fuel screen frequently.
2. Always be sure check valve is assembled correctly.
3. Check ball leaking will cause pressure pump to lose prime.
4. Always use gaskets of proper design and thickness.

DISTRIBUTOR HOUSING

1. Always be sure you have .004 gear lash on distributor drive gear.
2. Loose gears cause defective timing.
3. Priming valve leaking will cause engine to overspeed.
4. Distributor top and disc scored will cause:
   a. Defective fuel delivery.
   b. Loss of power.
   c. Dilution and dirty exhaust.
5. Metering pump worn will cause falling off in power.

HAND CONTROL ECCENTRIC

1. Eccentric bushings worn will cause loss of power.
2. Worn control links will cause:
   a. Bad governor action.
   b. Loss of power.
   c. Poor acceleration.

CAM ROCKER LEVER

1. Worn roller or pin causes loss of power.
2. Eccentric radius pitted will cause poor governor action and acceleration.
3. Always be sure lubricating holes are properly indexed in lever and pin.

VERTICAL LEVER

1. Roller pin pitted causes poor governor action and acceleration.
2. Plunger pin pitted causes poor governor action and acceleration.
3. Vertical lever spring weak causes poor governor action and acceleration.

FUEL INJECTOR

MODELS A, H, NH

The Cummins Diesel fuel injection system is divided into three separate operations:

1. The fuel charge is measured or metered at low pressure.
2. It is delivered to the injector.
3. It is then injected into the cylinder.

The injector is mechanically operated and very simple in design. It consists of a forged body with a properly fitted plunger. Mounted on the end of the body is the injector cup.

On the intake stroke of the engine, the fuel metering pump forces a charge of fuel of the exact amount for the load and speed of the engine into this cup. The fuel line and the passage leading to the cup were already full of fuel from previous discharges of the metering pump. It naturally follows that any fuel added at the fuel metering pump end will push the same amount of fuel into the injector cup. The fuel lies in the cup through the compression stroke of the engine and the compressed air is forced through the small spray holes in the injector cup. The fuel oil in the tip of the cup is exposed to the intense heat and blasting of the compression and thus is preheated and broken up.

A few degrees before top center, the mechanically operated plunger starts down and the preheated fuel charge is driven out into the cylinder, where it burns cleanly and completely. A small check valve is located in the lower end of the fuel passage in the injector body. The check valve, in conjunction with the injector plunger, prevents the compression from blowing the fuel back and filling the lines with air.

REMOVING INJECTOR FROM ENGINE

Never remove an injector from the engine unless it is absolutely necessary.

Before attempting to remove the injectors wash engine and all fuel lines thoroughly. This prevents dirt from getting into the engine when valve covers and fuel lines are removed.

Cleanliness cannot be too strongly emphasized when doing any work on the engine. A little cleaning before starting saves considerable time during the operation.

Disconnect the injector fuel inlet and drain line.

Unscrew the fuel inlet connection and drain connection. These connections screw directly into the injector body and are sealed between body and connection with a small copper gasket. These gaskets are especially threaded to prevent them from coming off and dropping into the crankcase when the connections are removed.

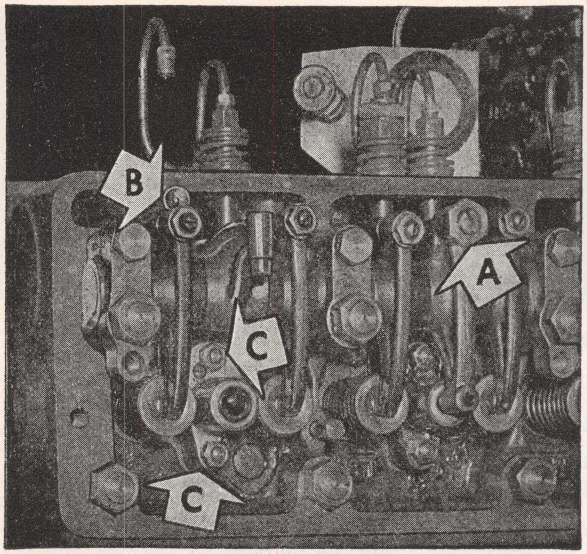


Fig. 97. Model A. Typical of Model H.
A—Injector adjusting screw lock nut. B—Push rod. C—Injector hold-down nuts.

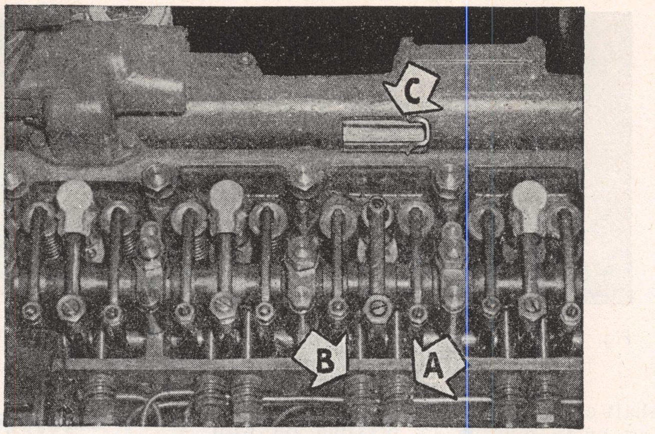


Fig. 96. Model A. Typical of Model H.
A—Fuel inlet strainer connection. B—Drain connection. C—Oil guard.

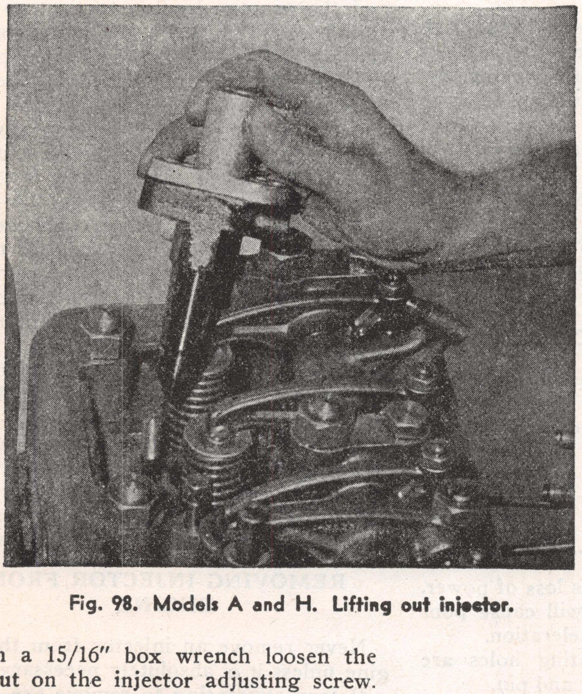


Fig. 98. Models A and H. Lifting out injector.

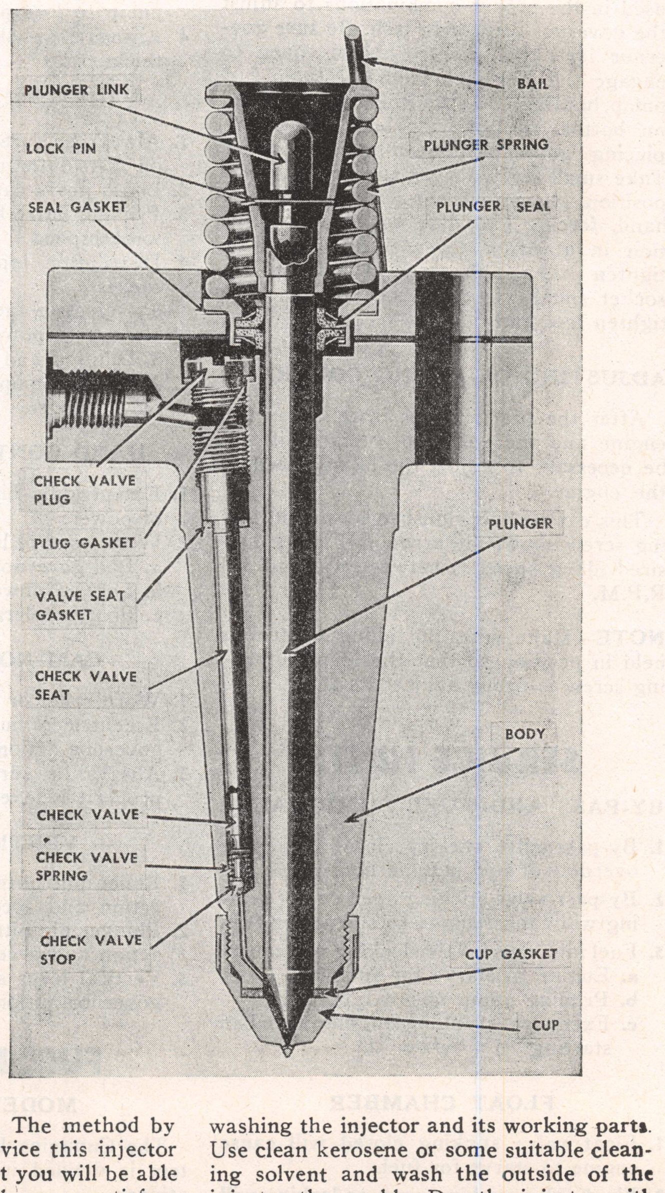

PLUNGER LINK
BAIL
LOCK PIN
PLUNGER SPRING
SEAL GASKET
PLUNGER SEAL
CHECK VALVE PLUG
PLUG GASKET
PLUNGER
VALVE SEAT GASKET
CHECK VALVE SEAT
BODY
CHECK VALVE
CHECK VALVE SPRING
CHECK VALVE STOP
CUP GASKET
CUP

Fig. 97A. H and NH. Injector cross section.

With a 15/16" box wrench loosen the lock nut on the injector adjusting screw. With a 10" screwdriver, back the adjusting screw out of the lever. Move the push rod to one side far enough to permit the injector lever to be rocked back in a vertical position.

CAUTION—Always put the adjusting screws back in their original levers.

With a socket remove the two injector hold down nuts.

With extreme care, lift injector from the cylinder head. Be very careful when handling not to hit or bruise the tip on the bottom of the injector.

SERVICING THE INJECTOR

The only reason for removing an injector is because it is not functioning properly or not doing its job. The method by which you attempt to service this injector determines whether or not you will be able to correct the trouble and secure satisfactory service after you have reinstalled it.

First, have separate clean containers for washing the injector and its working parts. Use clean kerosene or some suitable cleaning solvent and wash the outside of the injector thoroughly. Dry the injector with clean compressed air.

Place injector in fixture similar to the

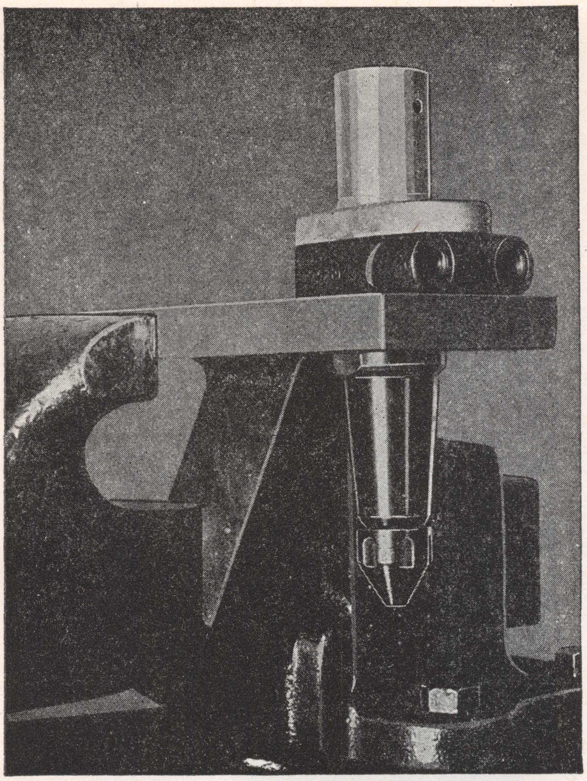


Fig. 99. Models A, H, NH. Showing type fixture to use when servicing injector.

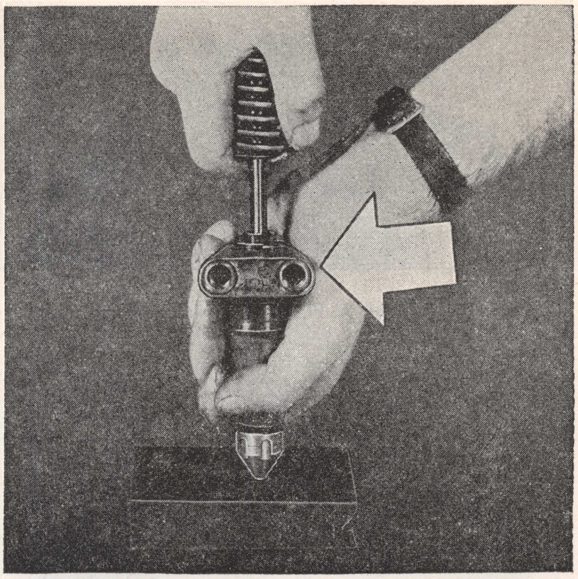


Fig. 101. Models A, H, NH. If check valve leaks, it will be indicated at arrow.

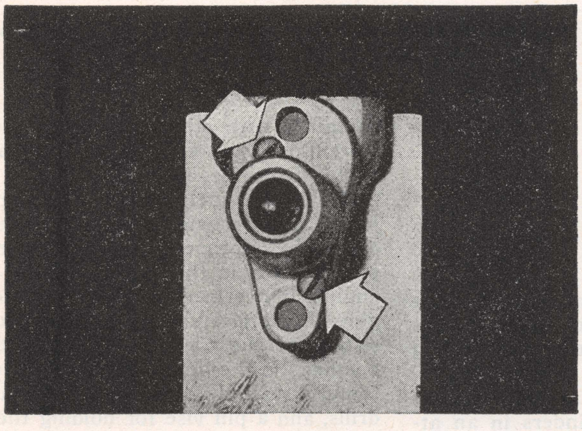


Fig. 100. Models A, H, NH. To remove top housing, remove two screws shown.

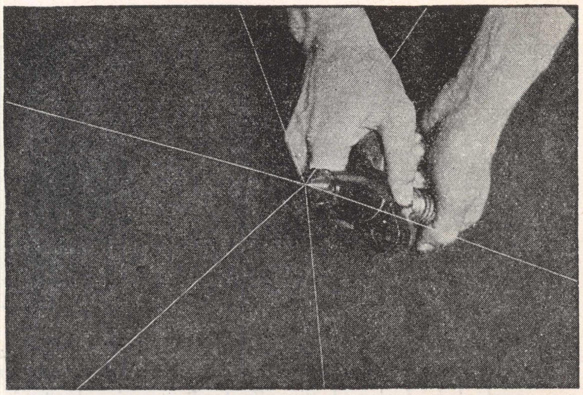


Fig. 102. If injector cup spray holes are clean, six clean sprays will be seen on Model H, and five on Model A.

one shown in Fig. 99 with cup end down. Do not clamp directly in vice or damage will result.

Remove the fillister head screws holding top housing in place. (Fig. 100.) After removing the top housing, wash the inside of the housing, plunger and spring before the plunger is removed from the body.

Remove the injector plunger and spring. Fill the injector plunger hole about two-thirds full of clean fuel oil. Hold injector spray tip firmly against a piece of hard rubber. Insert plunger in place and exert as much pressure on the plunger as possible. If the check valve has a leak, it will show at point indicated in Fig. 101.

With cleaning brush furnished with each engine, brush the injector tip clean of carbon. To lengthen the life of the brush it is always best to pull the brush across the tip. **Do not use any other method in doing this.**

Refill the injector body with clean fuel as previously instructed. Holding injector in hand, push the fuel out with the plunger and check the fuel spray at the injector cup tip. If five clean even sprays (six on Model H) can be seen, it is needless to remove the cup unless the injector has been removed due to dilution. (Fig. 102.)

IMPORTANCE OF PROPER INSPECTION AND CLEANING OF INJECTOR CUP SPRAY HOLES

In the accompanying illustrations you can see what to look for when inspecting the injector cup. It is recommended that you use a magnifying glass to give the cup the inspection it should have and to determine where you are having any of the conditions illustrated.

Fig. 103: A new injector cup under your magnifying glass.

Fig. 104: Fine abrasives in fuel, such as dust, dirt, etc., have a sand blasting effect and usually cause this type of cup failure. This can also be caused by the improper use of a cup cleaning drill of improper size for the spray hole. Such a condition is frequently caused by breaking the drill off in spray hole and failing to remove it before putting the injector back in the engine. The extreme pressures that are created in the injector cup have a tendency to start cutting out some place around the drill, wearing the metal away.

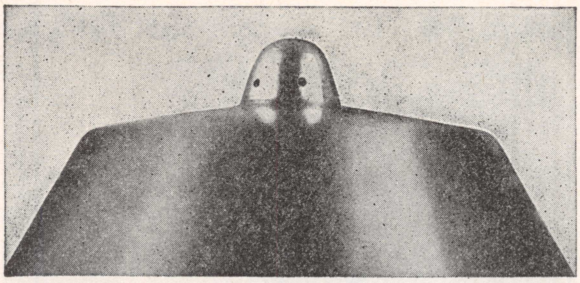


Fig. 103. Models A, H, NH. New injector cup tip.

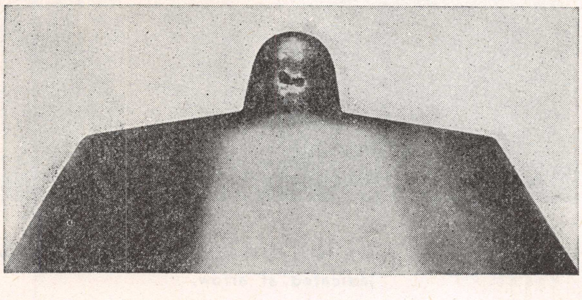


Fig. 104. Models A, H, NH. Defective injector cup which is usually caused by fine abrasives in fuel.

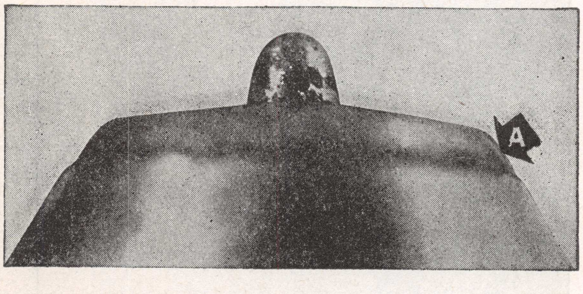


Fig. 105. Models A, H, NH. Defective injector cup tip. "A" shows metal eaten away due to high acid or sulphur content in fuel and the effect of excessive heat.

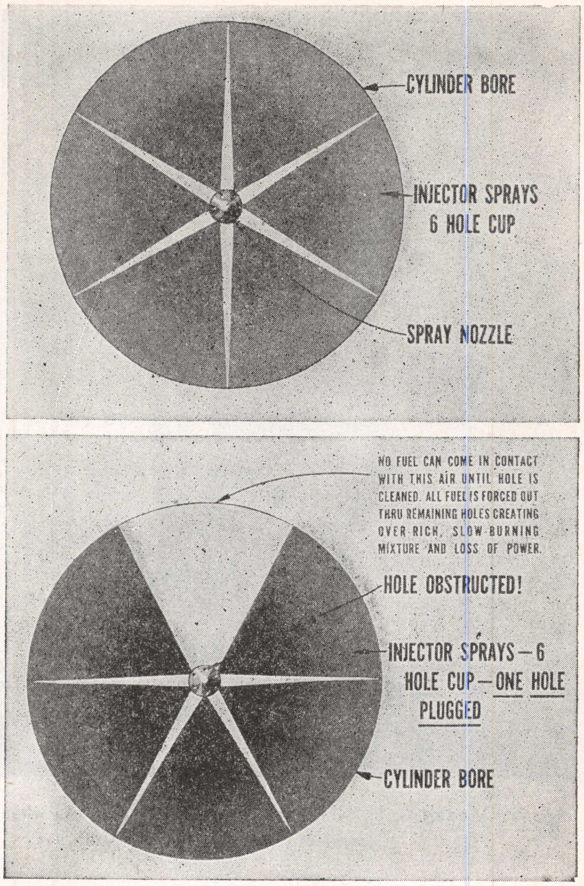

CYLINDER BORE
INJECTOR SPRAYS 6 HOLE CUP
SPRAY NOZZLE
NO FUEL CAN COME IN CONTACT WITH THIS AIR UNTIL HOLE IS CLEANED. ALL FUEL IS FORCED OUT THRU REMAINING HOLES CREATING OVER RICH, SLOW BURNING MIXTURE AND LOSS OF POWER.
HOLE OBSTRUCTED!
INJECTOR SPRAYS—6 HOLE CUP—ONE HOLE PLUGGED
CYLINDER BORE

Fig. 106. Model H and NH. Injector spray diagram. Model A injector has only five spray holes.

Fig. 105: This shows the effect of high acid or sulphur content in the fuel, as well as the effect of excessive heat which could be caused by an overload condition. On the bottom of this cup at "A" the metal has been eaten away.

The spray holes of the injector cups must be kept free and open at all times. To continue to operate with holes obstructed will cause damage to the engine and loss of power.

The cup is so designed that the preheated charge of fuel is injected into the cylinder in a fan shaped spray in order to bring the fuel into contact with all available air.

Fig. 106 shows that, in case one injector cup spray hole is plugged with dirt or metal, part of the available air in the cylinder chamber is not in contact with fuel and, over rich mixture is present in the other part of the cylinder. This causes a falling off in power because of slow burning of the fuel.

The additional burden is then put on the remaining cylinders. To make up for this loss of power in one cylinder, more fuel is fed to the other cylinders, overloading them and causing them in turn to clog.

Another effect is that, as more fuel is forced into the other cylinders in an attempt to make up for the lost power, more fuel is injected than can be burned with the available air in the cylinder. This excess fuel runs down the cylinder walls, causing piston rings to become gummy and stick, and in addition causes dilution of the lubricating oil in the crankcase.

WARNING—Never alter the size of the injector cup spray holes.

CLEANING THE INJECTOR CUP

Place the injector in the holding fixture with cup end up. Apply the splined wrench (furnished with each engine) on the injector cup, and, with a sharp rap of the hand in a counter clockwise rotation, loosen the cup.

When starting these operations, it is very important to have a separate clean container with clean fuel oil or cleaning solvent to wash all parts as they are removed from the injector.

If the fine fuel spray holes of the injector cup become clogged, it is usually caused by improper setting of the injector plunger, dirt in the fuel, operating of the engine at overload, or an overheated engine. A cup cleaning kit is furnished, consisting of the file card brush, with two openings in the brush end in which will be found a small drill, several very small wire drills, and a pin vise for holding the small wire drills.

As indicated by "A", Fig. 107, hold the injector cup upside down when using the large drill in order that any foreign matter may fall out of the cup. **Never use a drill other than the one furnished by the engine builder.** This drill is ground to the proper taper to fit the cup.

Before using the small wire drills that are furnished for cleaning the spray holes, place the wire in the pin vise, letting it project about 1/16" from the end of the vise. With a very fine hone sharpen the end of the drill. (C, Fig. 107.) This must be done every time a new drill is used or the old one is broken. When a wire drill is cut off or broken, burrs are always present to scratch the inside of the spray holes in the cup. This will cause deflection of spray and poor combustion.

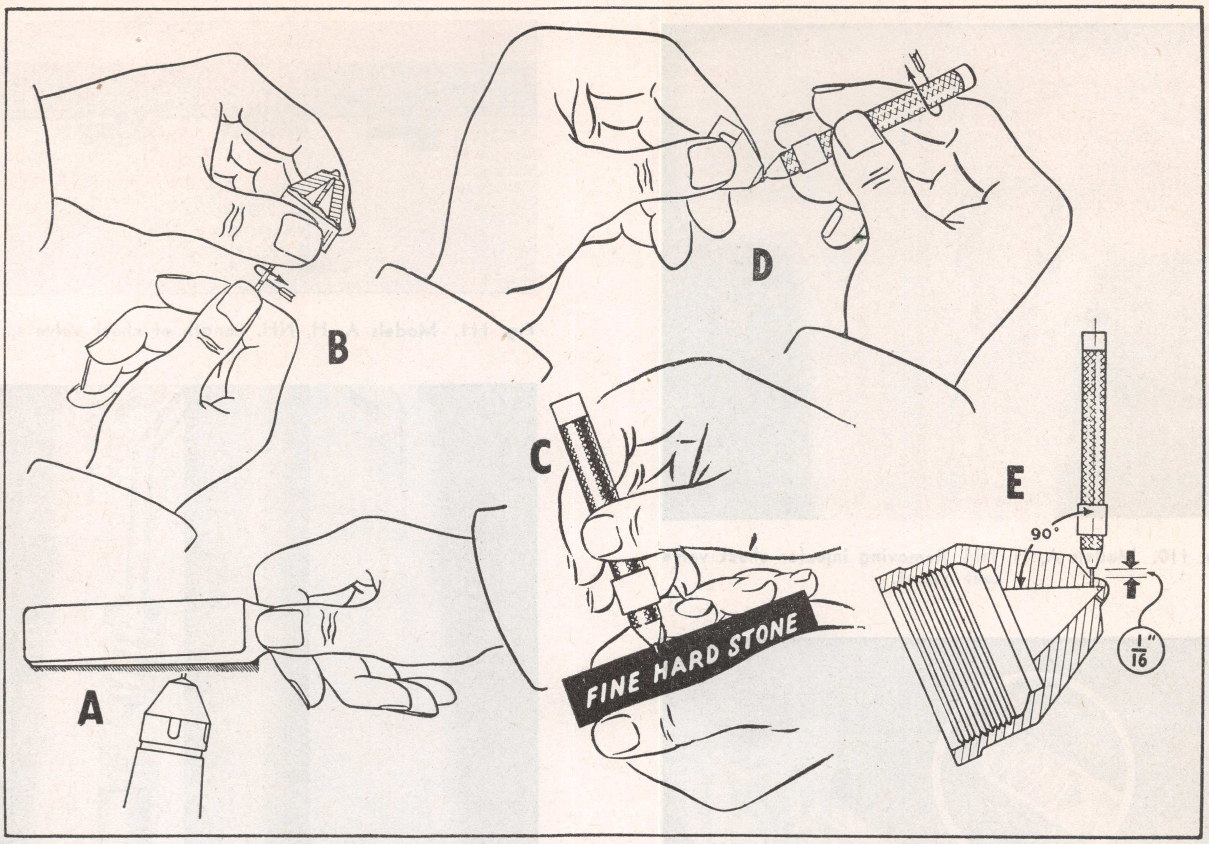


Fig. 107. Models A, H, NH. Cleaning injector cup.

A—File card brush. B—Hold injector cup as shown when using drill. C—Sharpen end of drill as shown. D—Method of cleaning spray holes. E—Hold drill at this angle. NOTE—The dimension shown is for Model H and NH. For Model A, this dimension is 1/32".

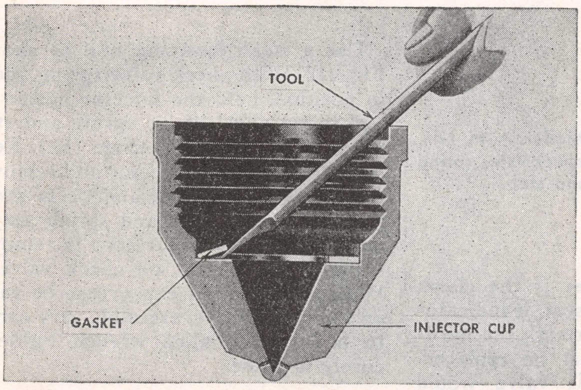


Fig. 108. Models A, H, NH. Removing injector cup gasket.

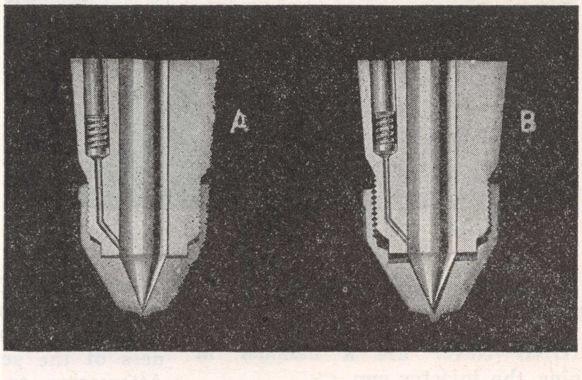


Fig. 109. Models A, H, NH.

A—Showing injector plunger seated properly. B—Injector plunger not seating properly.

Hold the cup in the fingers as shown by "D", Fig. 107. Be sure to hold the drill to the proper angle as indicated by "E" in Fig. 107. This will be at a right angle to the tip so that the drill will follow the hole as it was originally drilled.

NOTE—The 1/16" dimension shown in Fig. 107 is for H and NH; for Model A, this dimension should be 1/32":

Placing the injector cup in a good penetrating compound helps to loosen the carbon in the holes and saves considerable time.

Excessive use of the cup cleaning drill is discouraged so do not use it except when the spray hole becomes clogged. **Never use drills other than those furnished by the Cummins Engine Company.** A .001 or .002 of an inch variation in size of the drill will cause considerable trouble.

ASSEMBLING INJECTOR CUP

Never assemble an injector cup to the body unless a new cup gasket is used. A tool similar to the one shown in Fig. 108 will enable you to remove the gasket without damage to the cup.

Place a new gasket in the cup coated with clean cup grease so that it will stay in place while assembling to the injector body. (Use only gaskets furnished by Cummins Engine Company.) Old or improper gaskets will result in leakage around the cup causing dilution of lubricating oil.

Remove the spring from the injector plunger. Lubricate the plunger with clean oil and assemble in place in the body. With the injector body on the fixture and with the cup end up, hold the plunger against the body and screw the cup in place. In-

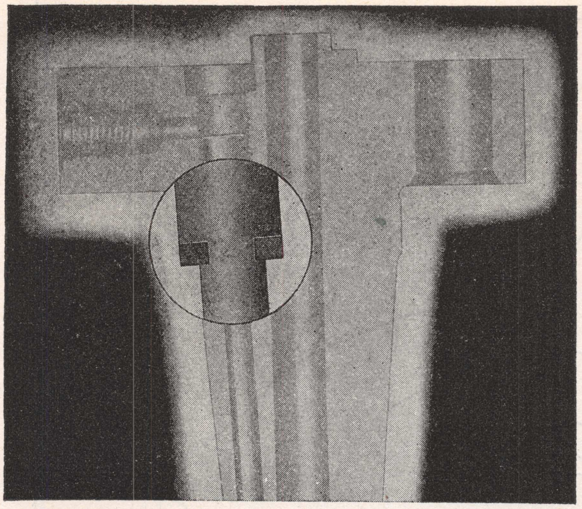


Fig. 110. Models A, H, NH. Removing injector check valve seat gasket.

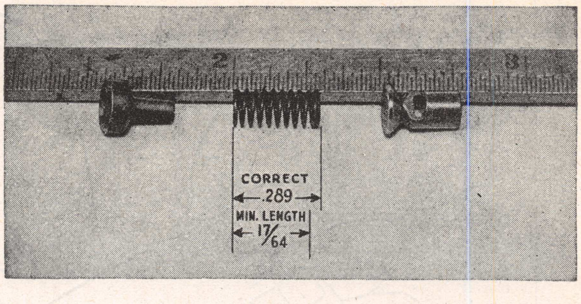


Fig. 111. Models A, H, NH. Length of check valve spring.

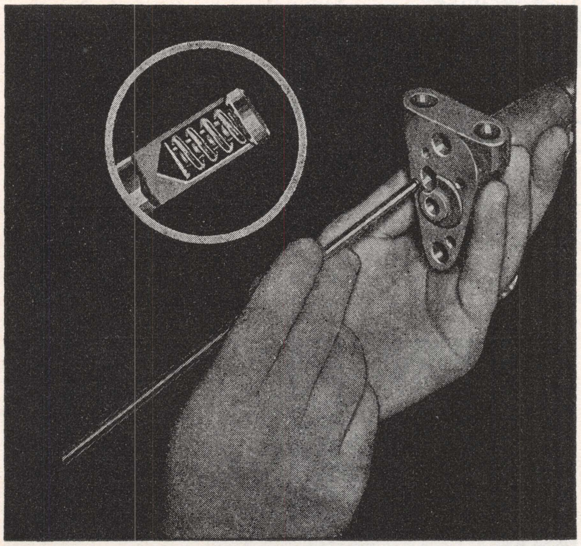


Fig. 112. Models A, H, NH. Inserting check valve spring and stop.

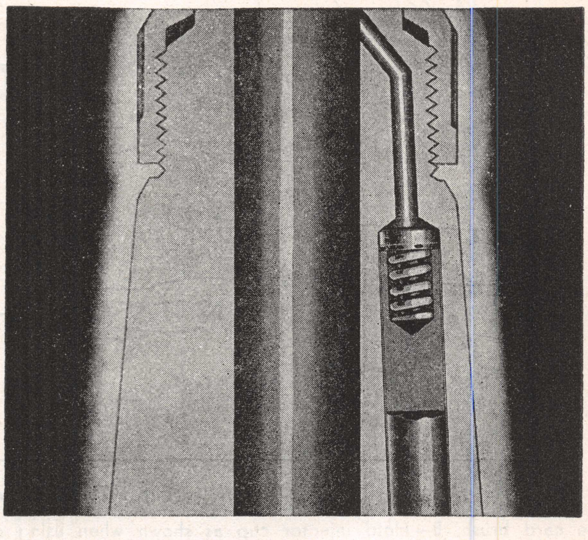


Fig. 113. Models A, H, NH. Check valve spring and stop in working position.

jector plunger must seat as shown by "A" in Fig. 109.

WARNING—Never use a hammer in tightening the injector cup.

The above method will help eliminate injector plunger sticking. If the taper of the plunger does not fit freely in the taper in the cup, sticking of the plunger will result. **Tightening of the cup with a hammer aggravates this condition.** (Shown by "B", Fig. 109).

SERVICING INJECTOR CHECK VALVE

Removing Injector Check Valve: Place the injector in the holding fixture. With screw driver, remove body plug. With allen wrench remove check valve.

Turn the injector body over and tap in the palm of the hand to remove the check valve spring and stop.

Inspection of Check Valve: If the check valve is stuck in the valve seat, it indicates that the valve has worn through the hardness of the seat and must be replaced. Attempting to reseat this valve would mean only short life from the injector. (Check valve and seat are sold only in pairs and must be installed that way.)

Replacing Check Valve: The check valve gasket must be replaced each time the check valve is removed. The gasket can be removed with a tool made from an old check valve seat as shown in Fig. 110. It may be necessary to tap the tool a few times with a bronze punch and hammer to enable you to pull the gasket out. **Do not use a chisel to remove gasket or damage will result to injector body.**

With clean fuel or cleaning solvent wash the injector body thoroughly and dry with clean compressed air.

If the check valve spring is shorter than 17/64", it must be replaced. (Fig. 111.)

Use a small inserting tool as shown in Fig. 112. With check valve spring and stop in position, hold the injector upside down and insert check valve spring and stop to its working position. (Fig. 113.) Reverse the position of the injector and remove the tool. Be sure the tool and parts are free from oil or the stop and spring may pull out of place when the tool is removed.

Place new gasket on check valve seat. With a little clean cup grease or vasoline on the check valve, assemble very carefully to body. With allen wrench tighten securely in place.

Check Valve Travel: The check valve travel tool (Fig. 114) should be used to determine the check valve opening. Limits are from .015" to .025". Too much travel will cause early failure of check valve spring and too little travel will deprive the cylinder of fuel. The tool has graduations of .020" each, and, if the check valve opens one graduation, the opening is correct.

If the travel is under .015", it may be that the check valve seat gasket has collapsed too much, and it will be necessary to replace with a new gasket. If there is too much travel, the seat should be tightened more.

Inspecting For Check Valve Leak: This should be checked as previously instructed in "SERVICING INJECTOR."

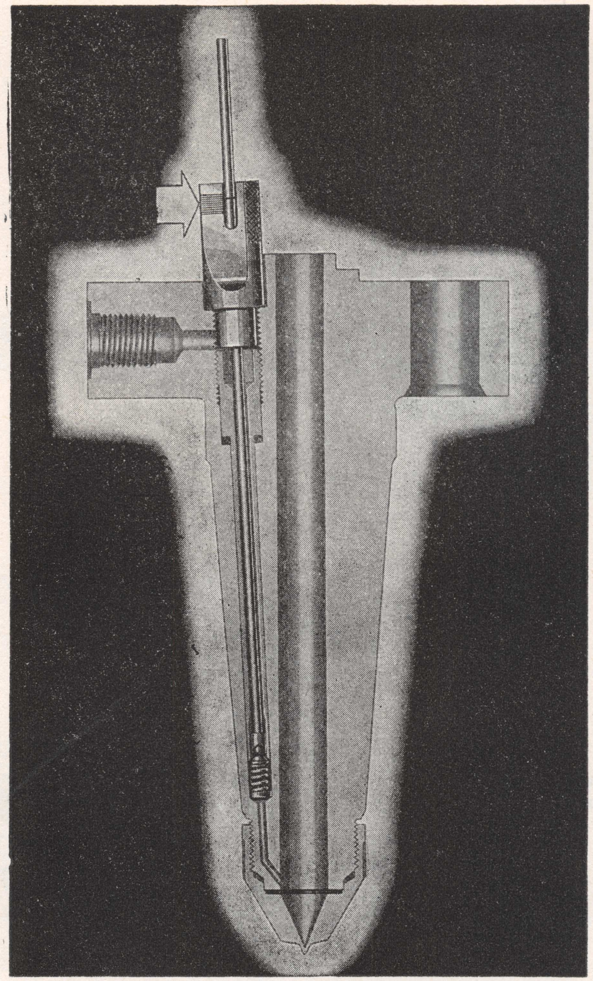


Fig. 114. Models A, H, NH. Checking injector check valve travel.

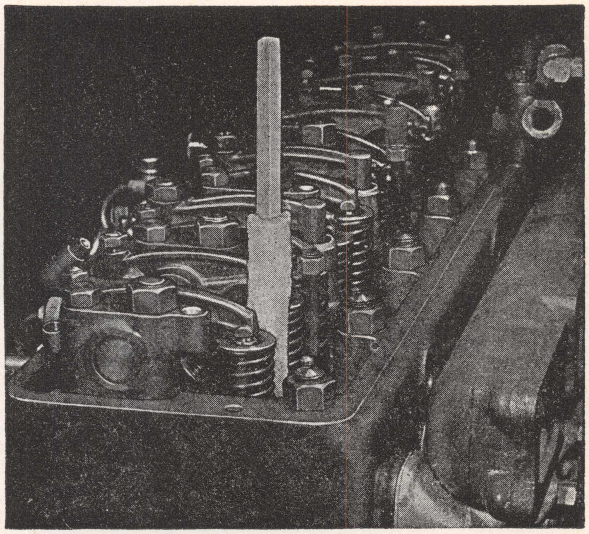


Fig. 115. Models A and H. Method of cleaning injector cup seat.

Body Plug: With a new gasket, assemble body plug. If this plug leaks, dilution will occur in lubricating oil.

Finished Assembly: Lubricate injector plunger with clean oil and assemble top body with plunger spring in place. Be sure to assemble gasket in place so that the plunger drain hole will be open.

Assemble top housing to body and tighten the two fillister head screws in place.

INJECTOR INSTALLATION

When the injector is removed, a small amount of lubricating oil from the head will run down over the injector cup seat.

With a pine stick (not a screwdriver) around which a clean rag (not waste) is wrapped, wipe the injector cup seat clean. (Fig. 115.) **Do not attempt to scrape or ream this seat or damage will result.**

Place injector in its proper position in cylinder head. Assemble fuel inlet connection, and screw in three turns. This is to align the injector body with the fuel inlet connection so the fuel inlet connection gasket will seat squarely against the face of the injector.

If gaskets on the fuel inlet and drain connections are damaged or cracked, replace them. (Use gaskets furnished by Cummins Engine Company). These are special threaded gaskets, designed so they will not drop off when assembling the connections.

Assemble injector hold down nuts. It is absolutely necessary that these nuts be evenly tightened and not to a minimum of 10 and a maximum of 14 pounds feet on the torque wrench. **Tightening these nuts excessively will distort valve seats and crack cylinder head.**

Tilt the injector rocker lever into operating position. Assemble adjusting screw into lever and push rod socket, to hold them in place.

Tighten the fuel inlet and drain connection firmly to prevent any fuel leaks.

INJECTOR FUEL INLET CONNECTIONS

There are two check valves in the fuel line between the fuel pump and the injector cup. One is in the injector fuel inlet connection (Fig. 116) and the other is the injector check valve.

The check valves are opened by fuel pressure from the metering pump, and are closed when pump delivery is finished.

The operation of the injector fuel inlet connection check valve is very important and should be checked occasionally for leaks.

The check valve should not break at less than 35 lbs. and not more than 50 lbs. fuel pressure.

The check valve can be checked by applying fuel pressure to the regular fuel line connection from priming pump to pressure pump.

1. To service the check valve ball and spring, remove the small screw plug "A".
2. The strainer screen "B" should be cleaned occasionally. When the screen is cleaned, replace the cage gasket "C".
3. The copper gasket "D" on the check valve must be replaced if found to be damaged or cracked.

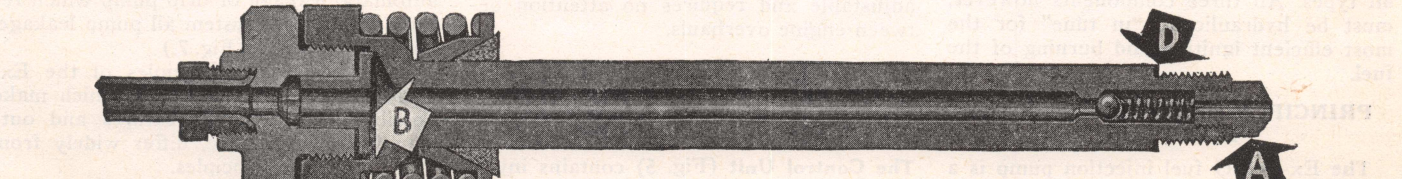


Fig. 116. Models A, H, NH. Injector fuel inlet connection.
A—Screw plug. B—Strainer screen. C—Cage gasket. D—Copper gasket.

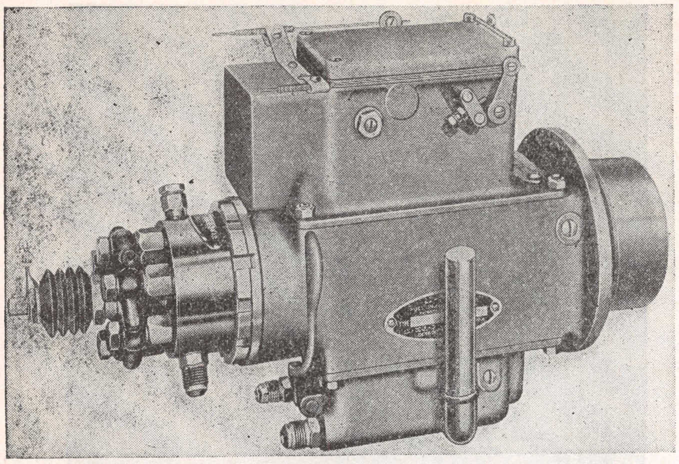


Fig. 1. Complete pump assembly.

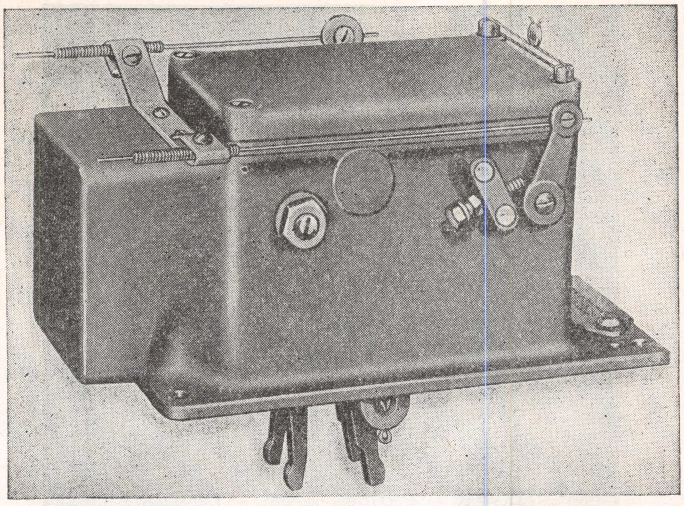


Fig. 1A. Control unit.

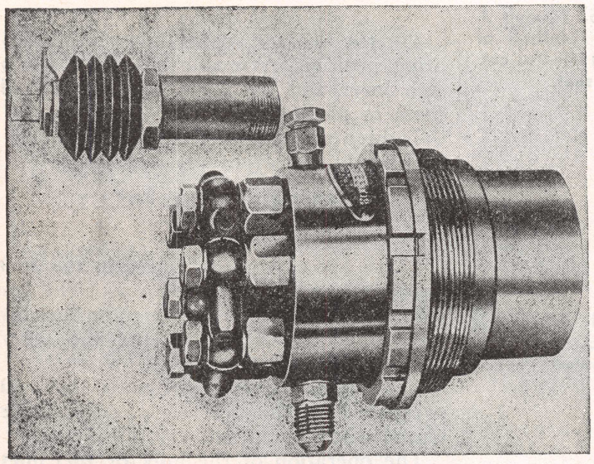


Fig. 1B. Hydraulic and accelerator units.

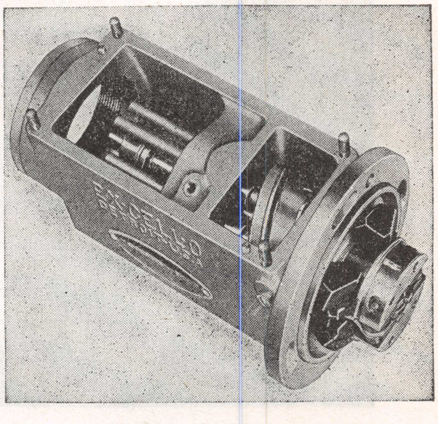


Fig. 1C. Drive unit.

EX-CELL-O

INTRODUCTION: The principal components of the Ex-Cell-O Fuel Injection System are: (1) An injection pump—which takes the fuel from the supply tank and delivers it under high pressure to the injection nozzles in the correct quantities, at the correct time, and at the correct rate, (2) the high pressure fuel lines—which transmit the fuel from the injection pump to the injection nozzles, and (3) the injection nozzles—which spray the fuel into the engine combustion chamber with the proper spray form, degree of atomization and rate to insure complete and efficient combustion. Each component of the injection system will usually vary somewhat in the details affecting injection characteristics for different types of combustion chambers, but the essential construction is the same for all types. All three components however, must be hydraulically "in tune" for the most efficient ignition and burning of the fuel.

PRINCIPLE OF EX-CELL-O FUEL INJECTION

The Ex-Cell-O fuel injection pump is a single, self-contained unit including a Fuel Transfer Pump, Hydraulic, Accelerator, and Control Units, each mounted on a Drive Unit arranged for flange mounting on the engine housing (See Fig. 1).

Perhaps the biggest advantage of the Ex-Cell-O fuel pump construction is the separation of each of these principal mechanisms into replaceable unit assemblies which are individually calibrated and which require no field adjustment.

The Drive Unit is bolted directly on the engine by a mounting flange and may be driven by a gear, sprocket, or coupling. It consists of simple, rugged mechanical parts used to operate the other units and is lubricated directly from the engine pressure supply system (See Fig. 2).

The Hydraulic Unit (Fig. 3) contains the precision parts which time, meter, and deliver fuel through the high pressure lines to the fuel injection nozzles. This unit is not adjustable and requires no attention between engine overhauls.

The Accelerator Unit (Fig. 4) controls speed and contains idling and maximum speed adjustments.

The Control Unit (Fig. 5) contains injection timing and fuel quantity controls and the adjustments for these controls are sealed in the unit.

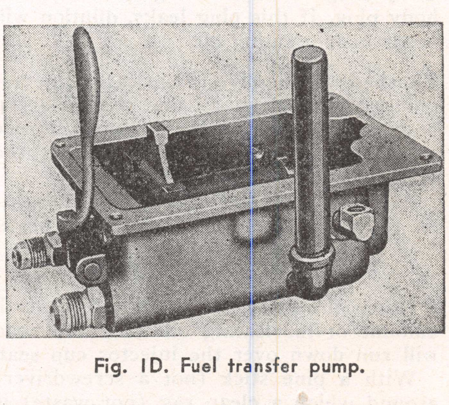


Fig. 1D. Fuel transfer pump.

The Fuel Transfer Pump (Fig. 6) draws fuel from the supply tank and forces it under low pressure to the Hydraulic Unit through suitable filters. It also contains an automatic leakage or drip pump which returns to the fuel system all pump leakage. (See Fuel Diagram Fig. 7.)

The engineering principles of the Ex-Cell-O Fuel Injection Pump, which make possible its automatic features and outstanding performance, differ widely from other pumping principles.

After passing through the fuel strainer, Transfer Pump and filter, fuel is supplied to a recess in the Hydraulic Unit which is

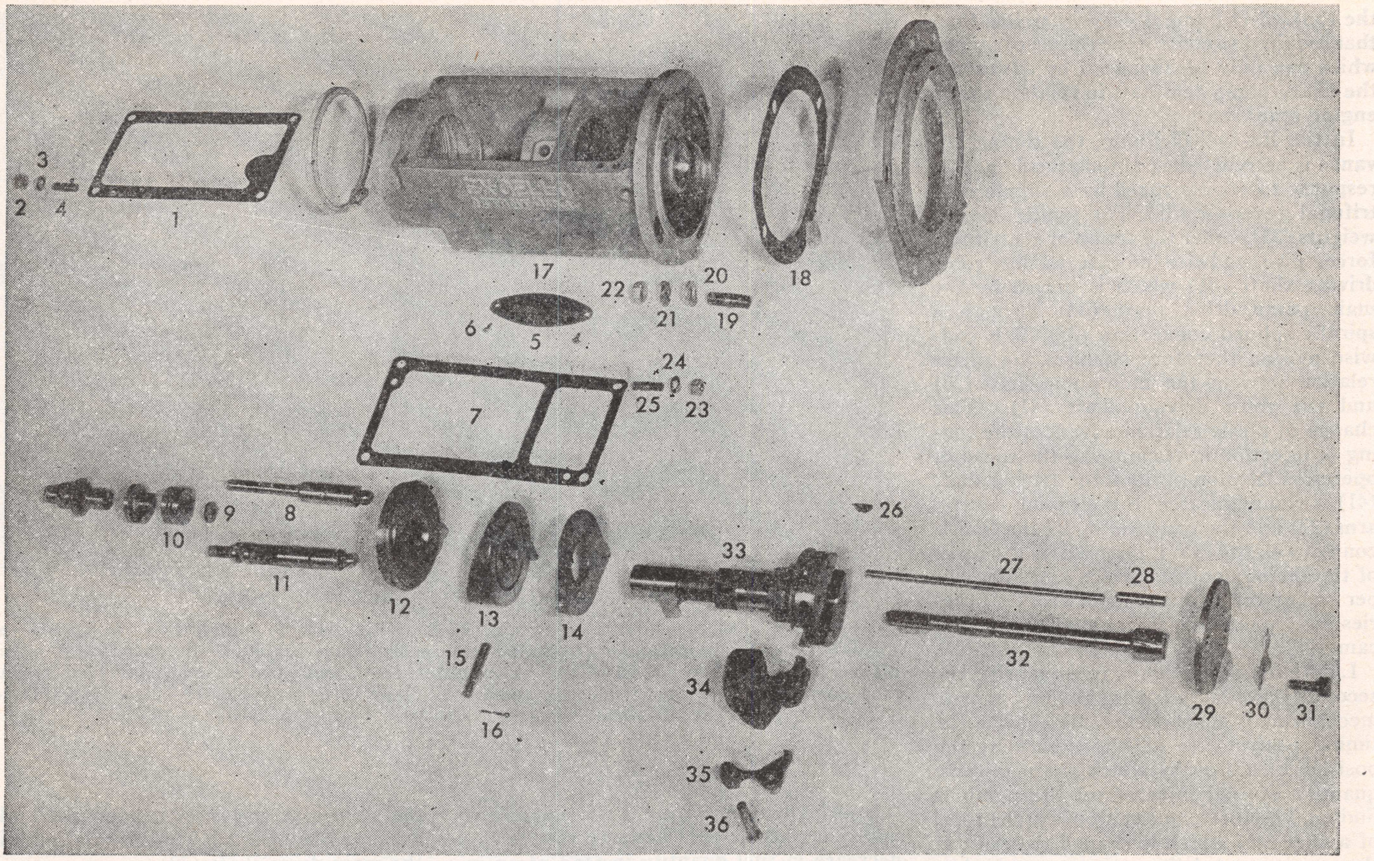


Fig. 2. LAYOUT OF DRIVE UNIT PARTS.

1—Transfer pump gasket. 2—Nut. 3—Lockwasher. 4—Stud. 5—Name plate. 6—Name plate pin. 7—Control unit gasket. 8—Plain tappet. 9—Timing bearing washer. 10—Timing fork bearing. 11—Slotted tappet. 12—Tappet shoe assembly. 13—Swash plate. 14—Swash plate bearing. 15—Swash plate pin. 16—Cotter pin. 17—Pump body. 18—Body gasket. 19—Mounting stud. 20—Washer. 21—Washer. 22—Stud nut. 23—Nut. 24—Lockwasher. 25—Stud (long). 26—Woodruff key. 27—Push rod. 28—Push pin. 29—Mounting plate. 30—Mounting screw lock. 31—Mounting plate screw. 32—Rotor driver and timing member. 33—Drive shaft assembly. 34—Timing weight. 35—Throttle weight. 36—Weight trunnion pin.

made, in part, by a spool-like reduction in the diameter at the center of the rotary valve, (Fig. 8). The ends of this valve are closely fitted in the central rotary valve bore, and prevent the escape of fuel endwise along the valve. The middle spool-like section of the valve, however, has one triangular shaped section, or "land" (Fig. 8-9), which is of the same diameter as the ends of the spool, and is therefore, a close pressure-tight fit in the valve bore.

The rotary valve 6 (Fig 9) is turned by an extension of the main fuel pump shaft 38 (Fig. 9) and the location of the "land" is timed in relation to the rotation of the pump shaft and reciprocation of the pump plungers (See Injection Cycle of Rotary Valve and Plunger shown by (Fig. (9) 1-2-3-4). The Hydraulic Unit, (Figures 3 and 9) contains one pumping plunger 4 (Fig. 9) for each engine cylinder; each plunger is given one suction and discharge stroke with each revolution of the pump shaft.

NOTE—All Illustration Numbers Refer to Fig. 9 unless otherwise stated.

A by-pass port (45) leads from the cavity at the end of each plunger bore to the central rotary valve (6). Through this by-pass port, the plunger cavity is supplied with fuel, and the fuel not injected into the engine is returned to the source of supply. In the end of each plunger cavity is a delivery valve (7) which, opened by sufficient hydraulic pressure, permits the delivery of fuel from the plunger cavity through the delivery valve into the injection tubing, (10).

To obtain zero delivery, the rotary valve (6) is moved endwise to a position where the by-pass ports are never closed; stroking of the plungers (4) then merely causes fuel to move in and out through these ports without building up a pressure sufficient to open the delivery valves (7) and cause injection. To cause the Pump to deliver fuel, the rotary valve (6) is moved endwise so that, during rotation, the triangular shaped "land" (6) closes the by-pass port (45) when the plunger (4) has its greatest velocity in the discharge direction.

During the time the by-pass port (45) is thus closed, the fuel in the plunger cavity is placed under pressure by the movement of the plunger (4), and its only means of escape is through the delivery valve (7) to the Injection Nozzle.

Further endwise movement of the rotary valve (6) causes a wider portion of the triangular "land" to pass across the by-pass holes (45); this increases the duration of the injection and the quantity of fuel injected.

The by-pass holes (45) of the several Pump cylinders are equal in diameter and are located in the same plane but at right angles to the axis of the central rotary valve (6). Each by-pass port (45), is closed for exactly the same duration of plunger travel; therefore exactly the same quantity of fuel will be delivered to each of the engine cylinders.

Because of the pumping principles used, advance of injection timing in the Ex-Cell-O Pump can be accomplished simply by advancing the phase relation of the central rotary valve (6) with respect to the timing of the drive shaft (38) of the pump. The drive shaft (38) always remains in fixed relation to the engine crankshaft by which the pump is driven through positive gearing. As the torque required to drive the central rotary valve (6) is very slight compared with the torque necessary to drive the entire fuel pump, it is seen that the amount of energy necessary to control the timing of

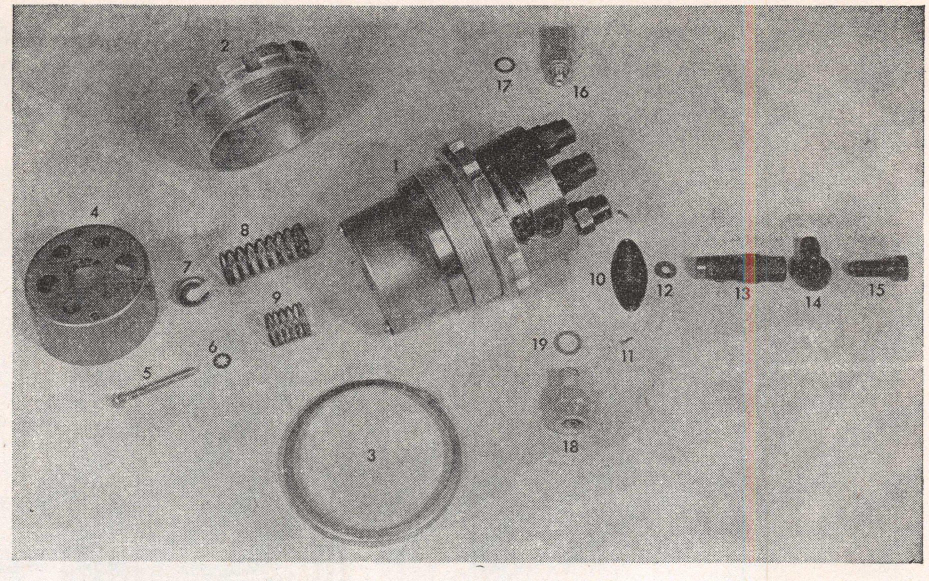


Fig. 3. LAYOUT OF HYDRAULIC UNIT PARTS.

1—Hydraulic unit—complete. 2—Ring nut. 3—Ring nut lock. 4—Spring case. 5—Spring case screw. 6—Spring case lockwasher. 7—Spring retainer. 8—Plunger spring. 9—Rotor spring. 10—Name plate. 11—Name plate pin. 12—Check valve gasket. 13—Check valve assembly. 14—High pressure tube connection 15—Tube connection screw. 16—Bleed valve assembly. 17—Bleed valve gasket. 18—Inlet connection. 19—Inlet connection gasket.

the Ex-Cell-O Pump is very much less than that required to control the timing of pumps which can only be advanced by advancing the entire pump camshaft in relation to the engine crankshaft.

In the Ex-Cell-O Pump, the timing advance is accomplished automatically and in response to engine speed by a simple centrifugal governor (35). The timing control weights (35), under the action of centrifugal force, give endwise motion to the rotor driving shaft (41) which is driven by the main pump drive shaft (38) through a spirally splined connection (33). This endwise motion therefore changes the phase relation between the main pump shaft (38) and the rotor driving shaft (41). This change of phase relation advances the timing of injection in response to the speed of operation. Motion of the rotor driving shaft (41) is communicated to the timing control arm (27) and the force set up by the timing control weights (35) is opposed by the force of the timing control springs (28). The upper end of the timing control arm (27) carries the maximum fuel quantity limiting cam, (25).

Limitation of maximum fuel quantity, the second function of the timing control mechanism, is accomplished by causing the timing control arm (27) to determine the position of a stop by which the maximum quantity of fuel injected by the pump is limited. The fuel quantity stop is in the form of a cam (25) which is shaped to result in the pump speed delivery curve required to develop the speed/torque curve desired of the engine on which the pump is used.

This mechanism makes possible a device for securing an increased quantity of fuel at low cranking speeds which is especially desirable for cold weather starting. This is accomplished by mounting the cam follower on a pivoted lever. Thus, by manually operating from the control station, a lever (29) connected to an offset pin through this pivot the follower can be made to back off the cam (25). This allows the rotor (6) to move axially to a location in which it increases the effective displacement of the pump. The design of this mechanism is such, however, that operation of the "choke" while the engine is running at normal operating speeds actually results in a decrease in fuel quantity instead of an increase. This is a safety feature which avoids abuse of the engine.

GOVERNING CONTROL

Governing of the engine is controlled in the Ex-Cell-O pump by means of a simple centrifugal governor (37). The rotary valve (6) is held in balance axially by a set of small centrifugal weights, (37) and a spring (16) which opposes the force of these weights. The action of this mechanism is independent of the automatic timing control since the rotor is motivated by a pin (37A) running through the hollow rotor driving shaft (41) and the rotor driver thrust bearing (42) is free to slide axially on the splines of the rotor driving shaft (41) without disturbing its phase relation with the main drive shaft (38).

The Accelerator Unit, Fig. 4, which contain the Dual governor springs used for automotive service, consist of a light idling spring (17) and a pre-loaded high speed spring (16). The idling spring (17) governs only at idling speeds. At speeds above idling, the idling spring is collapsed and the rotor position is fixed by the operator of the vehicle, through the pre-loaded high speed spring (16) which acts as a solid member. With the speed control member (13) fully depressed, governing is obtained at the maximum speed desired by means of adjustments (14) which fix the maximum load that can be applied to the high speed spring (16). This type of governing has an ad-

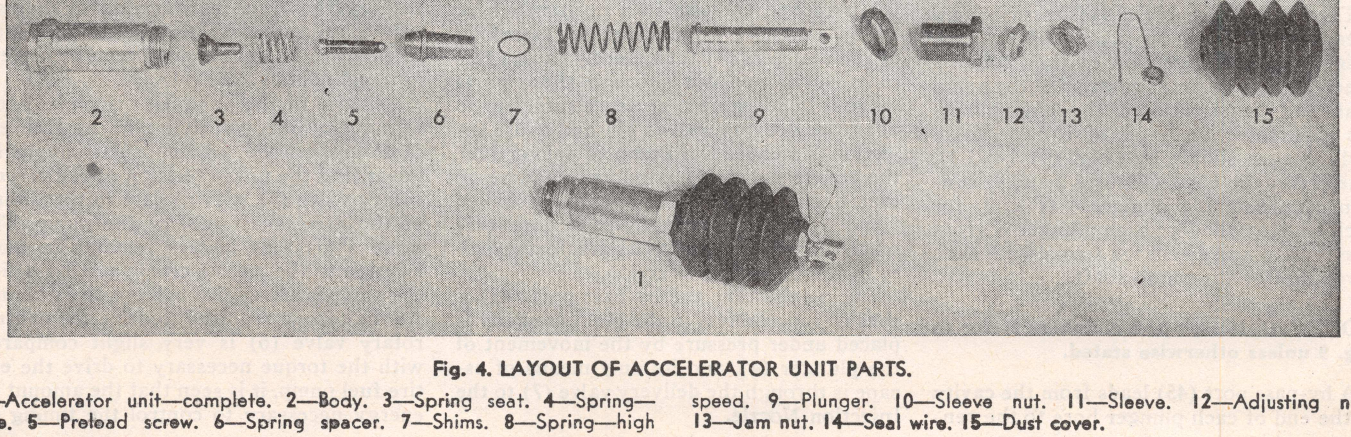


Fig. 4. LAYOUT OF ACCELERATOR UNIT PARTS.

1—Accelerator unit—complete. 2—Body. 3—Spring seat. 4—Spring—idle. 5—Preload screw. 6—Spring spacer. 7—Shims. 8—Spring—high speed. 9—Plunger. 10—Sleeve nut. 11—Sleeve. 12—Adjusting nut. 13—Jam nut. 14—Seal wire. 15—Dust cover.

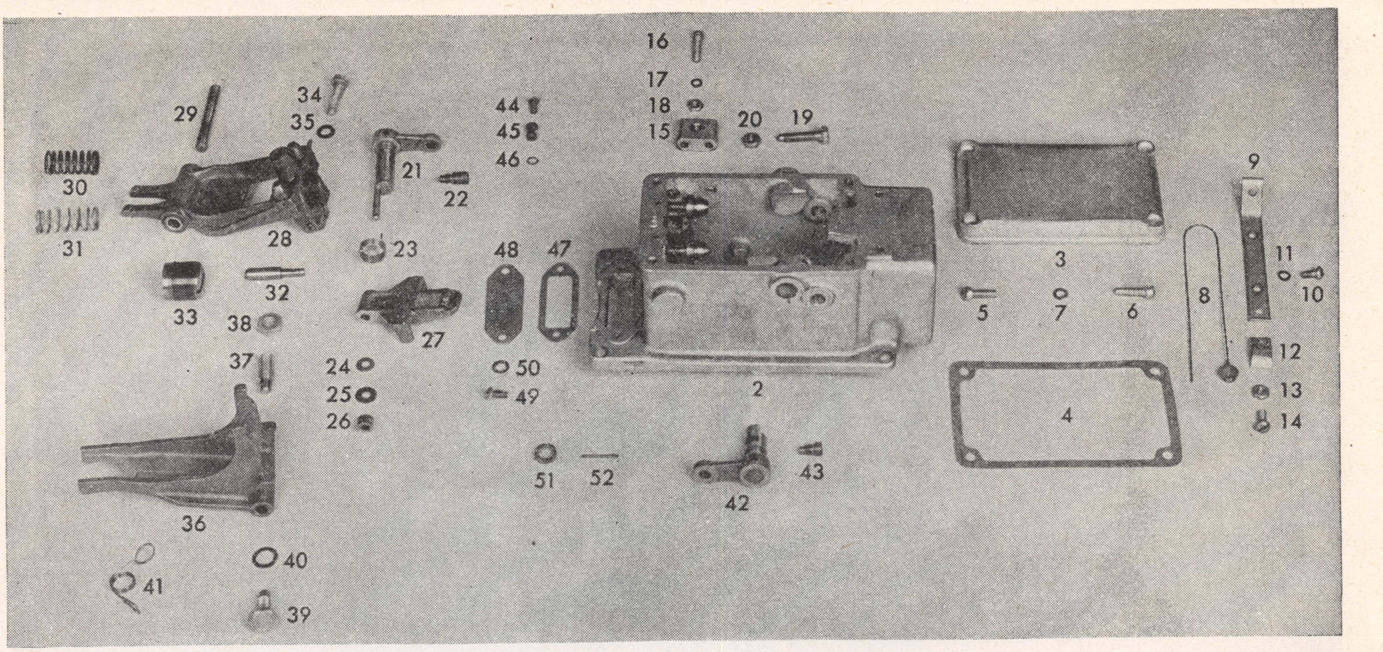


Fig. 5. LAYOUT OF CONTROL UNIT PARTS.

2—Housing. 3—Cover. 4—Cover gasket. 5—Cover screw—plain. 6—Cover seal screw. 7—Lockwasher. 8—Seal wire. 9—Cable bracket. 10—Cable bracket screw. 11—Lockwasher. 12—Cable clamp. 13—Clamp nut. 14—Clamp screw. 15—Starting lug. 16—Lug screw. 17—Lockwasher. 18—Lug nut. 19—Starting adjusting screw. 20—Adjusting screw jam nut. 21—Starting shaft and lever assembly. 22—Starting shaft retainer screw. 23—Starting shaft spring. 24—Starting shaft shim—thin. 25—Starting shaft shim—heavy. 26—Starting shaft collar. 27—Control link assembly. 28—Timing fork assembly. 29—Timing fork trunnion pin. 30—Timing spring—heavy. 31—Timing spring—light. 32—Timing fork—advance stop. 33—Fuel control cam. 34—Cam retainer screw. 35—Lockwasher. 36—Throttle fork. 37—Throttle fork adjusting screw. 38—Adjusting screw jam nut. 39—Throttle fork trunnion screw. 40—Washer. 41—Throttle fork spring. 42—Control stop shaft and lever assembly. 43—Stop shaft retainer screw. 44—Cable trunnion screw. 45—Cable attachment trunnion. 46—Cable attachment trunnion retainer. 47—Timing cover gasket. 48—Timing cover. 49—Cover screw. 50—Lockwasher. 51—Control shaft gasket. 52—Cotter pin.

vantage in automotive applications since the injection quantity is directly responsive to accelerator movement.

IDLING SPEED ADJUSTMENT

To alter the engine idling speed loosen the lock nut holding the idling speed adjustment (15)—Figure 9. To increase the idling speed turn the adjustment in the direction to increase the compression of the spring (17). To decrease the idling speed turn the adjustment in the opposite direction. This adjustment should be made when the engine is running and should not be made until the engine has been warmed up to normal operating temperature. Any normal change in the engine idling speed will have slight effect upon the maximum speed adjustment, (14).

MAXIMUM SPEED ADJUSTMENT

To alter the maximum speed adjustment, loosen the lock nut which holds this adjustment (14). To increase the maximum speed back off the adjusting nut so that the speed control rod can be moved further toward the right or inward direction, increasing the compression on the spring (16). To reduce the maximum speed, move this nut in the reverse direction. Be sure to tighten lock nuts which have been loosened, and the speed should be checked after tightening.

An oil-proof rubber cover is provided for preventing the entrance of dirt, splash or dust through the sliding joints of the speed control member. If this becomes lost, torn or deteriorated, it should be replaced at once.

FUEL TRANSFER PUMP

The Fuel Transfer Pump, (Fig. 6) is of the general class of pumps which automatically delivers the required varying volume of fuel under approximately a constant pressure, regardless of the speed at which the pump may be operated. The main plunger (44) Fig. 9 of the Fuel Transfer Pump is power-operated through a vertical drive rocker or walking beam (19) from one of the tappets of the fuel injection pump. This plunger, therefore, has a constant stroke.

To allow the pump to deliver a variable volume, there is a spring pressed "subtractor" piston (43) located in the same bore with the main plunger. This "subtractor" piston (43) has a stroke which, at zero fuel delivery, is equal to the stroke of the main plunger (44). At maximum delivery of the fuel transfer pump, the stroke of the "subtractor" piston (43) is zero and, at any intermediate quantity of delivery, the stroke of the "subtractor" piston (43) accounts for a displacement volume which represents the difference between the maximum possible quantity of delivery and the quantity of fuel actually being delivered. The pressure of fuel delivery is controlled by the spring pressure exerted on the "subtractor" piston, (43).

The subtractor piston (43) has a second function in that manual operation of the hand priming pump lever (18) can cause the subtractor piston (43) to be stroked independently of operation of the main transfer pump plunger (44) for the purpose of manually priming or filling the system with fuel, preparatory to starting the engine.

A small automatic leakage pump (20-21) which is incorporated in the fuel transfer pump accomplishes the second purpose of the fuel transfer pump. This is to pick up drip or leakage fuel from the fuel pump and combine this drip fuel with the fuel being supplied to the Hydraulic Unit.

Ex-Cell-O pumps will not deliver fuel in opposite rotation for which they are intended. This is an important safety feature not possible with cam operated pumps and is especially desirable in automotive application.

CONSTRUCTION OF FUEL TRANSFER PUMP

NOTE—All Illustration Numbers Refer to Figure 9 unless otherwise stated.

The Fuel Transfer Pump contains two plungers, (43-44) one of which is power operated from the bottom tappet of the Fuel Injection Pump by means of a small vertical drive rocker (19) which causes a stroke of the Fuel Transfer Pump with each stroke of the transfer pump drive tap-

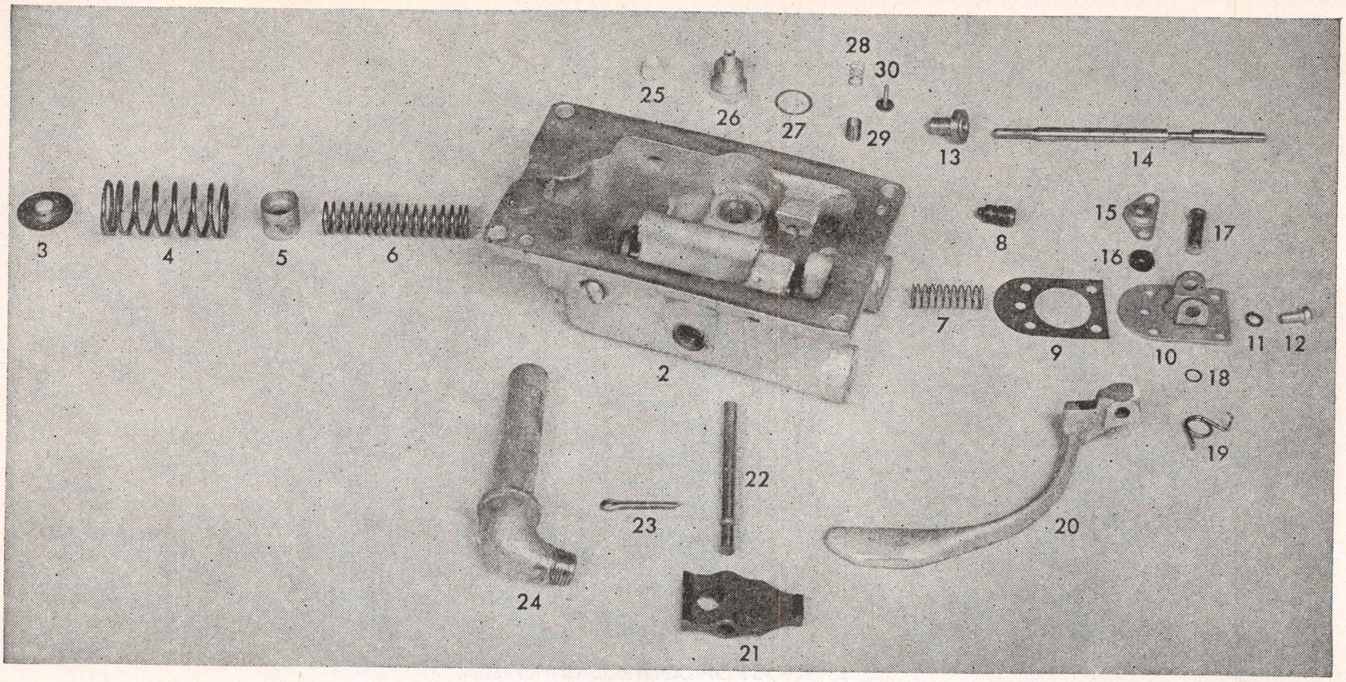


Fig. 6. LAYOUT OF FUEL TRANSFER PUMP PARTS.

2—Pump body sub-assembly. 3—Pump spring pilot. 4—Outer spring. 5—Spring spacer. 6—Inner spring. 7—Leakage piston spring. 8—Leakage valve assembly. 9—End plate gasket. 10—End plate assembly. 11—Lockwasher. 12—Screw. 13—Plunger stop. 14—Pump priming rod. 15—Priming rod packing retainer. 16—Priming rod packing. 17—Priming lever pin. 18—Lever pin retaining ring. 19—Priming lever spring. 20—Priming lever. 21—Pump rocker. 22—Rocker pin. 23—Cotter pin. 24—Pump suction bottle. 25—Pipe plug. 26—Pump valve assembly cap. 27—Valve cap gasket. 28—Suction valve spring. 29—Discharge valve spring. 30—Pump valve.

pet (40). The hand and spring operated plunger (43) has behind it a compound spring which serves to regulate the pressure of fuel delivered to the filter and hydraulic unit. This second plunger can be operated manually by moving the external hand priming pump lever (18).

The Transfer Pump also contains a spring closed suction and discharge valve. Also refer to Fig. 6.

See the instructions relative to Hydraulic Unit Bleed Valve.

TEST FOR FAULTS IN FUEL TRANSFER PUMP

The first indication of any trouble with the Fuel Transfer Pump will be a loss of pressure on the fuel pressure gauge, (See Fig 7). However, loss of pressure on this gauge does not necessarily indicate that the difficulty is in the Fuel Transfer Pump. Before suspecting the Fuel Transfer Pump, make sure of the following:

1. A supply of fuel in the fuel supply tank.
2. All valves between the fuel supply tank and the fuel transfer pump must be open.
3. The strainer between the fuel supply tank and the fuel transfer pump must be clean.
4. There must be no air leaks in the fuel supply line between the fuel supply tank and the transfer pump.
5. The fuel filter on the high pressure side of the fuel transfer pump must be clean, so that it does not restrict the passage of fuel to the Hydraulic Unit (as the pressure gauge connection is between the filter and the Hydraulic Unit, the loss of pressure in passing through the filter will be subtracted from the Transfer Pump pressure and the pressure gauge will, therefore, read low if the filter is dirty, regardless of the fact that the fuel transfer pump may be functioning properly).
6. The pressure gauge may be stuck so that it does not register properly. Oftentimes an air leak in the suction line can be confused with faulty operation of valves in the fuel transfer pump. Such air leaks in this line are sometimes quite hard to detect.

If operation of the hand priming lever (18)—Figure 9, does not cause a change in the reading of the pressure gauge, (Fig. 7) open one of the air bleed vents at the top of the filter, (Fig. 7) and then operate the fuel transfer pump manual priming handle (18) Fig. 9, to see whether fuel under pressure is delivered from this vent.

To test further the fuel transfer pump, disconnect the supply and discharge tubing from the transfer pump, and while operating the manual priming handle by hand, note whether there is a suction at the inlet connection to the pump (23) Figure 9, or a slight pressure build-up at the discharge exit (22)—Figure 9 from the transfer pump.

This can be determined by placing the fingers lightly over these connections, or by temporarily fastening a short piece of copper tubing or rubber hose to the suction inlet to see if the pump will lift fuel from a container approximately two or three feet below the level of the pump when operating the manual prime handle (18)—Figure 9.

One of the more common causes for fuel transfer pump failure is the lodging of some small foreign particles beneath one of the valves of the transfer pump. In this case, the particle can often be removed by disconnecting both the suction and discharge tubing from the fuel transfer pump and blowing into the suction inlet of the pump, preferably with a compressed air hose. This will lift both of the valves clear of their seats and usually will blow out the foreign particles.

If the spring loaded plunger, (43—Fig. 9) operated by the hand priming lever, (18) is stuck, this can be determined by the behavior of the manual priming lever, (18—Fig. 9). It will either be impossible to move this lever through its normal working stroke or, the lever will flop loosely through its entire stroke without moving the plunger and, in so doing, the manual operation of the transfer pump will deliver no fuel.

If the main or power driven plunger (44—Fig. 9) of the fuel transfer pump is stuck, it will probably cause the bottom tappet (40—Fig. 9) of the fuel injection pump to stop reciprocating, causing the engine to stop or at least to miss on the cylinder supplied by the bottom cylinder of the fuel injection pump. If fuel can be delivered by manual operation of the priming pump (18—Fig. 9) it is evident that the valves of the fuel

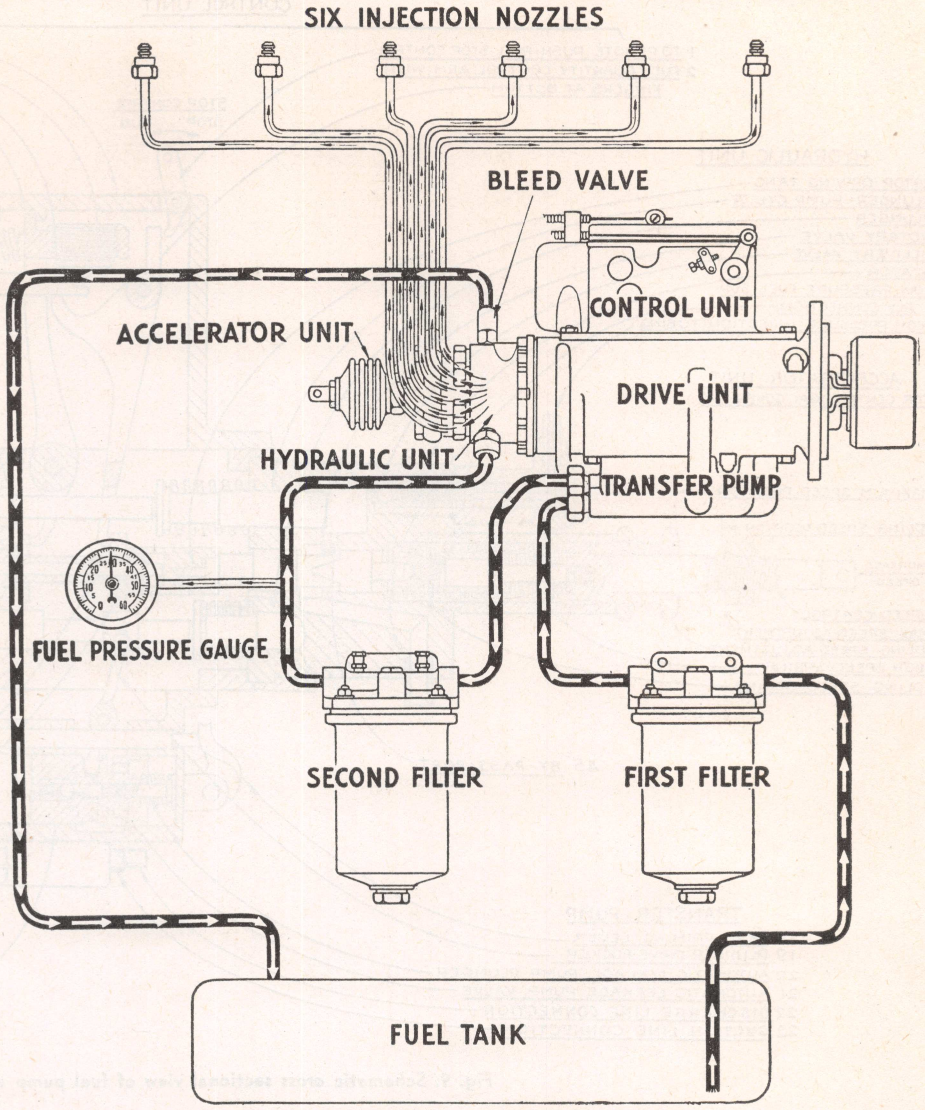


Fig. 7. Schematic drawing of fuel system.

transfer pump are functioning properly and it is probable that the power-operated plunger (44—Fig. 9) of the transfer pump is stuck. This latter condition may be checked by running the engine for a short time on fuel supplied by operation of the hand priming pump handle (18—Fig. 9). If the engine misses on the one cylinder, as just suggested and, especially if the engine runs out of fuel when ceasing to operate the hand priming pump, it may be concluded that the power-operated main plunger (44—Fig. 9) of the transfer pump is stuck, in which case the transfer pump should be replaced.

FUEL TRANSFER PUMP, REMOVE

To remove the Fuel Transfer Pump, loosen the four nuts on each corner of the pump and the entire pump assembly will then be free to move downwardly (See (1) Fig. 6).

The valves may then be inspected by removing the screws covering the valves. This will release the valve springs and small plate valves. In replacing the parts, be sure that they go back exactly as they came out and make sure the gaskets under the valve cover screws are replaced and snugly tightened, otherwise, there will be a leakage of fuel oil into the housing of the fuel transfer pump.

Major repairs to the Transfer Pump can best be made at the factory. Do not attempt to remove the plungers from the fuel transfer pump. If either of these is stuck, replace the entire fuel transfer pump assembly, returning the assembly to be reconditioned at the factory.

The Transfer Pump contains an automatic drip pump which pumps the fuel drip from the Hydraulic Unit, Transfer Pump and Nozzles (if other than Ex-Cell-O Nozzles are used) back into the fuel delivery going into the Hydraulic Unit. If the leakage pump fails to operate for any reason, some fuel drip may come from the vent or overflow in the side of the drive unit. Except for the inconvenience of catching and otherwise disposing of this drip, no damage will be done. Such a transfer pump should, however, be returned for correction.

REPLACING THE FUEL TRANSFER PUMP

NOTE—All Illustration Numbers Refer to Fig. 9, unless otherwise stated.

Before attempting to replace the fuel transfer pump, see that the bottom tappet (40) of the fuel injection pump is turned so that the slot for engaging the upper end of the vertical walking beam (19) which drives the fuel transfer pump power-driven plunger (44) is lined up with the position of the top end of this drive rocker (19) so that the end of the drive rocker will enter this slot. If the drive rocker (19) does not enter the slot, it will be impossible for the transfer pump body to take its normal position and there will be a gap between the gasket face of the Transfer Pump Body and the lower gasket face of the fuel pump body. It is therefore impossible to assemble wrongly the fuel transfer pump onto the main fuel pump body or housing. Do not forcibly draw the faces together, as when correctly assembled, the parts will go together easily.

HYDRAULIC UNIT

The Hydraulic Unit as explained under the "Principle of Operation" contains the precision parts which meter, time, and deliver fuel through the high pressure lines to the fuel injection nozzles. This unit, as shown by Figure 3 is not adjustable and requires no attention between the engine overhauls.

TEST OF HYDRAULIC UNIT

NOTE—All Illustration Numbers Refer to Fig. 9 unless otherwise stated.

If fuel under pressure and free of air or gases is supplied to the Hydraulic Unit (8) and fuel seems not to be delivered to the nozzles when the speed control throttle (13) is depressed and the stop control (1) is in the "run" position, proceed as follows:

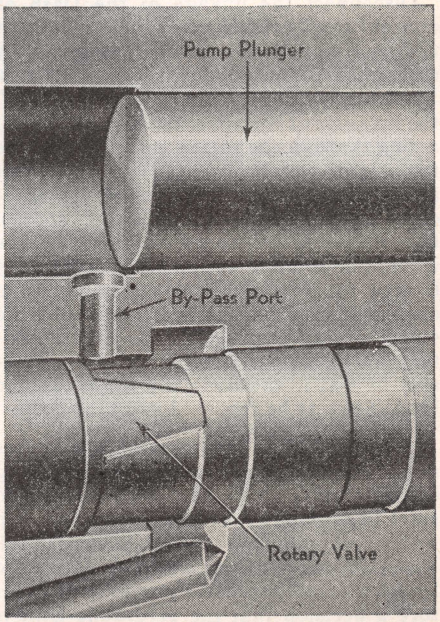


Fig. 8. Partial view of central rotary valve and plunger.

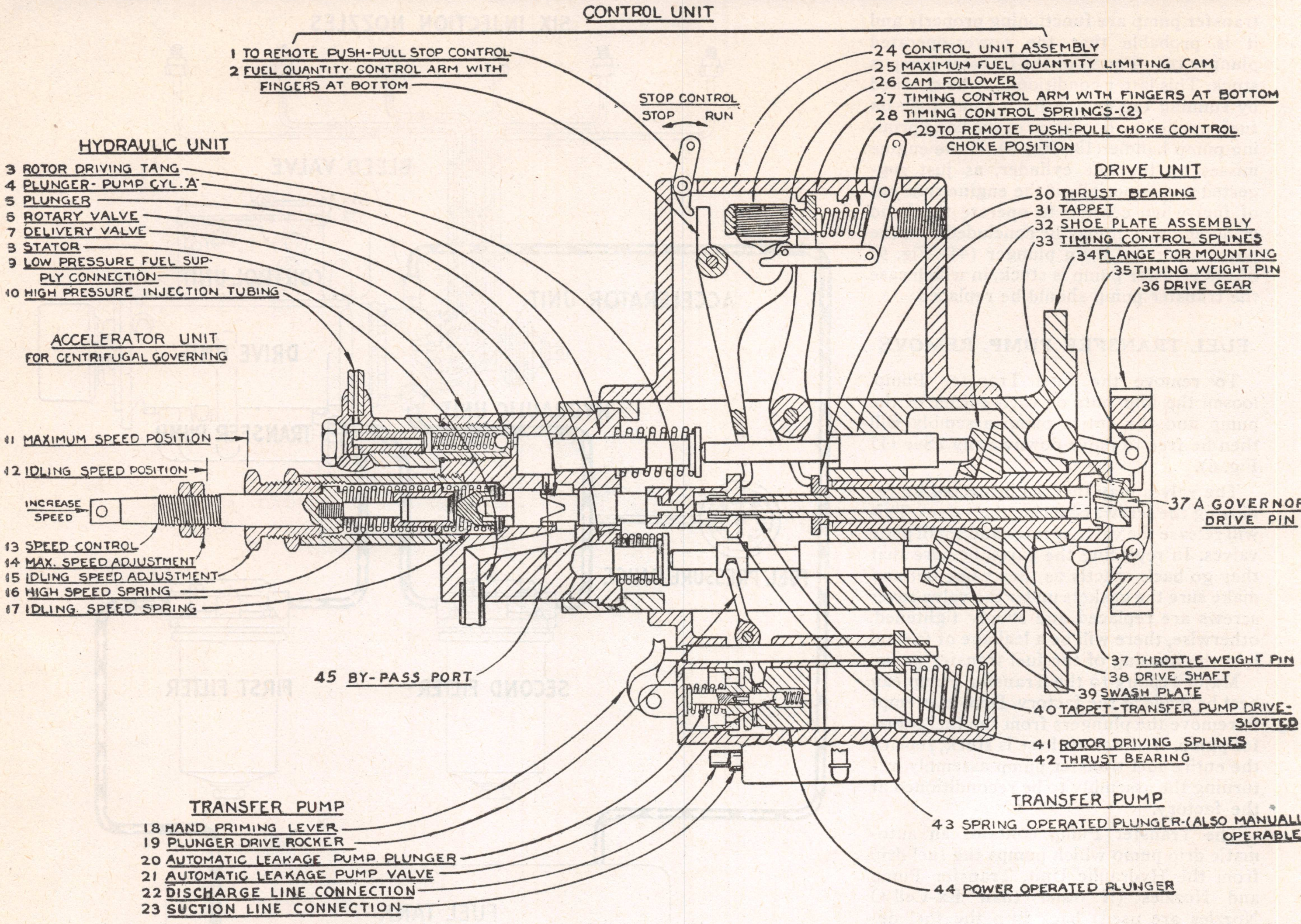

CONTROL UNIT
1 TO REMOTE PUSH-PULL STOP CONTROL
2 FUEL QUANTITY CONTROL ARM WITH FINGERS AT BOTTOM
STOP CONTROL
STOP RUN
HYDRAULIC UNIT
3 ROTOR DRIVING TANG
4 PLUNGER-PUMP CYL. "A"
5 PLUNGER
6 ROTARY VALVE
7 DELIVERY VALVE
8 STATOR
9 LOW PRESSURE FUEL SUPPLY CONNECTION
10 HIGH PRESSURE INJECTION TUBING
ACCELERATOR UNIT FOR CENTRIFUGAL GOVERNING
11 MAXIMUM SPEED POSITION
12 IDLING SPEED POSITION
INCREASE SPEED
13 SPEED CONTROL
14 MAX. SPEED ADJUSTMENT
15 IDLING SPEED ADJUSTMENT
16 HIGH SPEED SPRING
17 IDLING SPEED SPRING
45 BY-PASS PORT
TRANSFER PUMP
18 HAND PRIMING LEVER
19 PLUNGER DRIVE ROCKER
20 AUTOMATIC LEAKAGE PUMP PLUNGER
21 AUTOMATIC LEAKAGE PUMP VALVE
22 DISCHARGE LINE CONNECTION
23 SUCTION LINE CONNECTION
24 CONTROL UNIT ASSEMBLY
25 MAXIMUM FUEL QUANTITY LIMITING CAM
26 CAM FOLLOWER
27 TIMING CONTROL ARM WITH FINGERS AT BOTTOM
28 TIMING CONTROL SPRINGS-(2)
29 TO REMOTE PUSH-PULL CHOKE CONTROL CHOKE POSITION
DRIVE UNIT
30 THRUST BEARING
31 TAPPET
32 SHOE PLATE ASSEMBLY
33 TIMING CONTROL SPLINES
34 FLANGE FOR MOUNTING
35 TIMING WEIGHT PIN
36 DRIVE GEAR
37 A GOVERNO DRIVE PIN
37 THROTTLE WEIGHT PIN
38 DRIVE SHAFT
39 SWASH PLATE
40 TAPPET-TRANSFER PUMP DRIVE-SLOTTED
41 ROTOR DRIVING SPLINES
42 THRUST BEARING
TRANSFER PUMP
43 SPRING OPERATED PLUNGER-(ALSO MANUAL OPERABLE
44 POWER OPERATED PLUNGER

Fig. 9. Schematic cross sectional view of fuel pump assembly.

Disconnect the linkage of the Dash or remote "stop" control (1) at the control unit (24) and move this control by hand slowly throughout its range of travel several times. Particularly at and near the "stop position," the pressure of the governor springs (16-17) acting through the rotary valve (6) and the fuel quantity control arm (2) should be felt acting against the stop control (1) especially if the accelerator or speed control (13) is held in full-speed position. If there is no such pressure and the stop control (1) is free to "flop" without resistance from one position to another (especially near the stop position) it indicates the Central Rotary Valve (6) has been stuck (most probably by dirt in the fuel) and the Hydraulic Unit (8) must be removed and replaced.

A worn Hydraulic Unit usually becomes noticeable through requiring high cranking speed to start or, failure of the engine to start or, tendency of the engine to stop when left running at slow idling speed. However, these symptoms may be caused by other conditions in the engine and, therefore a decision that the Hydraulic Unit is worn out can only be determined positively by the following tests:

1. Disconnect all of the fuel injection tubes (10) and remove the injection nozzles from the engine. Reconnect all the nozzles so that they will inject into the outside air.

2. Next, turn the engine by hand or, by the electric starter, at a speed equal to the normal cranking speed of the engine. It is necessary that all other conditions necessary for proper performance of the pump as previously outlined, should first have been obtained. If the nozzles do not deliver under normal cranking speed and, if they do deliver at a speed which is higher than the normal cranking speed, it may be concluded that the Hydraulic Unit is worn and should be replaced. Any peculiarity in the appearance of the spray from any of the injection nozzles should not be attributed to faults in the injection pump, as the nozzles themselves may be responsible for these peculiarities. See Fuel Injector Nozzle and Holder Assembly.

If the engine misses or fails to fire on any cylinder, this does not necessarily indicate that fault exists in the fuel injection system, as one of the engine valves may be holding open or the engine compression may be insufficient for some other reason to permit the cylinder to fire.

Before suspecting the fuel injection pump, the injection nozzle should be removed from the cylinder which fails to fire and reconnected to its injection tubing in such a way that the injection from the nozzle will be shot into the external air where it can be observed by the operator while the engine is running on the remaining cylinders.

If no injection occurs from the nozzle in question, it should be replaced by another nozzle which is known to be in operating condition. A small particle of dirt (sometimes a small piece of copper from a gasket or scale from the fuel pump) may be holding a delivery valve from its seat. To determine if this is so, remove the delivery valve (7) from the Hydraulic Unit, dry it carefully with a clean rag and blow in one end while the opposite end is submerged in a container of clean fuel. If you can cause air bubbles to come through the valve, blow compressed air through the valve at the seat end. If this does not remedy the condition, replace with a new valve. Do not attempt to disassemble the valve, as permanent distortion of the seat may result. If no injection then occurs, it is safe to assume that the associated plunger (4) of the Hydraulic Unit has stuck or "hung up," possibly due to the presence of a small particle of dirt. Such an occurrence is unusual and the following should not be attempted until more probable difficulties have been checked.

However, a "stuck or hung up" plunger may often be permanently cured by removing the delivery valve (7) associated with that plunger (after first cleaning the end of the Hydraulic Unit). After the valve (7) is removed, the end of the plunger (4) may be reached with a small piece of soft material like a short section of brass welding rod or a small wooden stick (after being carefully cleaned). Pressure applied to the end of the plunger or lightly tapping the rod or stick, will usually free the stuck plunger, (see Fig. 16), after which, by motion of the rod when the engine is cranked, the operator will know that the plunger is moving in the normal manner. The delivery valve may then be replaced and the nozzle again tried to see if it properly injects. If stuck plungers do not respond, the Hydraulic Unit must be changed. However, if the plunger which sticks is driven by the lowest tappet, which also operates the Fuel Transfer Pump, read instructions pertaining to the Fuel Transfer Pump before changing the Hydraulic Unit.

There is no fault likely to occur in the Hydraulic Unit other than those just described. It is usually best to try the simple tests first and even the test for a worn Hydraulic Unit need not be tried until the operator has reason to believe that the cause for hard starting is not in the engine. (Too low cranking speed or too cold an engine, or both, are the most likely causes for hard starting.)

However, if the test for a worn Hydraulic Unit shows that fuel is being delivered from the nozzles at normal cranking speed and if it is known that the the pump has not been removed from the engine since it was last operated, or, if removed, that the pump has been properly timed on its replacement, there is no further reason for questioning the fuel injection system and the cause of starting difficulties must be looked for elsewhere.

See separate instructions for inspection and testing of injection nozzles and also for instructions relative to Hydraulic Unit Bleed Valve.

REMOVAL AND REPLACEMENT OF THE HYDRAULIC UNIT

Before deciding to remove the Hydraulic Unit, make sure there is sufficient cause for so doing. Do not jump to conclusions. Read carefully the instructions showing tests for determining the cause of fuel injection system troubles and be sure that the fault is in the Hydraulic Unit before removing it. Also read instructions relative to the Fuel Transfer Pump.

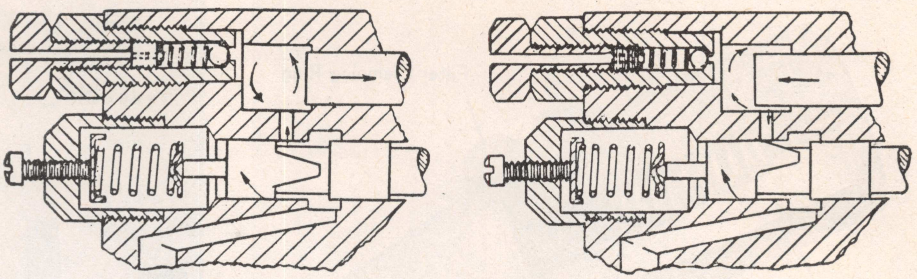
TO REMOVE THE HYDRAULIC UNIT

1. **Wash the accumulated dirt from the fuel pump and tubing connections and dry with clean cloths.**
2. **Disconnect the high pressure injection tubing connections at both ends and remove the tubing.**
3. **Disconnect the low pressure fuel supply line to the Hydraulic Unit. To make sure no dirt enters the supply tubing, tie a clean paper sack over the end of the supply tube until ready to reconnect this line.**
4. **With a screw driver or other suitable tool, pry up the portion of the lock ring, (3—Fig. 3) which is depressed into one of the spanner wrench slots of the large ring nut which locks the Hydraulic Unit in place.**
5. Unscrew the large retaining ring nut, (2—Fig. 3) using the spanner wrench provided for that purpose. **Do not use a hammer or punch.**
6. Remove the Hydraulic Unit rearwardly from its socket.

   Make sure that the splined rotor driving member and thrust washer are not lost. If the Hydraulic Unit is not to be immediately replaced, cover the pump with a cloth to keep out dust and dirt. Do not unwrap the new Hydraulic Unit until you are ready to screw it in place. Do not lay it in a dirty place. If by accident it comes in contact with dirt, it should be rinsed off with clean fuel freshly drawn in a perfectly clean container.

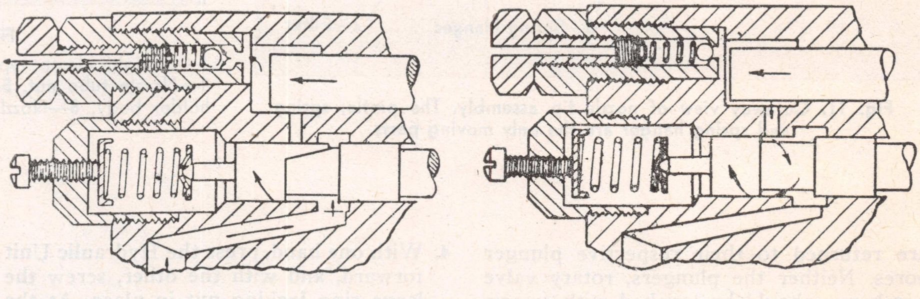
Ordinarily the Hydraulic Unit should not be disassembled for inspection or cleaning except at the factory. If this is done by others, care must be taken that the plungers

Fig. 9A. Injection cycle of rotary valve and plunger.



A—End of filling stroke—duration of filling stroke is one-half revolution of rotary valve.

B—Portion of expulsion stroke preceding injection—approximately one-fourth revolution of rotary valve.



C—Delivery portion of expulsion stroke. The axial position of the rotary valve determines the duration of closure of the by-pass port from zero to one-tenth revolution—approximately.

D—Portion of expulsion stroke following injection—approximately one-fourth revolution of rotary valve.

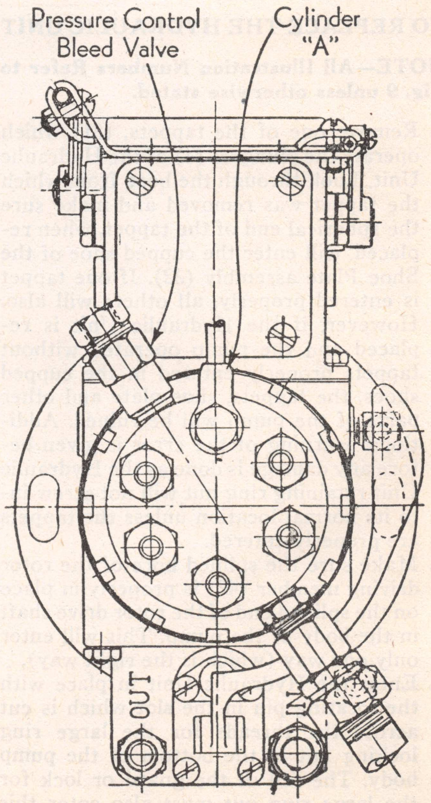


Fig. 10. End view of six-cylinder pump.

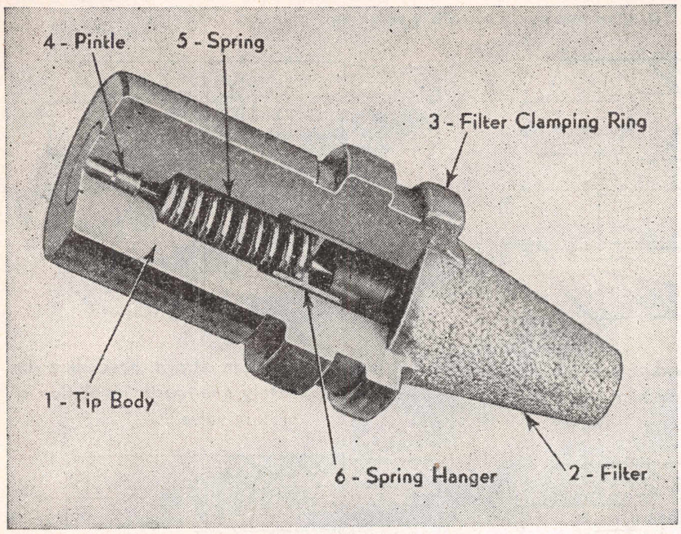


Fig. 11. Cutaway view of nozzle tip assembly. The pintle, spring and spring hanger are the only moving parts.

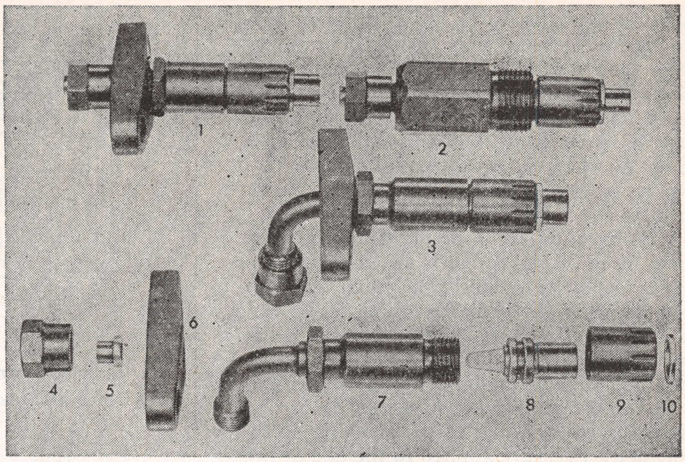


Fig. 13. INJECTION NOZZLES.

1—Straight clamp type. 2—Straight screw type. 3—Angle clamp type. 4—Nozzle tube nut. 5—Nozzle tube sleeve. 6—Nozzle clamp. 7—Nozzle holder body. 8—Nozzle tip assembly. 9—Nozzle holder nut. 10—Nozzle gasket.

are returned to their respective plunger bores. Neither the plungers, rotary valve nor bores, should be touched with emery, crocus cloth or any abrasive or polishing compound. They may, however, be washed in clean fuel. The polished or highly finished parts should not be clicked, scraped or rattled together and should not be laid on anything but a clean paper or cloth. Before reassembling, they should be rinsed in fresh clean fuel, then dipped in light clean lubricating oil.

TO REPLACE THE HYDRAULIC UNIT

NOTE—All Illustration Numbers Refer to Fig. 9 unless otherwise stated.

1. Remove one of the tappets, (31) which operate the plungers (4) of the Hydraulic Unit. Look through the bore from which the tappet was removed and make sure the spherical end of the tappet, when replaced, will enter the cupped shoe of the Shoe Plate assembly (32). If one tappet is entered properly, all others will also. However, if the Hydraulic Unit is replaced and the pump operated without tappets properly entered in the cupped shoes, the tappets, shoe plate and other parts of the pump will be ruined. Additional warning of the error is given before any damage is done as the Hydraulic Unit retaining ring nut will not screw into its normal location unless the tappets are properly entered.
2. Make sure the splined bore of the rotor driving member (42) is properly in place on the splined end of the rotor drive shaft in the body of the pump. This will enter only one way (which is the right way).
3. Enter the Hydraulic Unit in place with the locating pin in the slot which is cut across the threads for the large ring locking nut in the bottom of the pump body. The tail of the guard or lock for the large ring nut must also enter this slot.
4. With one hand, press the Hydraulic Unit forward, and with the other, screw the large ring locking nut in place. At the forward end of the rotor, is an offset rotor driving tang (3) which enters an offset slot in the splined rotor driving member (42). If this tang does not enter the slot, no damage will be done, as the rotor return spring simply is compressed until the engine is cranked, when the tang (3) will snap in place. This should require little force or effort until the nut draws the Hydraulic Unit tightly in place close to the end of the thread, when the nut should be tightened firmly by the special spanner wrench. Do not use a pipe or hammer on the wrench and do not use a hammer or punch for tightening the nut. When the nut is tight, a hammer and punch should be used to depress a section of the lock ring into one of the spanner slots of the large ring nut, thus locking it against loosening.
5. Reconnect the fuel supply line. As this connection is beyond the filter, be extra careful to avoid dirt.
6. Reconnect the high pressure injection tubing and bleed valve tube.
7. Follow the instructions for removing air from an "Air Bound" system, and the engine may then be started.

HYDRAULIC UNIT BLEED VALVE

The bleed valve (16—Fig. 3) should maintain a back pressure of approximately 30 to 35 pounds per square inch of fuel. Failure to maintain this pressure in normal operation or when operating the manual priming pump may be due to a fault in the Fuel Transfer Pump. If the fuel pressure gauge

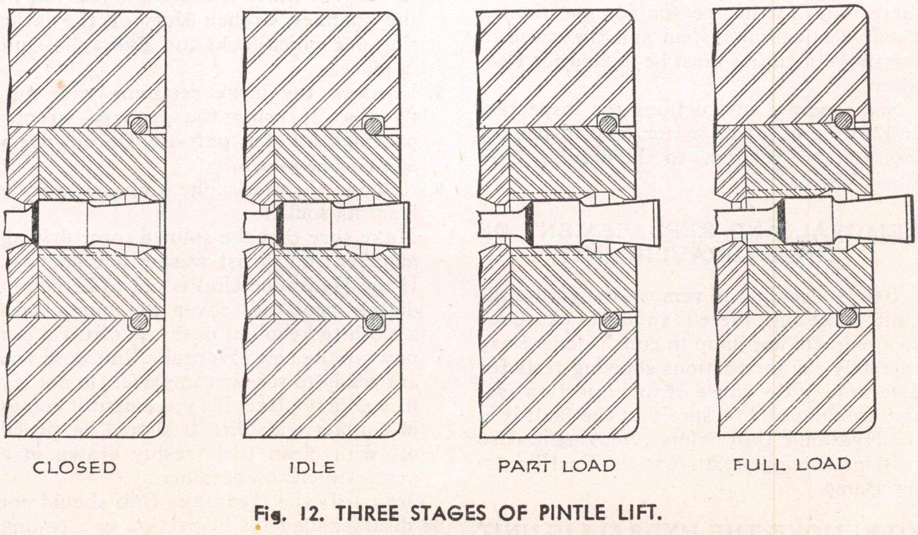


Fig. 12. THREE STAGES OF PINTLE LIFT.

In operation, pintle lift is proportional to engine speed and load. This variable orifice area feature eliminates excessive pressures at high speed, and assures excellent spray characteristics at all speeds

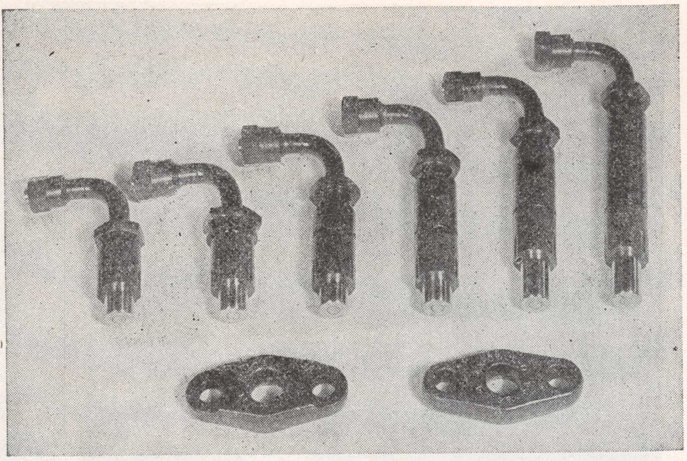


Fig. 14. Various angle clamp type nozzles.

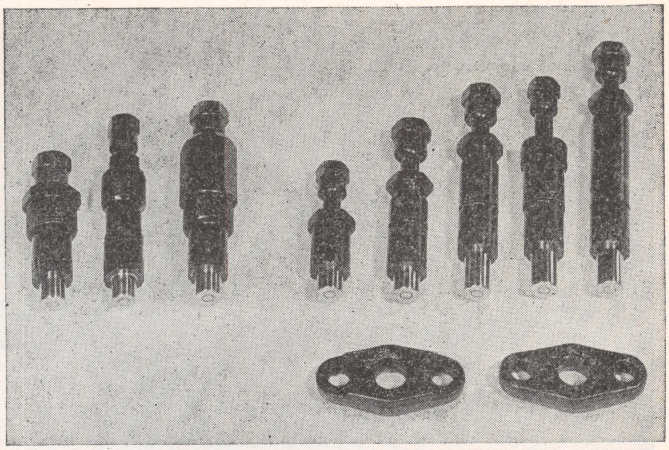


Fig. 15. Various straight nozzle assemblies. The three at the left are screw type while the others are clamp type nozzles.

shows normal pressure when the engine is in operation or when the manual transfer pump is operated, this may usually be taken as sufficient indication that the fuel transfer pump is not at fault. (See the instructions relative to testing the Fuel Transfer Pump). If the pressure as shown on the Fuel Transfer Pump Pressure Gauge drops quickly to zero upon stopping the engine or immediately after ceasing to operate the Fuel Transfer Pump, it may be suspected that the Hydraulic Unit Bleed Valve is leaking. Inspection of the parts of the valve will quickly show whether the valve, the seat and the spring are in proper relation. This unit has practically no wearing parts and if faulty it should be replaced in its entirety.

DRIVE UNIT

The drive unit is bolted directly to the engine by mounting flange, as shown by 17, (Fig. 2), and supports all of the attached units as an integral part of the pump equipment. The various parts in this unit are all simple, rugged, mechanical ones that normally would stand considerable service before any attention is required. Lubrication is supplied directly from the engine pressure system.

REPAIRS TO DRIVE UNIT

The parts of the Drive Unit (See Fig. 2) are extremely rugged and long lived. It is unlikely that parts replacement will be required between engine overhaul periods. There are no adjustments in the Drive, and as all parts likely to be worn or damaged are exposed to view upon removal of the replaceable unit assemblies, there is little excuse for its removal. The Drive Unit should not be disassembled or dismounted from the engine except by an experienced service representative of the engine builder. However, if such service is not available, any careful engine man should have no difficulty if the following instructions are observed:

TIMING MARKS

The timing marks of the pump manufacturer will be seen by removing the cover plate stamped "Timing Mark," which is on top of the pump and between the mounting flange and the control unit (See Fig. 10).

Pumps which rotate in right hand or clockwise direction when looking on the drive or gear end of the fuel pump drive shaft, will start injection from cylinder A (this is the topmost cylinder of the Hydraulic Unit) when the rotating reference mark "R" is in line with the stationary pointer.

Pumps which rotate in the left hand direction, will start injection from the same pump cylinder when the rotating reference mark "L" is in line with the stationary pointer.

Before removing the nuts from the studs passing through the slotted Drive Unit flange bolt holes, note any existing marks or make a punch or chisel mark on the Drive Unit Flange and registering with a similar mark on the engine or adapter flange (34—Fig. 9). The two marks may then be returned to exactly the same relation on remounting the pump.

Also, before the above nuts are removed, examine the edge of the drive gear teeth (36—Fig. 9) for marks showing where the driving gear should be meshed when the pump is replaced. If the driving gear is not marked, remove the cover stamped **"Timing Marks,"** roll the engine to the point where injection should start in the reference cylinder. (The engine cylinder connected to pump cylinder A, frequently No. 1.) Usually this can be determined by flywheel markings and valve position. When in the position where the timing marks coincide, the pump may be removed, and when replaced, should be set so that the timing marks again coincide as before. Unless you are sure you can return the engine to its original and proper setting before the pump was removed, it is best not to turn the engine until the pump has been replaced.

TIMING THE FUEL PUMP TO THE ENGINE

The Ex-Cell-O Injection Pump should **not** be timed by the **flow** method because the rotary valve (6) Fig. 9, which meters the fuel, allows too much leakage to apply this method satisfactorily. Therefore, the timing mark (See Fig. 10) provided on the fuel pump housing should be used in preference.

This timing mark position has been carefully scribed to indicate the start of injection at the Ex-Cell-O factory, by means of a Stroboscope.

To time the fuel pump to the engine, proceed in the following manner: Turn the engine over by hand until the pump timing position recommended by the engine builder appears directly in line with either a scribe line or pointer, usually located in the center of the timing hole in the bell housing. Be sure cylinder No. 1 is just completing the compression stroke and beginning the expansion. The flywheel of practically all engines are provided with some suitable marking to facilitate the proper position of piston No. 1 cylinder B. T. C. (Before top center). Usually the flywheel is marked off in degrees from ten (10) to forty (40) with numerals.

Then install the pump assembly to the engine so that the fuel pump timing mark is in alignment with the pointer at the same time the flywheel position is in the established position recommended by the engine builder.

If this position cannot be accomplished, it may be necessary to alter the chain or gear position. If a chain is employed, the backlash in the pump drive should be taken up by inserting the end of a drift into the pin hole in the swash plate and then pull the top of the drift in the direction of the pump rotation, to remove all of the backlash while timing the pump. If this backlash is too great, the timing chain adjustment should be adjusted in accordance with the engine builders recommendation.

After the pump is properly timed, all fuel lines may be installed and the engine started after air is removed from the injection system as already described.

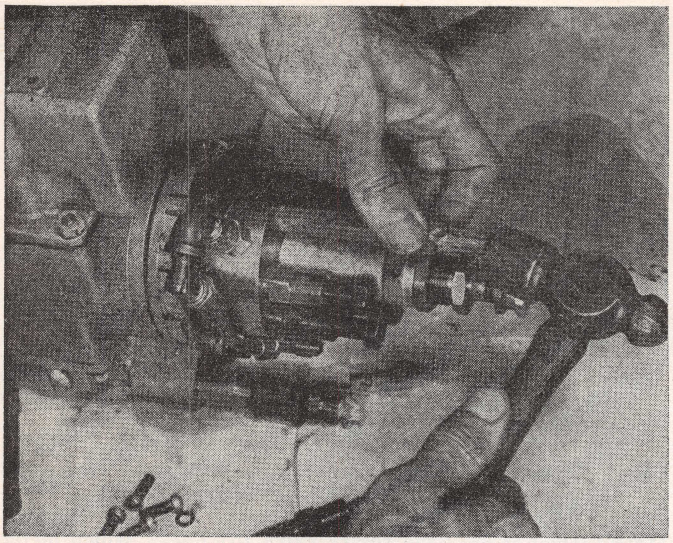


Fig. 16. Method of freeing a sticking plunger.

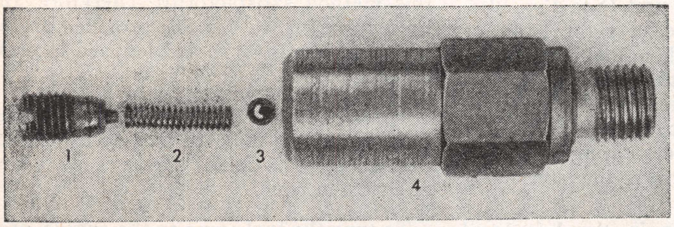


Fig. 17. RELIEF VALVE ASSEMBLY.
1—Spring retainer. 2—Spring. 3—Ball. 4—Valve body.

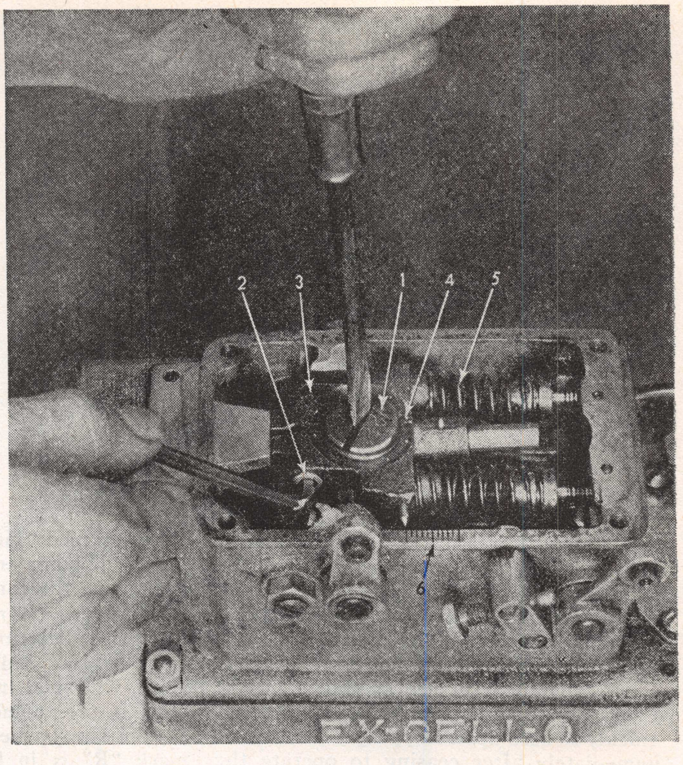


Fig. 18. MAXIMUM FUEL ADJUSTMENT.
1—Maximum fuel quantity limiting cam. 2—Clamp screw. 3—Cam holder. 4—Punch marks. 5—Timing control springs. 6—Adjustment marks on case.

CONTROL UNIT

The control unit is located on top of the fuel injection pump body (See Fig. 1) or drive unit housing. The control unit contains no rotating or power-driven reciprocating parts. None of the parts in this box are highly stressed or are likely to break or be affected by wear or change of any kind.

There is less likelihood of difficulty in the control unit than in any other part of the pump. Therefore, there is little occasion for its removal. The only adjustments contained in the control unit are set and sealed at the factory of the engine builder and should be changed only by a representative of the engine builder.

The control unit, however, can be removed and replaced without disturbing any of these adjustments in case removal should become desirable for the purpose of making more accessible some other parts of the pump drive unit.

If the control unit must be removed, it will be found fastened by four nuts, one at each corner. After removing these, the unit may be lifted directly upward.

MAXIMUM FUEL ADJUSTMENT

(See Figs. 9 & 18)

The control unit fuel adjustment is properly adjusted and sealed at the factory and the adjustment will not be changed by normal operation. In case some part or unit of the fuel pump assembly is replaced, the operating position of the Maximum Fuel Quantity Limiting Cam (1) Fig. 18 may be slightly changed causing slight loss of power or black exhaust smoke at full throttle. In that event, the seal and cover can be removed from the control unit, and the Maximum Fuel Quantity Limiting Cam (1) Fig. 18, may be reset as follows:

After loosening the clamp screw (2) Fig. 18 in the cam holder (3) turn the cam (1) in a counter-clockwise direction to increase fuel delivery and correct loss of power. Turn the cam (1) in a clockwise direction to decrease fuel delivery and eliminate smoke. Usually one tenth of a turn (as indicated by punch marks (4) on the cam holder (3) (Fig. 18), from the original setting, will be sufficient to correct either loss of power or smoky exhaust. No attempt should be made to re-adjust the timing control springs (5) Fig. 18 under any condition, unless full knowledge of its advance characteristics are known.

REPLACING THE CONTROL UNIT

Before attempting to replace the control unit, the races of the ball thrust bearing (30—Fig. 9) which are contacted by the fingers of the timing control arm (27—Fig. 9) should be moved toward the mounting flange as far as possible. It will be found that these races will stay in the forward position if the pump is turned so that the pins (35—Fig. 9) supporting the timing weights are in the vertical position. As you will not be able to see these pins if the pump is mounted on the engine, it is best to simply turn the engine by hand until a point is found where the ball thrust bearing races will remain in the forward position toward the mounting flange when once moved into that position by hand pressure.

Also the rotor driving member (42—Fig. 9) should be pushed toward the Accelerator Unit as far as possible. By thus placing the two ball thrust bearings, there will be room between the bearings for both of the pairs of fingers which extend from the under side of the Control Unit Box.

When replacing the Control Unit Box, the cover should be off the box and the two springs (28—Fig. 9) which move the timing control lever arm (27) should be compressed into their forward position.

This will be found to move the timing control fingers toward the center portion of the box. While holding the timing control springs in this position, there will be room for the two pairs of fingers to enter between the bearings previously mentioned, and the Control Unit Box may then be slipped into place. It is important to make sure that both of the pairs of fingers projecting from the control unit are located between the inner face of the rotor drive member bearing (next to the Hydraulic Unit end of the pump) and the in-

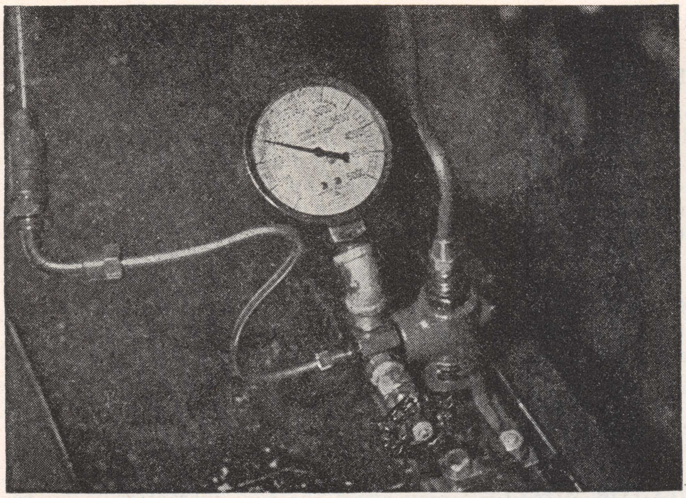


Fig. 19. Showing spray pattern when nozzle is in good condition.

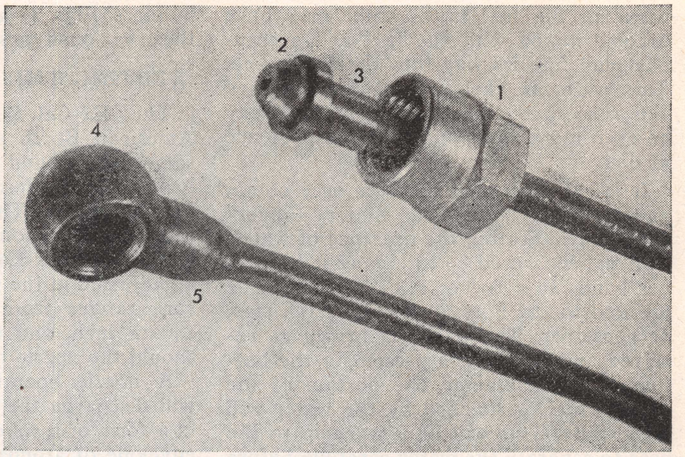


Fig. 20. FUEL LINE CONNECTION.

ner face of the ball thrust bearing, which is next to the flange end of the pump. The purpose of the fingers projecting from the lower side of the Control Unit Box is to bear against the sides of these bearings which face the center of the pump. (See Cross Section, Figure 9.)

IF THE ENGINE STOPS OR FAILS TO START

First make sure that the "STOP" control has been moved to the position for running. The most common cause for failure of the fuel injection system to inject fuel is an "air bound" system. The most common cause for air binding is allowing the pump to run out of fuel from one of the following causes:

(a) Fuel tank allowed to become empty.

(b) Attempting to operate the engine with the tank shut-off valve closed.

(c) Clogged fuel strainer or filter (evidence of clogging will first appear when the engine is operating at top speed full load). Usually sufficient fuel will flow through a filter even when it is very dirty, to operate the engine at slow speed idling or at light load. If the fuel pressure gauge shows less than 20 lbs./sq. in., clean strainer and filter at once.

(d) Air leak in the suction line between the tank and the fuel transfer pump (assuming that the supply is lower than the Fuel Transfer Pump). Operators must realize that merely refilling of the fuel supply tank or re-establishing the fuel supply after stoppage because of lack of fuel, will not remove the air which has filled the system. To do this, follow these instructions:

TO REMOVE AIR FROM INJECTION SYSTEM

Installed instructions for this pump show that a pressure gauge which will indicate the fuel pressure supplied to the injection pump, should be installed in the line between the filter and the hydraulic unit of the fuel injection pump (see Fig. 7). This gauge will indicate the pressure built up by the Fuel Transfer Pump, minus the loss of pressure caused by passage of fuel through the Filter.

The occurrence of any of the conditions just described, will immediately be shown by loss of pressure on the fuel pressure gauge and until the cause of this loss of pressure has been determined and remedied, it is useless to make any changes to the fuel injection pump, as damage is likely to be the result. Therefore, first make sure that there is fuel in the tank, that all necessary valves are open, that the filter is clean and there are no air leaks in the suction line.

On the top cylindrical surface of the Hydraulic Unit will be found a small spring loaded pressure relief valve which serves several purposes (16, Fig. 3 and Fig. 17):

1. This valve maintains a back pressure of approximately 30 to 35 pounds per square inch on the fuel delivered by the Fuel Transfer Pump.
2. This valve automatically permits the escape of air or gases which may become mixed with the fuel.
3. This valve permits the passage of a certain amount of fuel back to the fuel tank, which circulation prevents overheating of the Hydraulic Unit when little or no fuel is being used, such as when a truck is coasting downhill using the engine as a brake.

The operation of clearing the system of air should be performed in the following order:

1. Operation of the hand priming pump (18—Fig. 9), should cause circulation of fuel through this pressure relief valve and this circulation will carry out any air which may be contained in the system. Usually the pulling of the Manual Priming Handle of the Transfer Pump will indicate when the air has been cleared.
2. If you wish to be sure that all the air is out of the system, disconnect the tube through which fuel is returned from the top of the pressure relief valve to the fuel tank.

When solid fuel (free of bubbles or foam) is discharged from the top of the pressure relief valve upon operation of the Manual Priming Pump, and fuel pressure shows on the Transfer Pump Gauge, the pump is then clear of air and the engine may be started in the usual way.

Operation of the hand priming pump should cause fuel pressure to show on the gauge, and cranking the engine with the starter should cause an increase in pressure to 20 or 25 pounds. The pressure shown on the fuel pressure gauge should not drop any great amount between cranking periods. If this pressure does not appear on the fuel pressure gauge, it indicates that fuel is not reaching the Fuel Transfer Pump or that the cause of the difficulty is in the Transfer Pump and not in the injection pump. If the Fuel Transfer Pump is suspected to be at fault, study the instructions already described and remedy the cause of the trouble before changing other parts of the injection system.

If the engine does not start with fair promptness, do not waste the battery charge but proceed to determine the cause.

NOTE—A Diesel Engine which is getting fuel and yet fails to start, usually indicates this fact by the appearance of a bluish white vapor resembling smoke from the exhaust pipe when the engine is being cranked. This vapor is unburned fuel and usually indicates that the temperature of the combustion chamber has not reached a point sufficiently high to ignite the fuel. Presence of such vapor is almost a sure indication that there is no difficulty in the pump or injection system. (Unless the pump has been removed and has been replaced "out of time." If it is known that the pump is not "out of time," the operator should see the engine builder's instructions for aiding the starting of a cold engine.)

TEST FOR PRESENCE OF WATER IN FUEL CONTAINERS

In the handling of fuel oil while in transit or due to condensation which may occur in the fuel tank, water may have become mixed with the fuel and eventually may find its way into the fuel pump. This water is likely to set up corrosive action so that the presence of water may be even more damaging than the presence of dirt.

It is recommended that the user obtain a supply of "Gasoline Water Finder" paper for indicating the presence of water. This paper is used by attaching it by rubber bands to a rod or stick which can be lowered to the bottom of the barrel, tank or container. The paper is brown as received and if water is present in the bottom of the container, the portion of the paper which is touched by the water will turn white. This will be a warning to the user to separate the water carefully before filling his fuel tank from the container in question.

This "Gasoline Water Finder" may be obtained from most wholesale drug houses.

FUEL INJECTOR NOZZLES AND HOLDER ASSEMBLY

The Ex-Cell-O Injection Nozzle (Fig. 13), is unique in its design and construction in that it is of the outwardly opening type (See Fig. 12) and because all the working parts of the nozzle are assembled as a sealed unit in the tip body (Fig. 11). Heretofore, most accepted injection nozzles were of the inwardly opening type of relatively heavy construction and necessitating long lapped fits with drainage lines to dispose of the fuel which leaked past these lapped fits. The Ex-Cell-O outwardly opening nozzle precludes the use of such drainage lines since the flow of fuel through the nozzle is in one direction only. This is an obvious advantage since it not only improves the appearance of the engine, but eliminates the dirty conditions which accompany an improper disposition of the nozzle leakage.

Essentially the Ex-Cell-O nozzle consists of seven parts (see Fig. 13): (1)—A sealed replaceable assembly containing all the moving parts in the nozzle (See Fig. 11). (2)—A nozzle holder body to which the tip assembly is attached and to which the injection line connects. (3)—A tip nut which holds the tip assembly in place on the holder body. (4)—A gasket for sealing the nozzle assembly against the engine. (5)—A clamp for holding the nozzle assembly in place in the engine. (6)—A tube nut for attaching the high pressure line to the holder body and, (7)—a tube nut sleeve which pilots the high pressure line in the tube nut and relieves the tube of high localized stress at the clamping point.

The nozzle holder contains no working parts and acts simply as a holder for the tip assembly (See Fig. 13). The tip nut (9) is designed for a ¾" standard 12 point box wrench when replacing the nozzle tip assembly. This part requires no field service.

Nozzle tip holders are made in screw type and clamp type design in various sizes to accommodate different engine builders. Figs. 14 and 15 illustrate some of these various types.

TESTING THE INJECTOR NOZZLE

The Ex-Cell-O Nozzle, like that of American Bosch should be tested in the same manner and with any of the various bench testers described in the American Bosch chapter. The only difference being that the injection discharge pressure is fixed at the Ex-Cell-O factory and cannot be adjusted in the field. Uusually this pressure ranges from 1400 to 2000 lbs. per square inch, and under no circumstances should the nozzle tip be disassembled.

A nozzle operating in good condition will discharge the fuel spray straight and in a form of a solid core surrounded by an envelope of atomized fuel.

CLEANING THE INJECTOR NOZZLE

If the spray pattern is distorted by carbon deposit collected around the nozzle tip, it should be cleaned by brushing it off with a brass wire brush. (Do not use a steel brush or sharp tool of any kind.)

If brushing alone does not correct the spray pattern, it should be cleaned by simply boiling the nozzle (1—Fig. 13) as a complete assembly, (or just the tip (8) assembly, as desired) in a solution of 3 ounces of Miccro Cleaning Compound and one-half gallon of water for 20 minutes. **To prepare this solution, add the 3 ounces of Miccro Cleaning Compound to one-half gallon of cold water (Important: Never add cleaning compound to hot water) always use a steel or heavy tin container, never aluminum.)** After the nozzles have been boiled, they should immediately be connected to the nozzle lines and the engine cranked to inject in the open air until all of the compound has been expelled. The nozzles should then be installed in the engine without delay and run for several minutes. If nozzle action and engine performance is not satisfactory after the carbon is removed, replace the nozzle tip assembly (6) only.

REASSEMBLY TO THE ENGINE

When replacing an injection nozzle assembly, clean away any carbon that may have accumulated on or around the gasket seat in the cylinder head, by blowing out the carbon deposit in the mounting hole, by turning the engine over with the starter, then wipe out any loose carbon with a soft wooden stick and lint free rag.

Then renew the nozzle gasket between the inner end of the nozzle tip and cylinder head each time the nozzle is removed; a gasket leak at this point will affect engine performance and often ruin the nozzle.

CAUTION—Always replace this gasket with the same type and material recommended by the engine builder so that the heat flow will remain the same around the nozzle tip.

HIGH PRESSURE FUEL INJECTOR LINES

The high pressure fuel injector lines which carry the fuel under high pressure, are made of high tensile steel. The nozzle end is usually furnished with an integrally-swaged connection (2) Fig. 20, and reinforced tube end (3). The pump end is fitted with an angle-type tube connection (4) Fig. 20, welded to the tube (5). All lines should be of equal length, the latter having been determined by the engine manufacturer, on the basis of extensive trials to be best suited to the injection characteristic required by the engine. It is therefore important that their length or inside diameter never be changed.

These lines should also be well supported at several points along their length, to prevent vibration which might lead to failure because of breakage.

Should failure occur, install a new line; never attempt to weld a failure, since this may affect the fuel characteristic by reducing the inside diameter of the tube.

PROTECT EQUIPMENT WHEN NOT IN USE

If the engine is not to be used for a period of 30 days or more, the injection equipment should be protected against corrosion, and more particularly against gumming, which is likely to occur if fuel oil is left in the system. This gumming causes parts to stick and may cause serious damage to the fuel transfer pump or to the hydraulic unit.

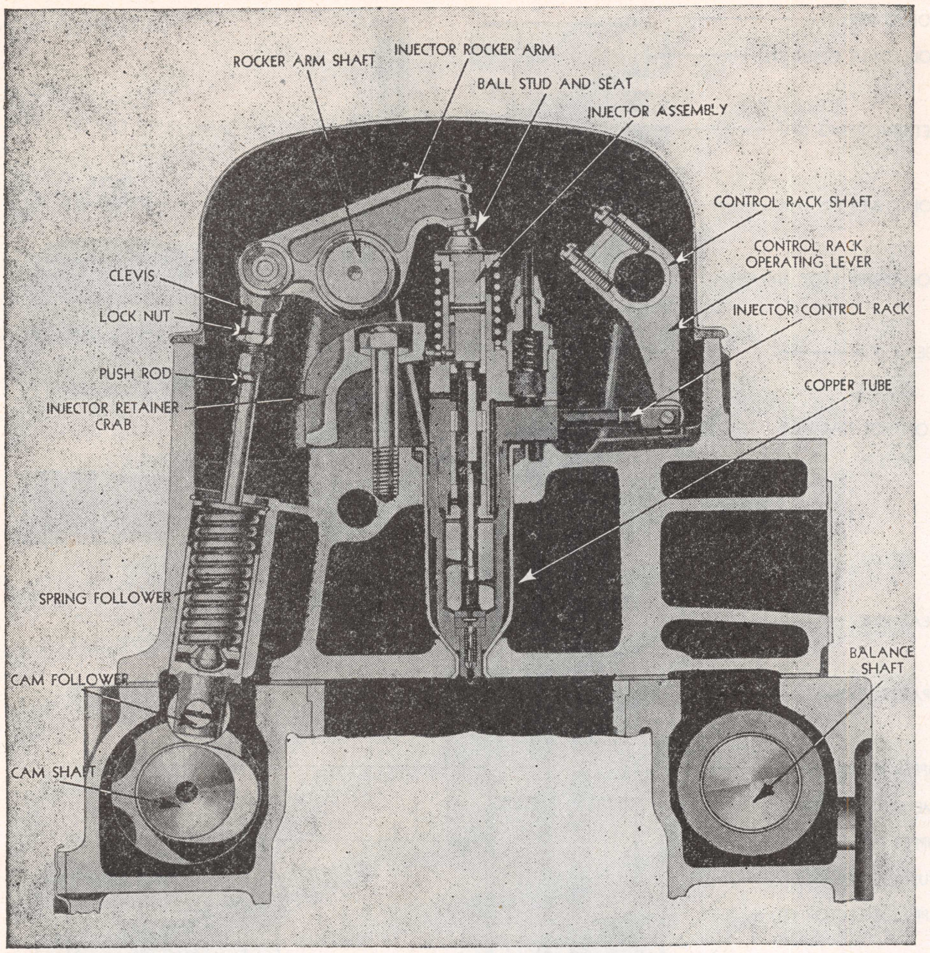
To protect both fuel pump and nozzles:

1. Remove the containers for the filter elements, clean the fuel filters in the usual way and fill the containers with rust preventative oil. Special oils are available for this purpose, but if not readily obtainable, use any high grade motor oil not heavier than SAE 10 W.
2. Disconnect the fuel supply line to the Transfer Pump, connect a short piece of copper tubing to the suction of the Fuel Transfer Pump and allow the Transfer Pump to take the rust preventative oil instead of the fuel. Allow the engine to run on this oil until all fuel is out of the system and is replaced by the preventative. On restarting at the end of the idle period, the preventative need not be removed, as it will be found to run the engine satisfactorily if fuel from the tank has been supplied as usual.

COLD WEATHER OPERATING INSTRUCTIONS

Use fuel of light grade which does not become thick or cloudy at temperatures well below those at which operation is anticipated. For extreme cold, the fuel may need to be almost as light as kerosene. It must contain no wax or other constituents which solidify or become viscous at the low temperatures encountered.

If the engine has been standing outside in temperatures lower than 20° F. above zero, the fuel pump should be warmed by pouring a half gallon of hot water slowly over the Hydraulic Unit of the fuel pump and a similar quantity over the filters before attempting to start the engine. The purpose of this is to insure fuel fluidity.



Fuel injector mounting.

GMC

The GMC Diesel fuel system comprises the fuel injector, fuel oil pump, fuel oil filters and fuel oil manifolds.

FUEL INJECTOR

To secure combustion, a small quantity of accurately metered, finely atomized fuel must be mixed, at the end of the compression stroke, with the charge of air which has been forced into the cylinder by the blower. This is accomplished by a high-pressure fuel injection device.

Before injection can be effected, the fuel pressure must be higher than that of the air charge in the combustion chamber. Consequently, the fuel injector performs a triple duty: 1st, metering and injecting fuel; 2nd, creating high fuel pressure; 3rd, atomization. The unit fuel injector used in these engines combines in a single unit all of the parts necessary to perform the above functions, thus providing a complete and independent injection system for each engine cylinder.

The injectors are mounted in the cylinder head, with their spray tips projecting slightly below the top of the inside surface of the combustion chambers. A crab, bolted to the cylinder head and fitting into a machined recess in each side of the injector body, holds the injector in place in a water-cooled copper tube which passes through the cylinder head. A dowel pin in the injector body registers with a hole in the cylinder head for accurately locating the injector assembly.

A taper seat on the lower end of the injector when seated in the copper tube, which is assembled in the cylinder head for holding the injector, forms a tight seal between the two parts to withstand the high compression pressures inside the combustion chamber.

The cross section of the Model 71 injector shows the various fuel injector parts. Fuel oil is supplied to the injector at a pressure of about twenty pounds per square inch and enters the drop-forged steel body at the top through the filter cap. After passing through the fine filter element in the inlet passage, the fuel oil fills the annular supply chamber between the bushing and the spill deflector. The plunger operates up and down in this bushing, the bore of which is connected to the fuel supply in the annular chamber by two funnel-shaped ports.

The motion of the injector rocker arm is transmitted to the plunger by the follower which bears against the return spring. In addition to this reciprocating motion, the plunger can be rotated, in operation, around its axis by the gear which is in mesh with the control rack.

INJECTOR OPERATION

Two helices are machined into the lower end of the reciprocating fuel plunger for metering purposes. The relation of these two helices to the two ports changes with the rotation of the plunger. As the plunger moves downward, the fuel oil in the high-pressure cylinder is first displaced through the ports back into the supply chamber until the lower edge of the plunger closes the lower port. The remaining oil is now forced upward through the center passage in the plunger into the recess between the two helices from which it can still flow back into the supply chamber until the upper helix closes the upper port. The rotation of the plunger, by changing the position of the two helices, retards or advances the closing of the ports and the beginning and ending of the injection period. At the same time it increases or decreases the desired amount of fuel which remains under the plunger for injection into the cylinder.

The accompanying illustration shows the various plunger positions due to rotation from "full load" to "no load." With the control rack pushed in completely (full load), the upper and lower ports close almost simultaneously, thus producing a full effective stroke and maximum injection. With the control rack pulled out completely (no injection), the upper port is not closed by the upper helix until after the lower helix has uncovered the lower port. Consequently, with the control rack in this position, all of the fuel charge is forced back into the supply chamber and no injection of fuel takes place. From this "no injection" position to "full load" position (full rack movement) the contour of the two helices retards or advances the closing of the ports as required for the load demand on the engine.

The illustrations show four positions for the downward travel of the plunger. On the downward travel of the plunger, the metered amount of fuel is forced through the center passage of the valve assembly, around the flat check valve and against the spherical check valve. When sufficient fuel pressure is built up, the spherical check valve is lifted off its seat and the fuel is forced through six minute orifices in the spray tip and atomized in the combustion chamber.

On the return upward movement of the plunger, the high-pressure cylinder is again filled with fuel oil through the lower port. The check valve prevents air leakage from the combustion chamber into the fuel system in case the spherical valve is accidentally held open by a small particle of dirt. This safety device allows the injector to continue to operate until the dirt works out of the valve.

The constant circulation of fresh, cool fuel through the injectors, helps to maintain even operating temperatures of the injectors and also effectively removes all traces of air which might otherwise accumulate in the system and interfere with the metering of the fuel. No venting of the fuel lines or injectors is required at any time, even when starting from "empty."

The fuel injector outlet opening, which returns the excess fuel oil supplied by the fuel pump, is directly adjacent to the inlet opening and is protected against dirt or other foreign matter by a fine filter element, exactly like the one on the inlet side.

INJECTOR CONTROL

Each injector control rack is connected by an easily detachable joint to a lever on a common control shaft, which, in turn, is linked to the governor and throttle. These levers can be rotated on the control shaft by the adjustment of two screws, which permit a uniform setting of all injector racks for governor to injector linkage.

SERVICING PRECAUTIONS

The injector is one of the most important and carefully constructed parts of the engine. On this unit depends the injection of the correct amount of fuel at exactly the right time into the combustion chamber.

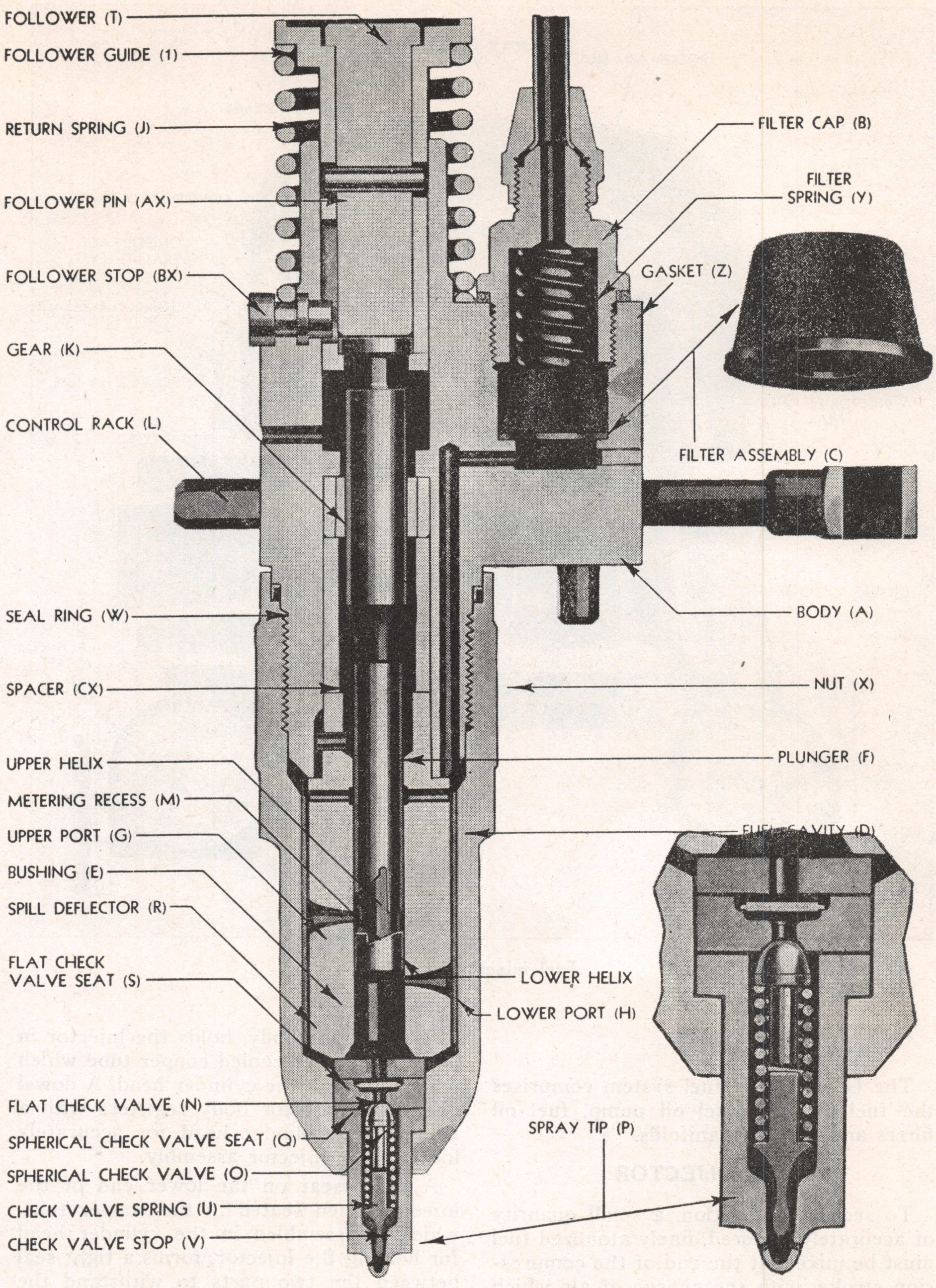
NOTE—No mechanic should attempt any service operations on the injector without first acquiring a complete understanding of its construction and operation. Before starting to dismantle an injector, it is necessary to have an extremely clean work bench on which to work and to store the parts.

When preparing to assemble an injector, it is absolutely essential to wash the hands thoroughly and to clean all the injector parts in either clean naphtha or carbon-tetrachloride. Parts should then be blown dry by high-pressure air, filtered of course preferred, making sure to blow through all the passages in the injector body and all the drilled holes, slots, etc., in the injector parts.

NOTE—Waste or rags should never be used for cleaning the injector parts, since this would leave lint and other particles which could collect and clog parts of the injector when assembled. Toilet tissue is a good and cheap material for cleaning any injector part or on which to place injector parts after the cleaning with liquid and the blowing dry with air. Clean, light oil should be used liberally on injector parts during assembly to protect them from rust in case the injector is not used immediately.

Whenever the fuel lines are removed from an injector which is installed in the engine, protect the two fuel fittings with the shipping cap to exclude dirt from the injector.

Clean injectors one at a time. Never mix the parts of injectors. Each plunger must always be fitted with its bushing. The spherical check valve and spherical check valve seat must also be kept as a unit since these two parts are matched together for the seat seal. Keep the parts of the tip assembly—the spring, stop, spherical check valve and seat, as a unit. It is impossible to clean injector filters with the injectors in the engine.


FOLLOWER (T)
FOLLOWER GUIDE (1)
RETURN SPRING (J)
FOLLOWER PIN (AX)
FOLLOWER STOP (BX)
GEAR (K)
CONTROL RACK (L)
SEAL RING (W)
SPACER (CX)
UPPER HELIX
METERING RECESS (M)
UPPER PORT (G)
BUSHING (E)
SPILL DEFLECTOR (R)
FLAT CHECK VALVE SEAT (S)
FLAT CHECK VALVE (N)
SPHERICAL CHECK VALVE SEAT (Q)
SPHERICAL CHECK VALVE (O)
CHECK VALVE SPRING (U)
CHECK VALVE STOP (V)
FILTER CAP (B)
FILTER SPRING (Y)
GASKET (Z)
FILTER ASSEMBLY (C)
BODY (A)
NUT (X)
PLUNGER (F)
FUEL CAVITY (D)
LOWER HELIX
LOWER PORT (H)
SPRAY TIP (P)

Fuel injector assembly.

Whenever an injector has been removed and reinstalled, or a new one installed, it must be: first "timed" and then "equalized" after the engine is started.

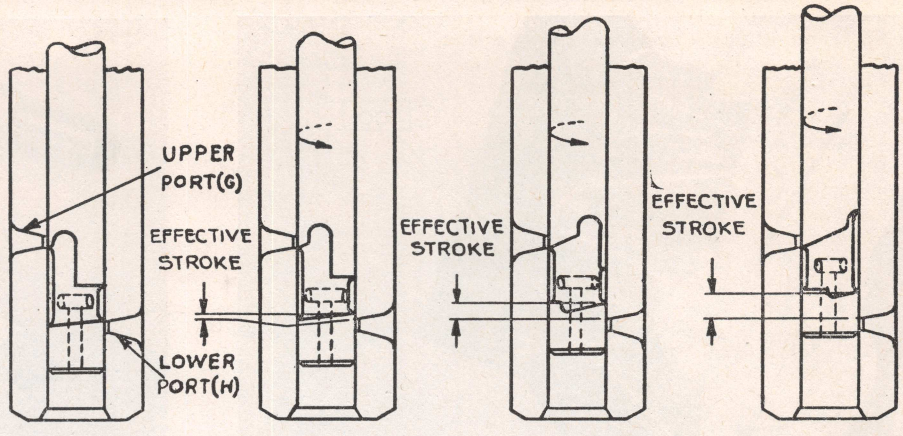
INJECTOR, REMOVE

The following procedure should be observed in removing an injector: Remove valve cover. Remove fuel lines from both the injector and fuel connectors. Remove the two cap screws holding the rocker arm shaft brackets to cylinder head and remove rocker arm shaft. Remove injector hold-down stud, nut, special washer and crab. Pry injector from its seat by means of the special injector puller. Lift injector from seat and, at the same time, disengage the control rack linkage.

SPRAY TIP, INSPECT AND CLEAN

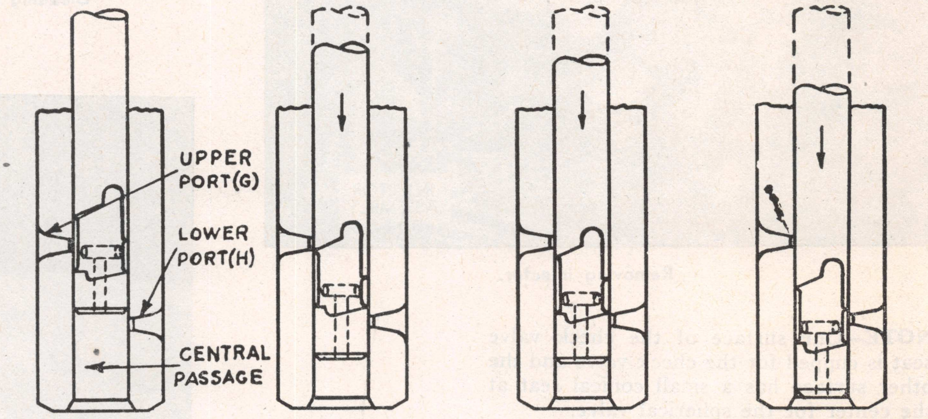
NOTE—Fuel injectors are precision parts on which no service work should be attempted except by competent mechanics and in absolutely clean surroundings.

After removal of an injector from the engine, the plunger follower should be depressed with the thumbs and forefingers and the control rack moved back and forth to see if these parts operate freely. When these parts stick or bind in operation, the injector should be completely overhauled and cleaned or exchanged for a factory built unit.



NO INJECTION IDLING LOAD HALF LOAD FULL LOAD

Load control from "Full Load" to "No Load" produced by rotating plunger with control rack.



TOP OF STROKE START OF INJECTION STROKE END OF INJECTION STROKE BOTTOM OF STROKE

Phases of injector operation by vertical travel of plunger.

Possible causes of injector failure: Plugged fuel passages in spray tip. Inoperative spherical valve.

These parts may be inspected and cleaned as follows after the injector has been removed from the cylinder head: Clamp the injector in an injector vise, spray tip up, and loosen nut from injector body with special wrench provided. Finish removing the nut by hand. When nut is removed, the spray tip, valves, valve seats and spring will be released. Retain these parts in a clean receptacle until ready for use. Thoroughly wash and inspect the small flat check valve for flat smooth surfaces, the valve seats for smoothness and chips, the spherical valve seat (conical surface on lower side of the thick disc) for smoothness and chips and the spherical valve and check valve stop for smoothness.

CAUTION—Do not attempt to regrind either the flat check valve or seats or the spherical valve. If any of these parts show signs of damage, replace the valve assembly, which includes check valve and check valve seat, spherical valve and spherical valve seat. Check valve stop and check valve spring are sold separately.

To recondition the spray tip, ream it out with the special reamer that is available. While reaming, hold spray tip in fingers, insert reamer down into tip, press lightly and turn with fingers to remove any carbon or foreign matter. After thoroughly reaming, blow tip out with compressed air to remove any loose particles.

Clean the six spray tip orifices with another special tool. This tool consists of a small hand vise holding a piece of .006" music wire. Before using the tool, the sharp burrs should be removed from the wire on a honing stone.

After reaming, clean the holes with the .006" wire and blow out with compressed air, re-ream the tip, again clean the holes, then wash with gasoline or naphtha and again blow out with compressed air.

INJECTOR, DISASSEMBLE

Support the injector in an inverted position in the special holding fixture, clamp in vise and loosen (don't remove) the injector nut with special wrench. Reverse the injector to right side up position in the holding fixture and loosen (don't remove) the two fuel oil connections with a 9/16" socket wrench. Insert a special tool beneath the injector spring. Raise spring away from stop pin, then withdraw the pin. Remove the plunger, follower guide, and follower pin. Remove the follower pin from the follower guide to separate the parts. Holding the injector in an inverted position, unscrew injector nut and lift away from the injector body, being careful not to dislodge the spray tip and the other small parts resting on the end of the plunger bushing. Carefully lift the spray tip, spherical check valve, spherical valve spring, spring stop, flat check valve, check valve seat, and spherical valve seat, away from the plunger bushing. Jar the spill deflector from the nut. Jar the spacer and gear from the injector body. Pull the rack from the injector body. Remove the two fuel connections, two filters, and the two springs, from the injector body.

Examine the parts and if any of them have become scored, they are unfit for further use and should be replaced. Examine all mating parts for free movement, then clean the injector tips. All parts must be carefully protected from dirt and stored so the parts will not be misplaced until used.

INJECTOR, ASSEMBLE

Holding the injector body right side up, place one of the filters in each of the fuel cavities in the top of the injector body.

NOTE—The fuel filters are made of sintered bronze with a copper washer on the largest end. When assembling the filters, always have the washer at the bottom.

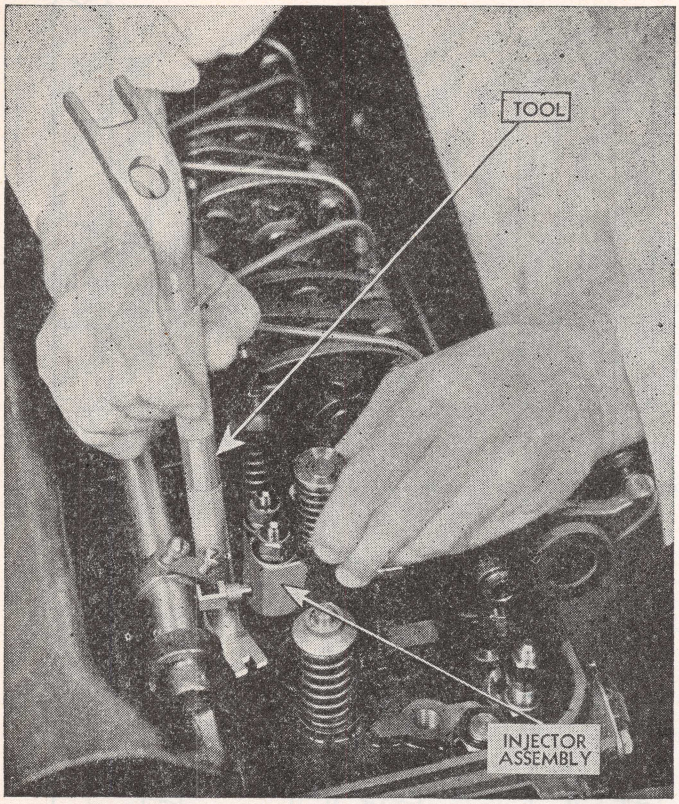
Place a spring above each filter, a copper gasket up against the shoulder of each filter cap, lubricate the threads and tighten the filter caps in place in the injector body.

NOTE—Whenever a filter cap is removed from the injector body, use a new copper gasket under each cap.

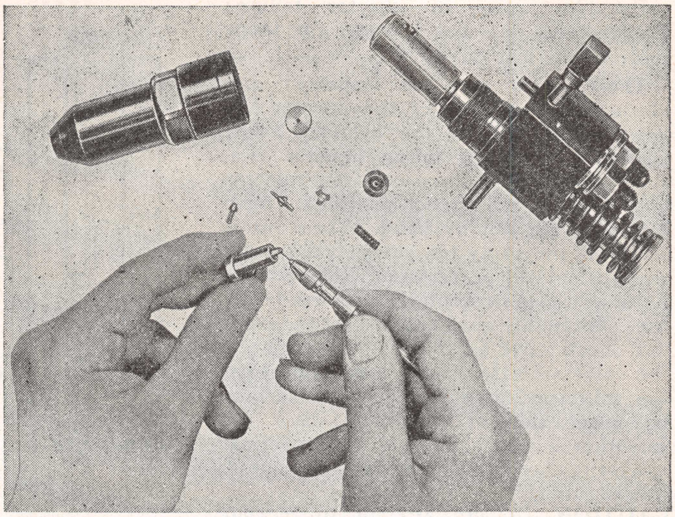
Next assemble rack and gear. Two of the teeth of the injector rack have a drill spot mark on one end; also one tooth of the mating gear is similarly marked. When the rack and gear are assembled, the marked tooth of the gear engages between the two marked teeth on the rack. This relation of rack and gear must be maintained for proper timing of the injectors.

Hold the injector body bottom end up and slide the rack through the ¼ inch (approximately) hole in the body so the two marked teeth can be observed when looking from the bottom into the bore for the gear. Holding the rack in position so the teeth marks show, slide the gear into proper engagement with the rack. Slide spacer down on top of gear and plunger bushing down onto spacer with locating pin in bushing guided into slot of injector body. Slide the spill deflector down into injector seal nut and the rubber seal ring down into counter bore, against shoulder on upper end of the nut.

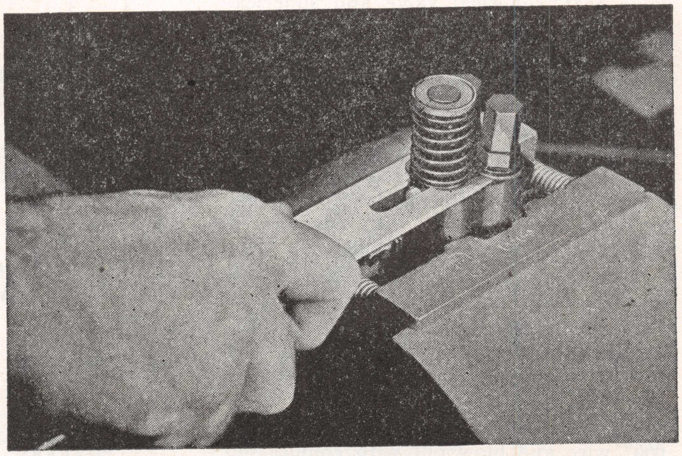
Assembling spray tip, place flat check valve seat flat down on clean piece of paper, place flat check valve on seat and spherical check valve seat (cupped side down) over check valve.



Removing injector.



Cleaning the 6 spray tip orifices with .006" wire.



Removal of stop pin from injector follower.

NOTE—One surface of the check valve seat is cupped for the check valve and the other surface has a small conical seat at the center for the spherical valve.

Holding the spray tip point down, assemble the check valve stop (tapered end down) with spring over end of stop and spherical check valve into spring into spray tip. Hold injector body in a vise, bottom end up, then centrally place the check valve assembly parts; flat check valve seat, valve, and spherical check valve seat, on the end of the plunger bushing and the tip assembly, spherical seat down, on the top of the check valve assembly. Lubricate threads and carefully place the injector seal nut down over the top of the tip and check valve assemblies so the tip will slide through the small hole in small end of the nut. Screw the nut in place by hand (don't use wrench), making sure that the check valve assembly has not shifted so the nut cannot be freely screwed in place by hand.

Install plunger and follower. Slide the plunger (large end up) down into the follower guide; follower (large end up) down on plunger; slide lock pin through hole in follower guide and follower. Drop this assembly through follower spring so end of spring seats against shoulder of follower guide. Invert the position of the injector in the vise (right side up), push the control rack way in—to hold in fixed position—then slide the plunger assembly parts in top of injector body, so the flat side of the plunger will engage the flattened side of gear. Align holes in the follower guide and injector body for the stop pin beneath the return spring, then insert slotted, wedged end of injector spring lifter tool beneath the spring end, press down on top of the follower, and insert the stop pin. When the injector spring lifter tool is removed, the spring will hold the stop pin in place. Invert the injector assembly in the vise, and by means of the special wrench, screw injector seal nut tight.

INJECTOR TEST

After an injector has been rebuilt, it should be tested before it is installed in the engine. This test is known as "Popping the Injector" and is accomplished with a special tool attached to the injector clamping tool.

Place injector in test fixture and, by means of an oil can, introduce fuel into one of the injector openings until fuel flows from the other opening. Set a beaker under and surrounding injector spray tip so fuel injected from tip hits inside of beaker.

CAUTION—Always use beaker and keep hands away from spray tip when "popping" injector; otherwise, the fuel from spray tip will penetrate the skin and may cause blood poisoning.

To determine if all six holes in spray tip are open, push injector rack in to "full" fuel position and press test handle down on plunger follower with a quick motion—fuel should be discharged from all six holes in spray tip.

If the check valve opening pressure is satisfactory, considerable downward pressure will be required on the fixture handle to open the check valve and discharge the fuel through the six holes. If considerable pressure is not required on the fixture handle to open the check valve so the fuel is discharged in a "fog" from the spray tip, the valve opening pressure is too low.

To test for a check valve leak, wipe or blow all fuel from spray tip and press down firmly on fixture handle to the point where check valve is about to open. (Do not force check valve open.) Continue to hold handle down against check valve pressure and no "dribble" should take place at spray tip. If "dribble" occurs, check valve is not seating properly. If the injector does not pass the above three tests satisfactorily, it should be disassembled, carefully and thoroughly cleaned and any worn or corroded parts replaced.

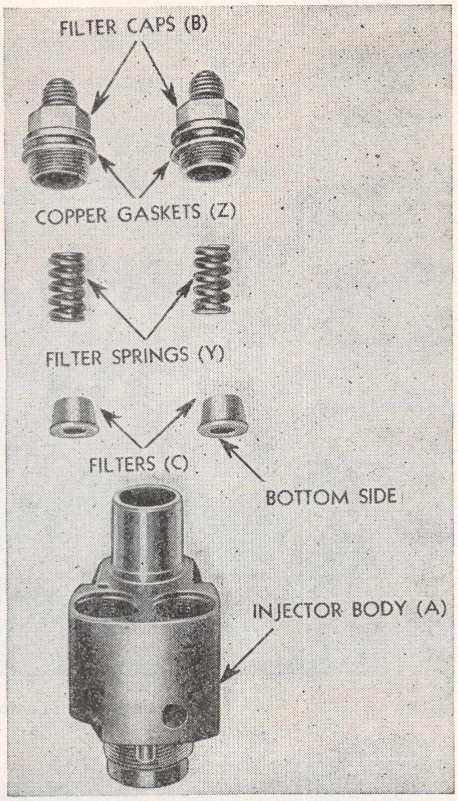
NOTE—Never remove filters from injector unless unit is entirely disassembled because there is a possibility of dirt entering injector when filters are removed.

TIMING FUEL INJECTORS

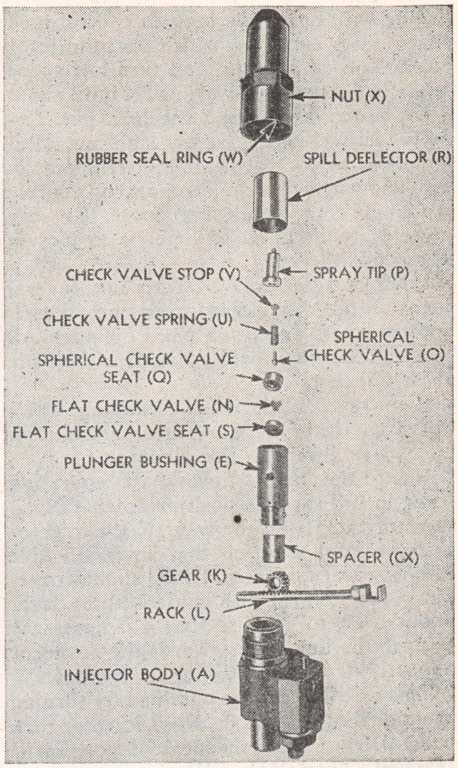
After installation, injectors must always be checked and readjusted before the engine is run.

NOTE—To insure the proper timing of the injection, the plunger follower of each injector has to be adjusted to a certain position in relation to the injector body. If the injectors are not properly timed, the engine operation will be "ragged."

The injectors should be timed as follows: Remove valve cover. Turn governor control hand knob to "off" position. Crank engine by hand or by means of the starting motor, until the exhaust valves of the cylinder to be timed are fully open. Place injector timing gauge in timing gauge hole on the top face of the injector body. Rotate timing gauge until the lower edge of one of the two flats on the knurled handle is right at the edge of the plunger follower guide. Adjust the injector rocker arm by means of the screw adjustment on the upper end of the push rod, until the lower edge of the timing gauge is just passing over the top face of the plunger follower guide. Tighten lock nut on push rod. If the above timing operation was carried out on an injector just installed in the engine, do not run the engine until after the injectors have been equalized as outlined below.


FILTER CAPS (B)
COPPER GASKETS (Z)
FILTER SPRINGS (Y)
FILTERS (C)
BOTTOM SIDE
INJECTOR BODY (A)

Injector filters, springs and filter caps.


NUT (X)
RUBBER SEAL RING (W)
SPILL DEFLECTOR (R)
CHECK VALVE STOP (V)
SPRAY TIP (P)
CHECK VALVE SPRING (U)
SPHERICAL CHECK VALVE (O)
SPHERICAL CHECK VALVE SEAT (Q)
FLAT CHECK VALVE (N)
FLAT CHECK VALVE SEAT (S)
PLUNGER BUSHING (E)
SPACER (CX)
GEAR (K)
RACK (L)
INJECTOR BODY (A)

Injector rack, gear and spray tip details.

NOTE—Two types of timing gauges are in use. One with a round knurled head having a height of 1.484" is used for setting the injectors of standard industrial, truck, coach and tractor engines and in the standard model of marine engines. The other, with a hexagonal head (or knurled head with reduced diameter), having a height of 1.460" is used for setting the injectors in the medium output and high output engines as found principally in special applications. It is important that the proper gauge be used for the engine that is being serviced. Otherwise, damage to parts is possible.

EQUALIZING FUEL INJECTORS

After the installation of a new injector, its control rack position must be adjusted to correspond with that of the other injectors.

The amount of fuel injected into each combustion chamber is governed by the control rack position of the fuel injector.

The maximum amount of fuel is injected when the rack is way IN. No fuel is injected when the rack is way OUT.

Two steps are necessary for a complete equalizing of injectors:

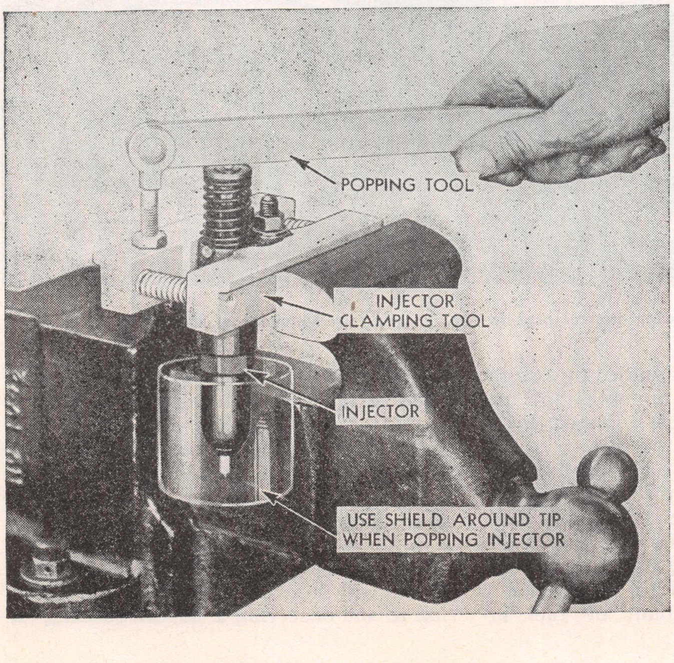
1. An approximate positioning of each control rack when the injectors are installed and before the engine is started.
2. An accurate positioning of the several racks for the best possible engine operation with engine hot and running.

NOTE—The injector racks must be way IN for maximum fuel injection; obviously each rack should be initially adjusted as near as practical to this position. Each individual rack may be adjusted IN or OUT relative to the other racks by the two adjusting screws on the rack operating levers. The limiting position of each rack either IN or OUT is the contact of one gear tooth with the end tooth on the rack. To avoid damage to the gear teeth, the teeth should not bump the rack at either end of rack travel, but approach this position as near as possible.

POSITIONING CONTROL RACKS (Cold)

The initial setting (engine cold) of the injector racks is made as follows:

See that all injectors are installed in the


POPPING TOOL
INJECTOR CLAMPING TOOL
INJECTOR
USE SHIELD AROUND TIP WHEN POPPING INJECTOR

Checking orifices in spray tip — "Popping" the injector.

engine with operating lugs on control rack shaft levers engaging with slots in injector racks. Loosen lock nut and turn low-speed adjusting screw on governor IN until about 1/16" protrudes beyond the lock nut. Remove buffer spring screw and nut. Put governor to control shaft link temporarily in place without lock. Temporarily replace governor control housing cover. Be sure dowels are in holes and pin is in slot in differential lever.

Using a screw driver, turn out several turns on both adjusting screws on all rack control levers except on No. 1 cylinder. All loosened levers should swing freely on the shaft about ¼".

Remove the clevis pin holding shaft operating lever to governor control link and place lever in IDLE notch.

Using the hand, hold shaft operating lever in full throttle position so that No. 1 injector rack is all the way IN the injector body. In this position the clevis pin hole in the governor control link should overhang the hole in the control shaft lever about 1/64" to 1/32" so that it is necessary to push the link back towards the governor about 1/64" to 1/32" to line up the holes.

This position can be obtained by turning the adjusting screws on No. 1 injector rack control lever until the desired position is reached. Then lock adjusting screws on No. 1 rack control lever.

While continuing to hold the rack control lever with the hand so that No. 1 injector rack is all the way IN, adjust each of the remaining rack control levers to the full IN position and lock the screws.

This must be carefully done by turning IN slowly on the inner of the two screws until the injector rack can just be felt striking "bottom" then locking the outer screw.

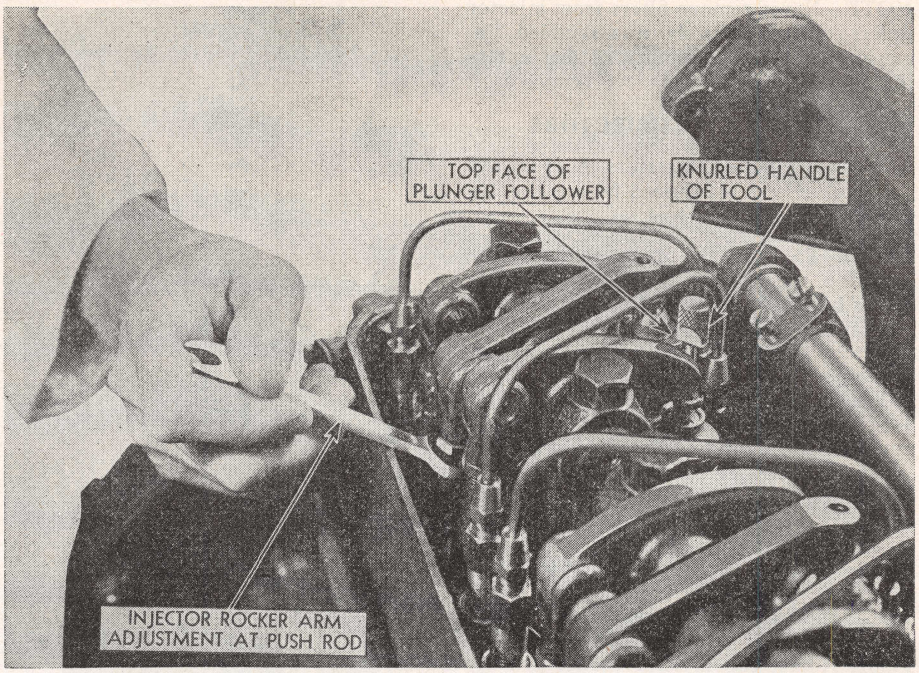
When correctly adjusted, all racks will be in full fuel position, and the ends of the racks will be in line.

Attach link to shaft operating lever and install cotter pin. Place throttle control lever in the OFF position. Injector racks should then be in the NO FUEL setting. Check by measuring the distance from the injector body to the shoulder of the collar on the injector rack. This distance should be not less than 27/32". Be sure that the NO FUEL position can be reached, otherwise dangerous engine speeds may result. If the measurement is 27/32" or more, the engine may be started for adjustment of the idling speed, and final accurate positioning of injector racks, if not, recheck adjustments.

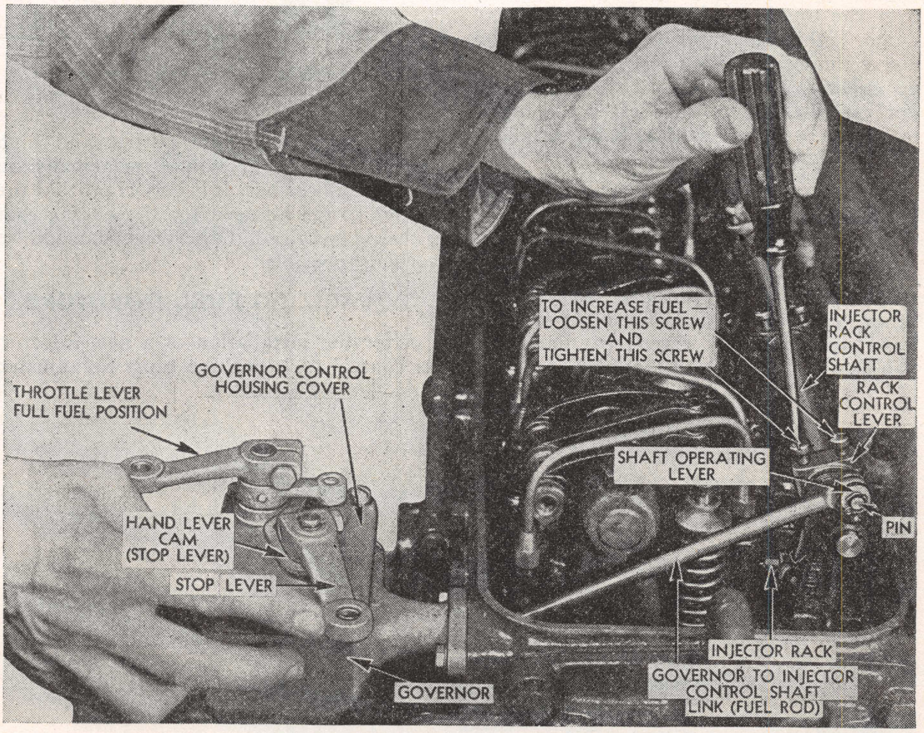
FINAL POSITIONING OF CONTROL RACKS

After equalizing the injectors as near as possible with the engine cold, the engine may be made to run somewhat smoother by further slight adjustments (equalizing) of the injector racks with the engine hot (approximately 160° F.) and running at about 1000 R.P.M.

NOTE—Do not attempt to carry out this equalizing unless the engine is hot and running.


TOP FACE OF PLUNGER FOLLOWER
KNURLED HANDLE OF TOOL
INJECTOR ROCKER ARM ADJUSTMENT AT PUSH ROD

Timing fuel injector with tool as shown.


TO INCREASE FUEL— LOOSEN THIS SCREW AND TIGHTEN THIS SCREW
INJECTOR RACK CONTROL SHAFT
RACK CONTROL LEVER
THROTTLE LEVER FULL FUEL POSITION
GOVERNOR CONTROL HOUSING COVER
SHAFT OPERATING LEVER
PIN
HAND LEVER CAM (STOP LEVER)
STOP LEVER
INJECTOR RACK
GOVERNOR TO INJECTOR CONTROL SHAFT LINK (FUEL ROD)
GOVERNOR

Setting injector control rack in No. 1 cylinder—Mechanical Governor.

A "heavy" injector is signified by a slight knocking noise due to an excess of fuel and should therefore be adjusted for a slightly smaller amount of fuel.

A good criterion of a well equalized engine is an even temperature of all exhaust manifold branches. If the manifold is cooler on one branch than on the others (by feel) this cylinder is not doing its share of work and should be adjusted for more fuel.

To increase the amount of fuel injected, loosen upper adjusting screw slightly and tighten lower adjusting screw—control rack must move inward. To decrease the amount of fuel injected, loosen lower adjusting screw slightly and tighten upper adjusting screw—control rack must move outward.

NOTE—An operator should become familiar with his Diesel engine. After listening to and observing a smooth running engine and noting the temperature of each exhaust manifold branch with properly equalized injectors, one can quickly detect an engine badly equalized by the "rough" running and the temperature of the various exhaust manifold branches.

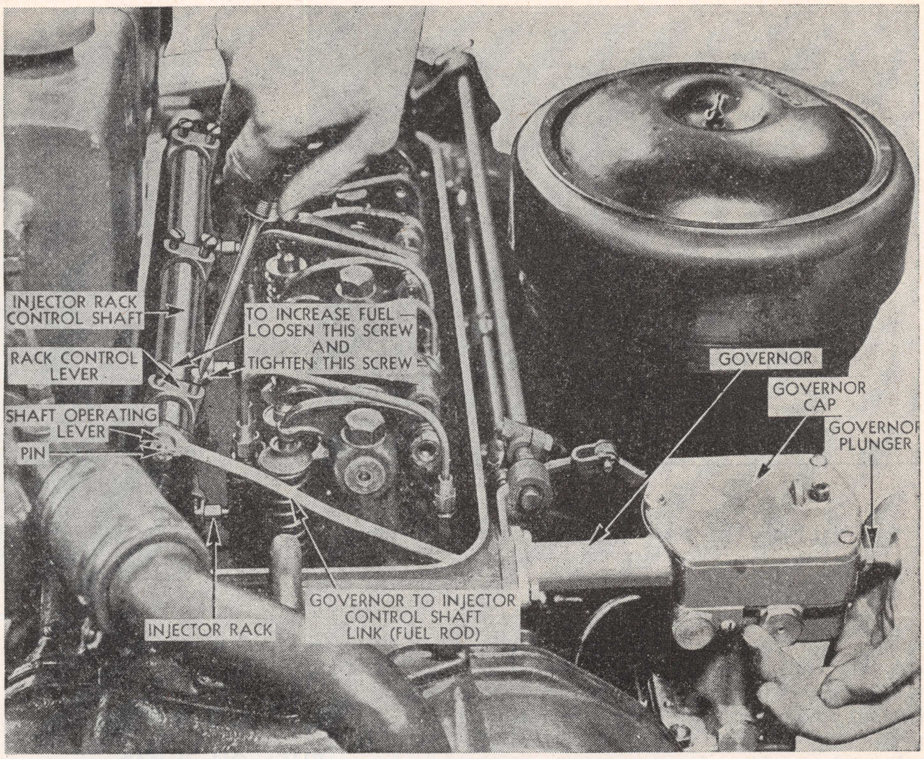
Under no circumstances should the rack operating levers be moved more than ¼ turn of the adjustment screws. If one injector is adjusted too far out of line with the others, the full travel of the racks will be prevented and the maximum power of the engine reduced.

INJECTOR COPPER TUBE

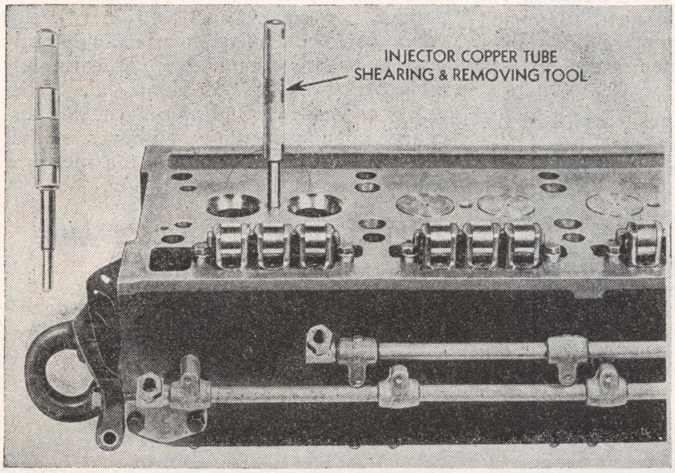
An injector copper tube for each cylinder is installed in the cylinder head. This tube is sealed at the top with a Neoprene ring and at the bottom peened into a flare on the lower side of the cylinder head to form a water-tight joint.

The taper seat on the lower end of the injector nut must seat firmly and true in the copper tube.

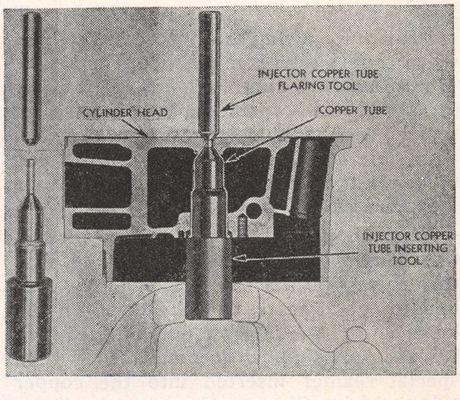
When removal of an injector copper tube becomes necessary, procedure given below and the tools provided will shorten the operation. After removing cylinder head, remove rocker arms and exhaust valves from


INJECTOR RACK CONTROL SHAFT
TO INCREASE FUEL—LOOSEN THIS SCREW AND TIGHTEN THIS SCREW
RACK CONTROL LEVER
SHAFT OPERATING LEVER
PIN
GOVERNOR
GOVERNOR CAP
GOVERNOR PLUNGER
GOVERNOR TO INJECTOR CONTROL SHAFT LINK (FUEL ROD)
INJECTOR RACK

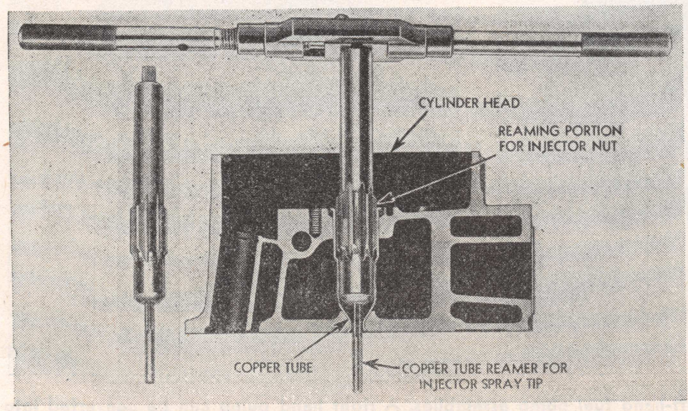
Setting injector control rack in No. 1 cylinder—Hydraulic Governor.


INJECTOR COPPER TUBE SHEARING & REMOVING TOOL

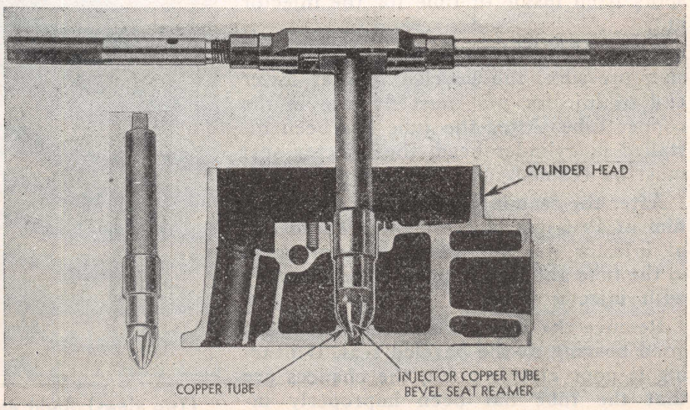
Removing injector copper tube from cylinder head.


INJECTOR COPPER TUBE FLARING TOOL
CYLINDER HEAD
COPPER TUBE
INJECTOR COPPER TUBE INSERTING TOOL

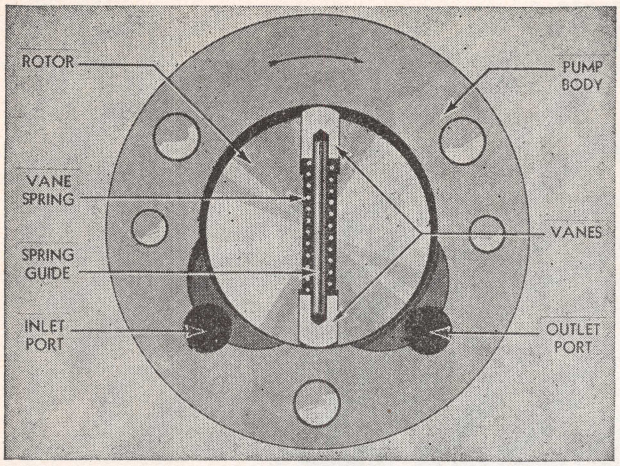
Installing injector copper tube into cylinder head.

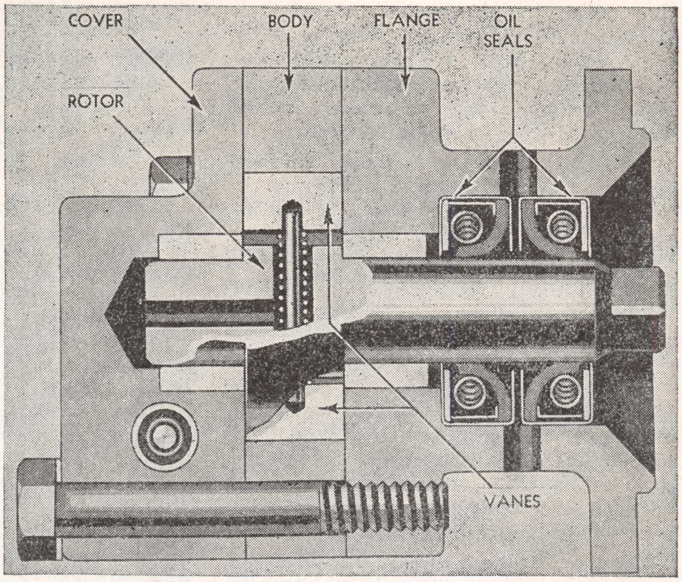

CYLINDER HEAD
REAMING PORTION FOR INJECTOR NUT
COPPER TUBE
COPPER TUBE REAMER FOR INJECTOR SPRAY TIP

Reaming copper tube in cylinder head for injector spray tip.


CYLINDER HEAD
COPPER TUBE
INJECTOR COPPER TUBE BEVEL SEAT REAMER

Reaming injector copper tube beveled seat for spray tip.





(Two views) Fuel oil pump assembly showing position of rotor and vanes in pump body.

cylinder head. Protect fuel connectors with shipping caps. Using a special tool provided for this purpose, turn cylinder head bottom up and drive the copper tube from position by shearing flange at bottom of tube with shoulder of tool.

The copper tube is installed in the cylinder head: By inserting a rubber ring into counter-bore of cylinder head at opening for injector tube, and crowding tube through ring and into position in cylinder head. The flange at upper end of tube will seat on rubber ring and into counter-bore when copper tube is in position. Drive tube in position with another special tool. After driving tube into position, support driving tool in vise, point up, and inside of tube; then slide flaring tool down over small end of driver tool and peen lower end of tube into flare of cylinder head.

After copper tube has been installed in the cylinder head, it must be reamed, first to receive the injector spray tip, and second for good seating of the bevel on the lower end of the injector nut. The reaming for the spray tip is accomplished with a special reamer inserted into the copper tube, which will not only ream the lower end to the proper size for receiving the spray tip, but will also remove any high spots from inside of tube for the injector nut.

In order to withstand the high compression pressure, the beveled seat at lower end of injector nut must fit true in the copper tube. After the tube has been installed in cylinder head, the injector seat must be reamed.

After the reaming operation, daub a thin film of Prussian blue on lower flared end of injector nut and insert injector down in the tube and lock in position temporarily with injector crab.

Remove the injector and see if it has a good bearing at the beveled seat. If bearing is poor at this point, the chances are that the tube has been improperly installed, in which case, install another tube and again proceed with reaming operations as outlined above.

FUEL SYSTEM

FUEL OIL PUMP

The fuel oil pump is a positive displacement vane type. The pump is bolted to the rear end of the blower housing. An integral steel rotor and shaft, supported at each end of the pump, revolves in a housing, the bore of which is eccentric to the shaft.

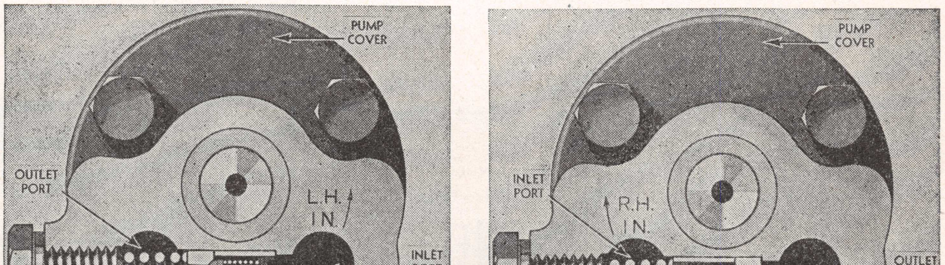
Two spring-loaded vanes, carried in the rotor, revolve inside the eccentric housing. Two oil seals are used inside the flange at the inner end of the rotor shaft. One seal retains the fuel oil under pressure, the other prevents the lubricating oil in the blower timing gear compartment from creeping along the pump shaft.

NOTE—The seals are located approximately 1/16″ apart and the feather edge of the leather on the inner seal faces the blower and that on the outer seal faces the pump body. A drain hole located between the two seals vents to the atmosphere.

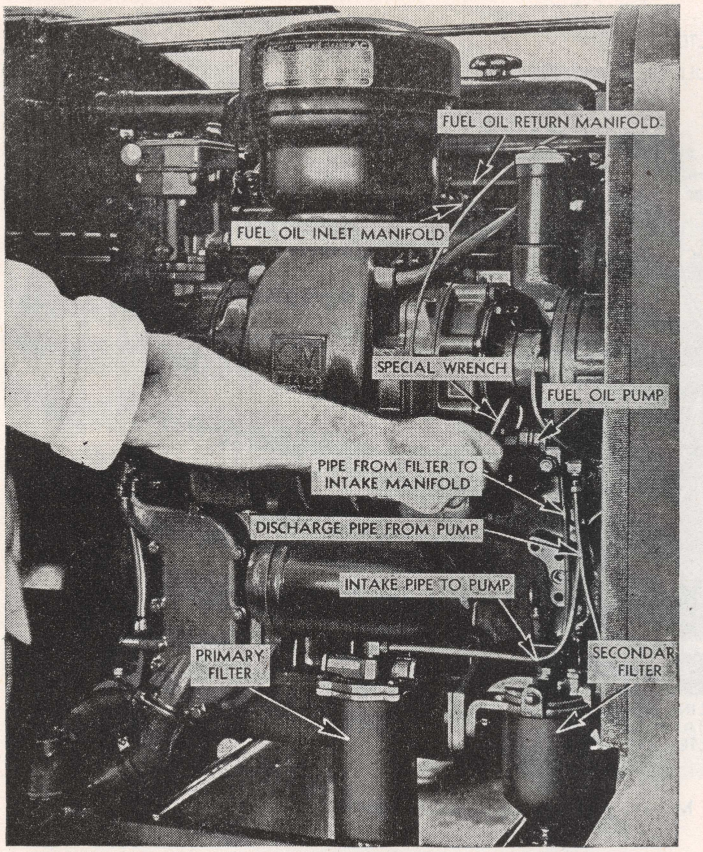
A spring-loaded, horizontal relief valve is provided in the cover of the pump, connecting the inlet and outlet ports, which opens at a pressure of approximately 60 pounds per square inch. Ordinarily this valve does not open since its only purpose is to prevent build up of extremely high pressures in the pump. The relief valve and its seat always face the discharge opening in the pump cover, so that when the relief valve opens, the fuel flow will be back to the pump suction.

FUEL PUMP, REMOVE AND REPLACE

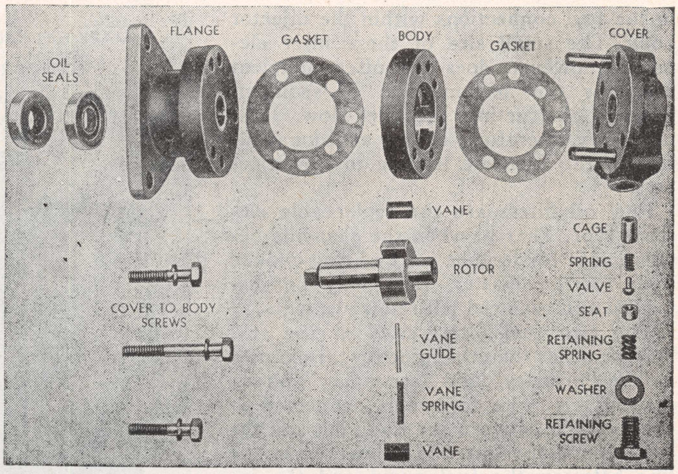
If the fuel oil pump is to be reconditioned, the pump assembly must be removed from the blower.



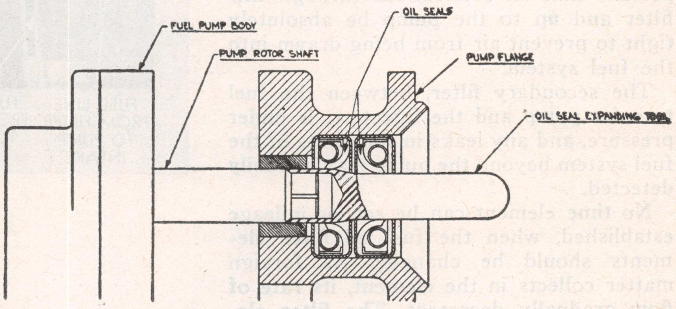
(Two views) Right and left-hand fuel pump assemblies. A right hand pump can be converted into a left-hand pump or vice-versa by re-assembling the relief valve parts as shown.


FUEL OIL RETURN MANIFOLD
FUEL OIL INLET MANIFOLD
SPECIAL WRENCH
FUEL OIL PUMP
PIPE FROM FILTER TO INTAKE MANIFOLD
DISCHARGE PIPE FROM PUMP
INTAKE PIPE TO PUMP
PRIMARY FILTER
SECONDAR FILTER

Fuel oil pump mounting.


OIL SEALS
FLANGE
GASKET
BODY
GASKET
COVER
VANE
CAGE
SPRING
VALVE
SEAT
ROTOR
COVER TO BODY SCREWS
VANE GUIDE
RETAINING SPRING
WASHER
VANE SPRING
RETAINING SCREW
VANE

Layout of fuel pump parts showing their relative position.


FUEL PUMP BODY
OIL SEALS
PUMP ROTOR SHAFT
PUMP FLANGE
OIL SEAL EXPANDING TOOL

Installing rotor shaft through pump seals.

In case the pump fails to rotate when blower is running, the cause may be due to a broken drive fork on the end of the fuel pump shaft. This condition may be checked by removing the pump from the blower as follows:

Disconnect both the intake and discharge fuel lines from the pump. Remove two outside cap screws that attach fuel pump assembly to the rear side of blower end cover with any ordinary wrench. The third cap screw at inside of pump flange requires a special wrench. Then remove the pump and coupling fork as an assembly. After the pump has been removed, rotate the shaft by hand to see that parts rotate freely. If inspection of the pump points to any binding or sticking inside the pump, the pump should be disassembled and thoroughly inspected.

The fuel oil pump is attached to the engine at the rear end of the blower. To attach the fuel oil pump:

Put the drive coupling fork (arms out), on the squared outer end of the pump shaft, and a new paper gasket on the pump supporting flange. Set the pump assembly up against the blower end cover, being sure that the drive fork engages the slots in the driving plate. The lugs will engage the plate when the pump body sets tight up against the end of the blower end cover. Check to be sure that the end of the valve seat housing casting marked "IN" faces the cylinder block, then slide the pump assembly into place and secure with three cap screws and lockwashers. Connect the fuel intake and discharge lines to the pump.

FUEL PUMP SERVICE

When disassembling a pump that has been removed from the engine, the rotor shaft must not be pulled from the seals in the pump flange unless you have the special tool that is available for guiding the rotor shaft back into the seals.

NOTE—If special tool is not used to guide shaft through the seals, the end of the shaft will destroy the feather edges of the leathers in the seals and the pump will leak excessively.

The relief valve assembly may be removed from the pump cover without disassembling the other parts of the pump by backing out the retaining screw and jarring the valve parts from the cover.

When removing this valve assembly, note the relative position of each part so they may be reassembled in their correct positions.

If relief valve only is to be inspected, no further disassembly is necessary. If entire pump is to be dismantled, proceed as follows:

Remove three cover-to-body bolts and install three bolts 3" long so that heads of bolts are about ¾" from pump cover.

Holding the pump assembly in the hand, tap on the heads of the screws with a soft hammer, driving the flange off the dowels.

Withdraw the rotor assembly and separate the pump body from the cover.

Drive dowels from the pump cover if necessary, using a small punch and hammer. If oil seals need replacing they may be removed with a special tool.

NOTE—The paper gaskets used on either side of the pump body are of the proper thickness to produce the correct clearance for the rotor and blades between the pump cover and flange. If these gaskets are not usable, new gaskets of the same thickness must be used.

If the relief valve does not form a tight seal with its seat, no attempt should be made to lap the valve or the seat; instead, use new parts.

If oil seals were removed, install new seals in pump flange. Locate seals with leather edge of outer seal pointing toward pump body and leather edge of inner seal pointing toward squared end of rotor shaft. Drive outer seal down tight against bottom of seal cavity and inner seal down to within approximately 1/16" from outer seal so as not to close vent hole. Use special tool to insert them.

FUEL OIL FILTERS

Fuel injector parts are protected against dirt and other foreign matter by two filters in the fuel connections within the injector body. The small size of these filter elements, however, does not offer sufficient area for the accumulation of sediment without obstructing the fuel flow. It is necessary, therefore, to use additional filters in the fuel line leading to the injectors.

Fuel oil filters are the replaceable element type. That is, when the elements become unfit for further use by being choked with foreign matter, they may be discarded and replaced with new elements.

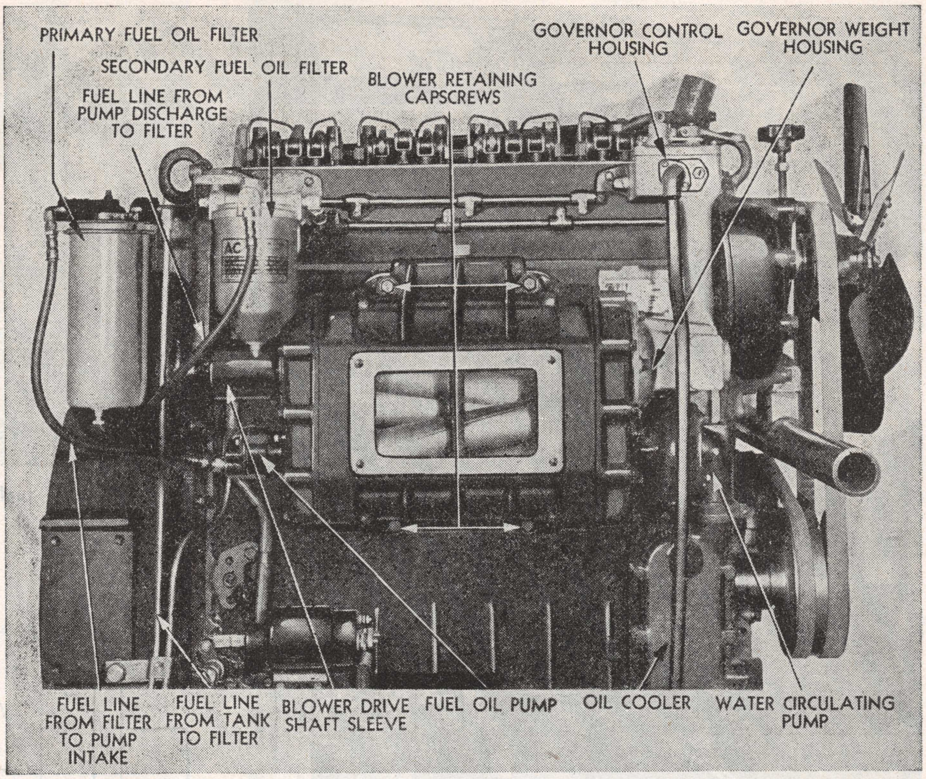
The two fuel filters used in the fuel system, other than the injectors, are known as the "primary" and "secondary" filters, respectively. The former is connected in the fuel line between the fuel tank and the fuel pump; the latter is connected in the line between the fuel pump and the injectors.

The primary filter, between the fuel tank and the fuel pump, is on the suction side of the pump; therefore, it is very important that all connections through this filter and up to the pump be absolutely tight to prevent air from being drawn into the fuel system.

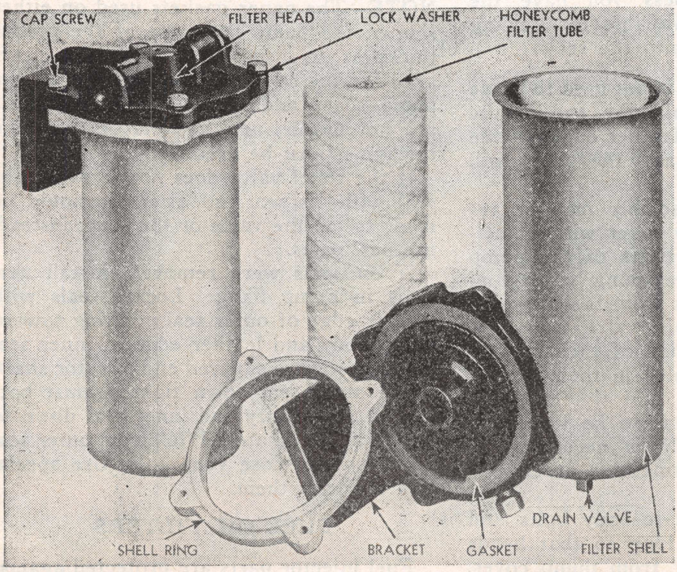
The secondary filter, between the fuel transfer pump and the injectors, is under pressure, and any leaks in the joints of the fuel system beyond the pump may be easily detected.

No time element can be set, or mileage established, when the fuel oil filter elements should be changed. As foreign matter collects in the element, its rate of flow gradually decreases. The filter element must be changed, of course, before complete stoppage of fuel flow takes place.

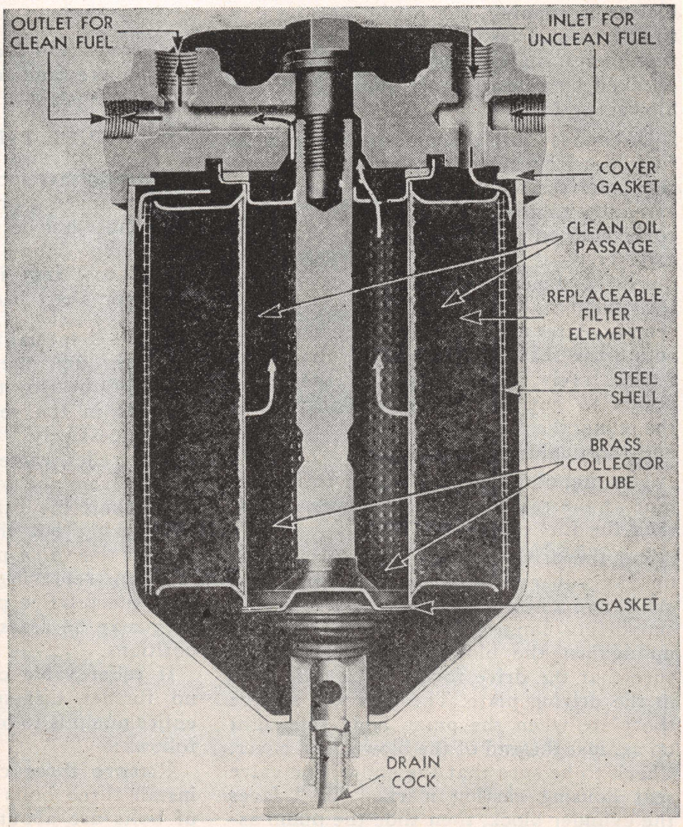
NOTE—The filter element must pass enough fuel not only to supply the injector, but show a good healthy stream from the fuel return manifold. Under normal conditions the approximate fuel flow at the return manifold on all series 71 engines is ½ gallon per minute at 1200 engine R.P.M.


PRIMARY FUEL OIL FILTER
SECONDARY FUEL OIL FILTER
FUEL LINE FROM PUMP DISCHARGE TO FILTER
BLOWER RETAINING CAPSCREWS
GOVERNOR CONTROL HOUSING
GOVERNOR WEIGHT HOUSING
FUEL LINE FROM FILTER TO PUMP INTAKE
FUEL LINE FROM TANK TO FILTER
BLOWER DRIVE SHAFT SLEEVE
FUEL OIL PUMP
OIL COOLER
WATER CIRCULATING PUMP

Mounting of primary and secondary fuel oil filters.


CAP SCREW
FILTER HEAD
LOCK WASHER
HONEYCOMB FILTER TUBE
DRAIN VALVE
SHELL RING
BRACKET
GASKET
FILTER SHELL

Layout of primary fuel oil filter parts.


OUTLET FOR CLEAN FUEL
INLET FOR UNCLEAN FUEL
COVER GASKET
CLEAN OIL PASSAGE
REPLACEABLE FILTER ELEMENT
STEEL SHELL
BRASS COLLECTOR TUBE
GASKET
DRAIN COCK

Secondary fuel oil filter.

Under ordinary conditions with clean fuel supply, and using No. 3 Diesel fuel, the primary filter element will give satisfactory results for 25,000 miles. If the fuel system, other than the fuel filters, is working satisfactorily, and the flow of fuel from the return manifold is insufficient, the filter elements should be replaced regardless of the length of time the elements have been used.

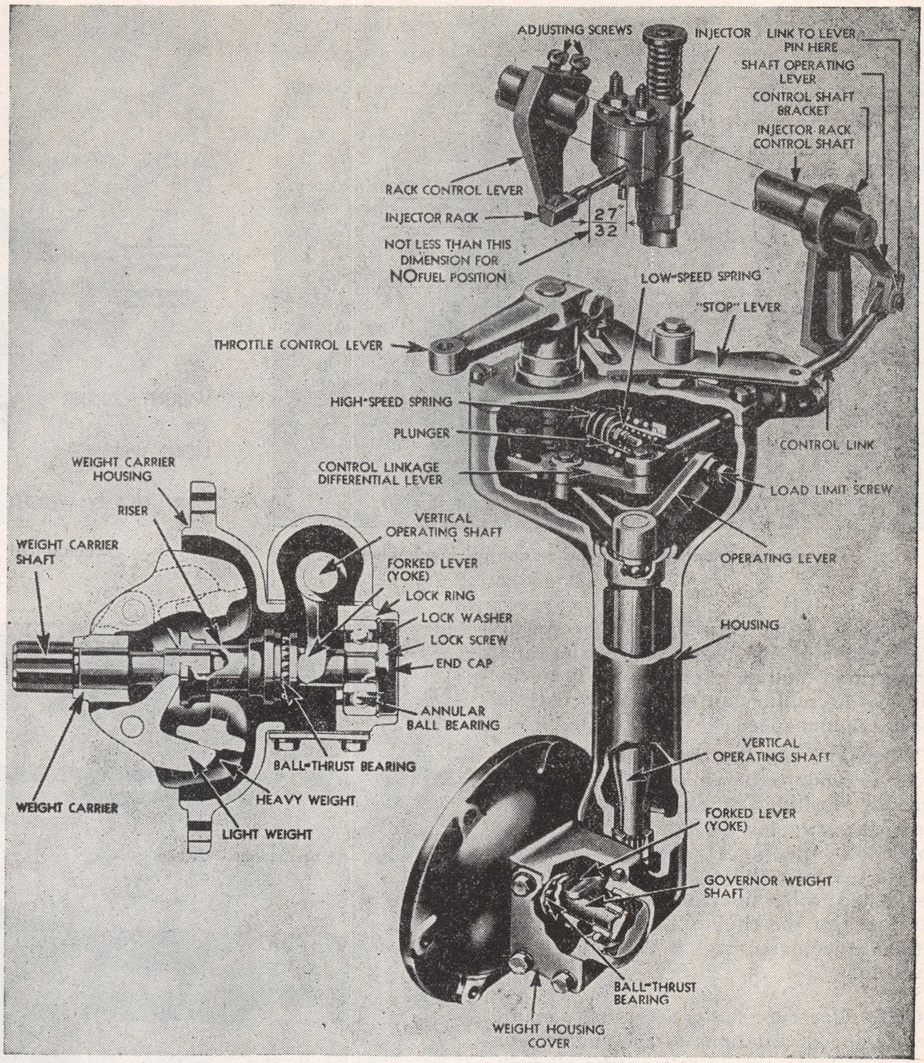
FUEL FILTERS, REPLACE

The primary fuel oil filter element may be replaced as follows: Remove cap screws in filter head, remove filter shell ring and filter assembly. Lift out and discard the old filter element and gasket at upper end of filter shell. Wash out filter shell thoroughly. Place new element in position (either end up) in filter shell and place a new gasket in filter head. Replace filter shell and filter shell ring assembly and tighten securely. Since this filter is on the suction side of the pump, it is important to have a tight seal between the filter head and the filter shell ring to prevent air from being drawn into the fuel system.

The secondary fuel oil filter element may be replaced as follows: Remove cap screw in center of filter head and remove bowl assembly. Lift out and discard the old filter element, and gasket at lower end of element. Wash out bowl thoroughly.

NOTE—The steel washer may stick to the bottom of the old element. Reinstall washer on top of spring. Install new lower element gasket over center post and on top of steel washer.

Place new element in position with end marked "TOP" upward. Before replacing bowl, remove old cover gasket and replace with new gasket. Replace bowl and element assembly and tighten securely. Run engine and observe if there are any oil leaks around cover gasket or any connections.


ADJUSTING SCREWS
INJECTOR
LINK TO LEVER PIN HERE
SHAFT OPERATING LEVER
CONTROL SHAFT BRACKET
INJECTOR RACK CONTROL SHAFT
RACK CONTROL LEVER
INJECTOR RACK
27" / 32
NOT LESS THAN THIS DIMENSION FOR NO FUEL POSITION
LOW-SPEED SPRING
"STOP" LEVER
THROTTLE CONTROL LEVER
HIGH-SPEED SPRING
PLUNGER
CONTROL LINK
CONTROL LINKAGE DIFFERENTIAL LEVER
LOAD LIMIT SCREW
WEIGHT CARRIER HOUSING
RISER
VERTICAL OPERATING SHAFT
WEIGHT CARRIER SHAFT
FORKED LEVER (YOKE)
OPERATING LEVER
LOCK RING
LOCK WASHER
LOCK SCREW
HOUSING
END CAP
ANNULAR BALL BEARING
BALL-THRUST BEARING
VERTICAL OPERATING SHAFT
WEIGHT CARRIER
HEAVY WEIGHT
LIGHT WEIGHT
FORKED LEVER (YOKE)
GOVERNOR WEIGHT SHAFT
BALL-THRUST BEARING
WEIGHT HOUSING COVER

Limiting speed mechanical governor assembly.

GOVERNORS

LIMITING SPEED MECHANICAL TYPE

On the Series 71 GMC Diesel engines, engine speed and power is controlled by means of a governor. The governor operating mechanism is connected to the engine throttle, or to the injector control racks, on the Series 71 Diesel engines, to adjust fuel as required. The functioning of the governor is brought about by centrifugal force created by the rotating weights and this is transmitted mechanically to the governor actuating mechanism. This governor has the following characteristics:

(a) Controls the engine idling speed.
(b) Limits maximum engine speed.
(c) Provides manual control between maximum engine speed and idling.
(d) Permits return of injectors to no fuel position at speeds above idling range.

This governor has two high-speed and two low-speed weights. Each set of weights having a fixed stop for the inner and outer positions. A high and a low speed spring is also employed in this governor; the former works in conjunction with the high-speed weights to limit the maximum engine speed, the latter works in conjunction with both the low and high-speed weights to control the engine idling speed.

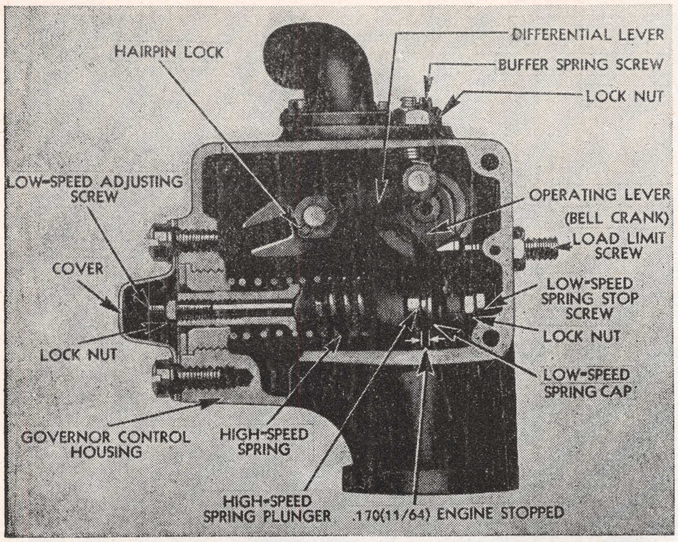
The motion produced by the travel of the governor weights, between their inner and outer positions, is transmitted to the injector racks by a system of cams and levers on which can be superimposed a manual control.

The governor, which is mounted at the front of the blower, is divided into three main assemblies embodied in separate housings. These assemblies are: The governor weights and housing, the control mechanism, and the cover.

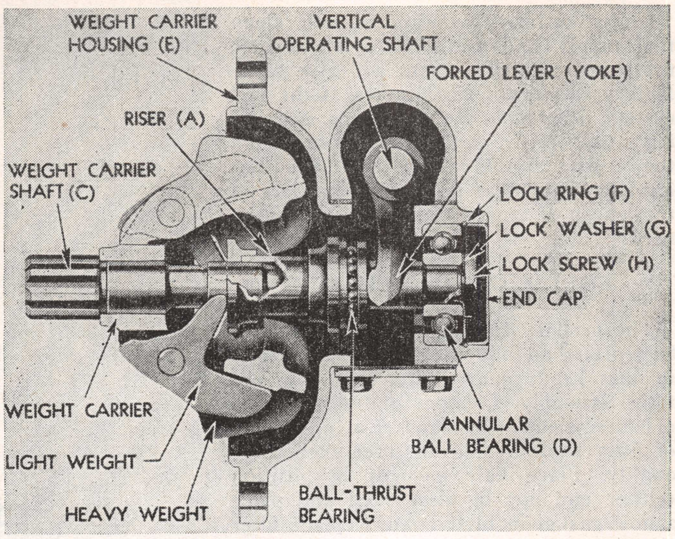
The cover assembly serves as a carrier for the stop lever and the hand throttle control lever, and closes the top of the control mechanism housing. This governor controls the maximum speed of the engine and also the low speed up to about 400 R.P.M. Intermediate **speeds are controlled manually through the governor** linkage.

The upper limit of the low speed governing range is reached when the projection on the low-speed weight, on the side of the pin opposite the main part of the weight, comes in contact with the weight carrier and stops. The position of the low-speed spring cap may be varied by means of the screw at the end of the bell crank arm. When the screw is correctly set, the gap between the cap and high-speed spring plunger closes at the same time the low-speed weight comes to its stop against the weight carrier. This, in effect, removes both the low-speed weight and the low-speed spring from operation The engine then goes into the intermediate speed range; **in which the speed control is entirely manual.**

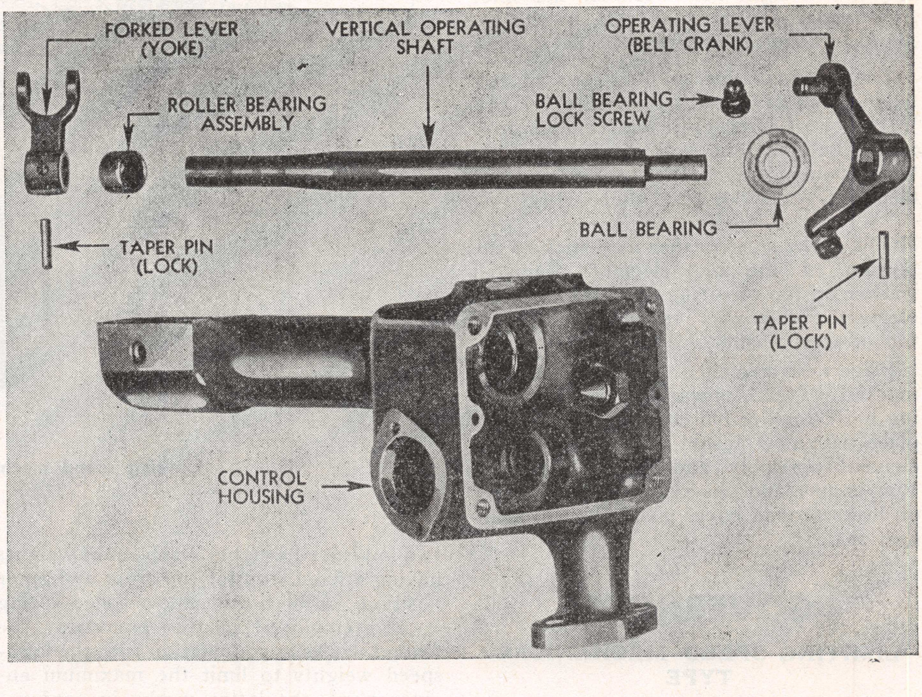
When the speed of rotation of the weights becomes high enough so that the force on the high-speed weights, as transmitted through the riser, the forked lever, the vertical shaft, and the bell crank to the


HAIRPIN LOCK
DIFFERENTIAL LEVER
BUFFER SPRING SCREW
LOCK NUT
LOW-SPEED ADJUSTING SCREW
OPERATING LEVER (BELL CRANK)
LOAD LIMIT SCREW
COVER
LOW-SPEED SPRING STOP SCREW
LOCK NUT
LOCK NUT
LOW-SPEED SPRING CAP
GOVERNOR CONTROL HOUSING
HIGH-SPEED SPRING
HIGH-SPEED SPRING PLUNGER
.170(11/64) ENGINE STOPPED

Top view of mechanical governor control mechanism.


WEIGHT CARRIER HOUSING (E)
VERTICAL OPERATING SHAFT
FORKED LEVER (YOKE)
RISER (A)
WEIGHT CARRIER SHAFT (C)
LOCK RING (F)
LOCK WASHER (G)
LOCK SCREW (H)
END CAP
WEIGHT CARRIER
ANNULAR BALL BEARING (D)
LIGHT WEIGHT
BALL-THRUST BEARING
HEAVY WEIGHT

Mechanical governor weight and housing assembly.


FORKED LEVER (YOKE)
VERTICAL OPERATING SHAFT
OPERATING LEVER (BELL CRANK)
ROLLER BEARING ASSEMBLY
BALL BEARING LOCK SCREW
BALL BEARING
TAPER PIN (LOCK)
TAPER PIN (LOCK)
CONTROL HOUSING

Layout of governor vertical operating shaft parts showing their relative position.

high-speed spring, is sufficient to overcome the preload on the high-speed spring and again cause motion at the control mechanism, this motion automatically controls the maximum speed.

When the pin on the throttle control lever is held fixed, as in the idle or full throttle positions, the governor motion from either the low or high-speed weights, applied at the pivot point of the lever, causes the long end of the lever, which is connected to the injector racks, to control the speed of the engine. Under these conditions injector control is entirely by the governor.

NOTE—Governor faults are usually manifest in speed variations of the engine, but it does not necessarily follow that all such speed variations indicate governor faults.

GOVERNOR SERVICE CHECK

When improper speed variations appear, the following procedure should be carried out in checking governor operation. Make sure that the speed changes observed are not the result of load fluctuations. If the load is uniform, carefully check the engine to be sure that all cylinders are firing properly. See that no bind exists in any part of the governor mechanism or operating linkage between governor and engine; also, that no bind is manifest in the injector control rack shaft or its mounting brackets.

With the governor control link connected to the injector rack control shaft, the mechanism should be free from bind throughout the entire travel of injector racks. Should friction exist in the mechanism it must be eliminated.

Injector racks may stick or move too hard. This may be due to the injector hold down crab being too tight or not positioned properly. An injector which has been in service a long time may get sticky due to an accumulation of gum and sludge. Wash in a pail of clean gasoline.

Control shaft may stick or turn hard in its small bearings. These bearings must be free from chips, dirt, or sludge, and must be well lubricated. Binding due to poor alignment of the bearing supports can be corrected by loosening the bearing support cap screws and realigning the bearing supports.

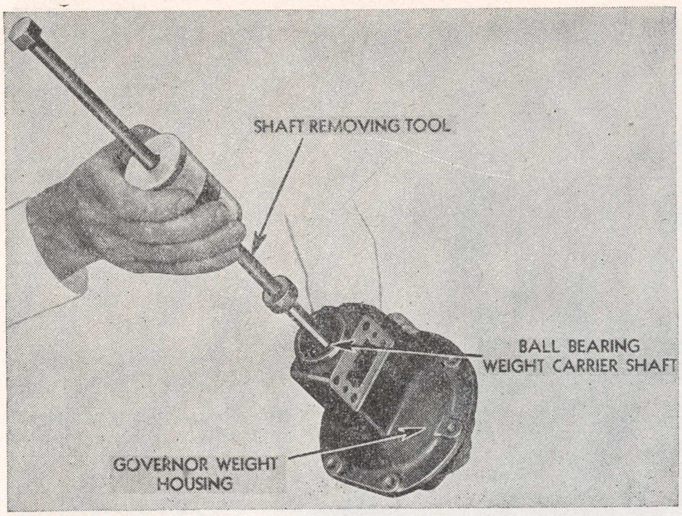
NOTE—Any time the control shaft bearing supports have been loosened, the adjustment of rack control levers should be checked.

Also never stretch or tamper with rack control spring to change the tension. If spring is not standard, replace. Control shaft may have too much friction due to control shaft spring being bent. Replace with a standard spring. Pin in link connecting governor to control shaft may be binding in the control shaft lever. Remove bind.

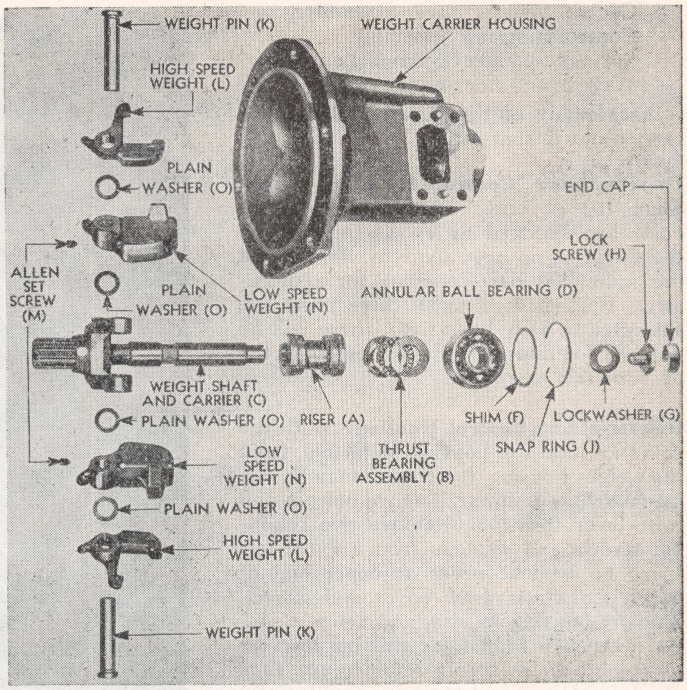
Having made all the above checks and the governor still fails to control the engine properly, the governor may be worn or otherwise unfit for further use until the unit has been completely disassembled, inspected, and rebuilt or replaced.

GOVERNOR, REMOVE & REPLACE

In cases of major repairs or a complete governor change, the unit may be removed from the engine as follows: Remove engine valve rocker cover. Disconnect rods


SHAFT REMOVING TOOL
BALL BEARING WEIGHT CARRIER SHAFT
GOVERNOR WEIGHT HOUSING

Removing governor weight carrier shaft from ball bearing.


WEIGHT PIN (K)
WEIGHT CARRIER HOUSING
HIGH SPEED WEIGHT (L)
PLAIN WASHER (O)
END CAP
LOCK SCREW (H)
ALLEN SET SCREW (M)
PLAIN WASHER (O)
LOW SPEED WEIGHT (N)
ANNULAR BALL BEARING (D)
WEIGHT SHAFT AND CARRIER (C)
PLAIN WASHER (O)
RISER (A)
SHIM (F)
LOCKWASHER (G)
THRUST BEARING ASSEMBLY (B)
SNAP RING (J)
LOW SPEED WEIGHT (N)
PLAIN WASHER (O)
HIGH SPEED WEIGHT (L)
WEIGHT PIN (K)

Layout of governor weight parts showing their relative position.

at governor throttle and stop levers. Remove screws which attach governor control housing cover to weight housing and remove cover. Disconnect governor to control shaft link from both the differential lever and the control shaft lever and remove link. Remove screws which attach governor control housing to cylinder head. Remove cap screws which attach cover and control housing to weight carrier housing and remove cover plate. Also separate control housing from weight carrier housing. Remove cap screws which attach weight carrier housing to front end of blower and separate governor shaft from front blower shaft by pulling straight out. The rear cap screw may be easily removed by using the same special wrench also used for removing fuel pump inner cap screw.

To install governor on engine proceed as follows: Shellac a paper gasket to the governor weight housing attaching flange, and slide the housing assembly up against the front end of the blower with splined end of governor shaft entering the hollow upper blower rotor shaft. Put attaching screws in place finger tight only. Set the control housing and shaft assembly against the weight housing using a paper gasket between them. Then put weight carrier housing cover and gasket in position, and lock cover, gaskets and the two housings together with four cap screws and lockwashers.

NOTE—Be sure that forked lever is assembled with machined faces bearing on outer thrust washer and not between washer and balls.

Insert a new gasket and attach upper end of governor housing to cylinder head with cap screws and lockwashers. Then tighten the cap screws that attach weight housing to end of blower, using special wrench where necessary. Pour at least ½ pint of engine lubricating oil into top of governor.

At this stage of the governor assembly and before replacing the cover, the low-speed spring plunger gap may be checked, and if necessary, adjusted. Before making this adjustment, the three following engine inspections and adjustments should be made: Set exhaust valve lash .011" GO .013" NO GO. Time injectors, position injector control racks.

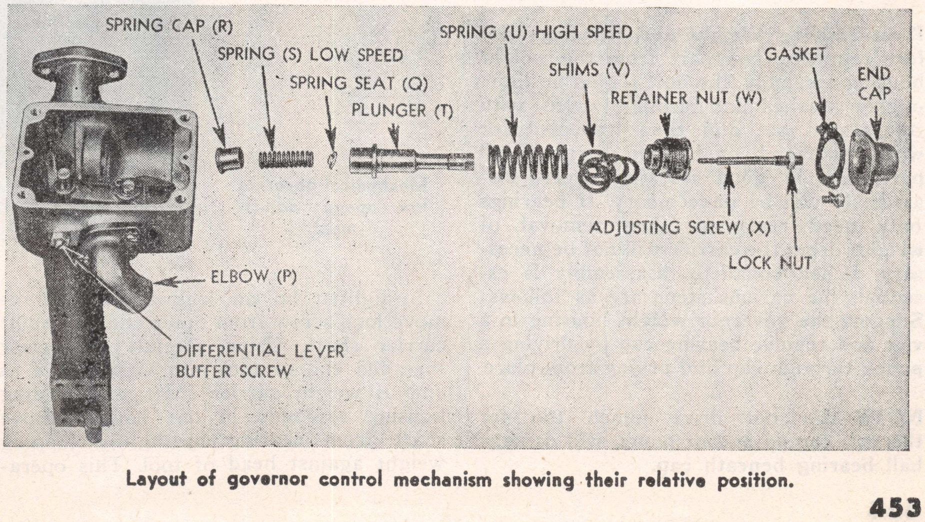
First, start the engine and regulate speed by hand control. Next adjust low-speed spring plunger gap.

CAUTION—BE CAREFUL NOT TO OVERSPEED THE ENGINE. Gradually increase engine speed from 350 to 700 R.P.M. In this range of speed, the bell crank should move IN, closing the gap between low speed spring plunger and seat before reaching 700 R.P.M. Gradually raise speed to 1500 R.P.M. No further motion of the bell crank should take place.

If adjustment is necessary, run the engine at any speed above 800 R.P.M. and adjust the low-speed spring stop screw until the plunger gap is closed to a smooth pull on a .0015" or .002" feeler. Install governor control link. The governor cover is serviced as an assembly and parts were not removed therefrom. After the assembly has been thoroughly cleaned and moving parts lubricated with engine oil, it may be reinstalled to housing. When replacing, be sure that gasket is in place and throttle control lever to differential lever pin is assembled in the differential lever slot. When correctly assembled, the throttle lever can be rotated smoothly through entire arc of travel. Position injector control racks for smoothest operation.

GOVERNOR, DISASSEMBLE

For purpose of simplicity of explanation the governor assembly may be divided into the following sub-assemblies:


SPRING CAP (R)
SPRING (S) LOW SPEED
SPRING SEAT (Q)
PLUNGER (T)
SPRING (U) HIGH SPEED
SHIMS (V)
RETAINER NUT (W)
GASKET
END CAP
ADJUSTING SCREW (X)
LOCK NUT
ELBOW (P)
DIFFERENTIAL LEVER BUFFER SCREW

Layout of governor control mechanism showing their relative position.

1. Control housing cover assembly.
2. Control housing assembly.
3. Springs and sleeve assembly.
4. Weight and housing assembly.

Disassembly of the governor should be carried out in that order.

Disassembling Control Housing Cover: Since the governor cover and its allied parts are serviced as an assembly only, there will be no need for removing any of the individual parts thereof for replacement. Furthermore, since these parts are subjected to very little wear, there will be no need for disassembling or removing the parts of this assembly.

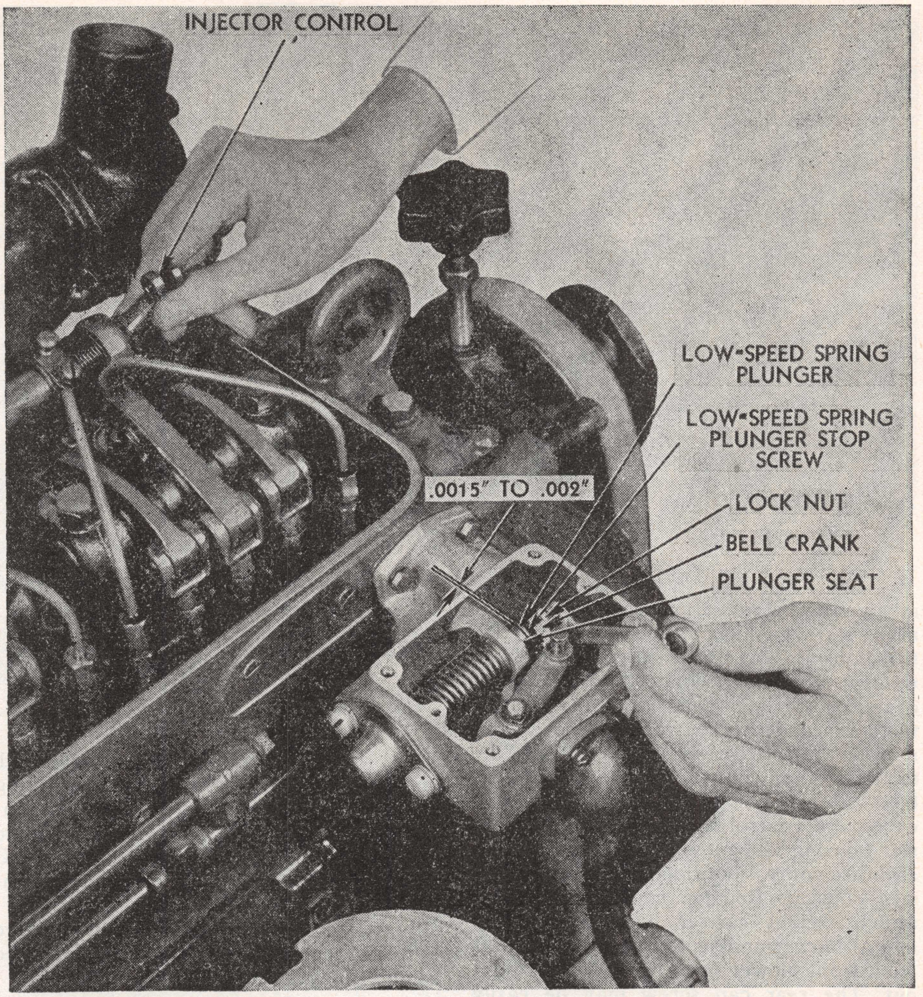
Disassembling Control Housing: With the governor control housing detached from the weight housing, the former may be disassembled as follows: Remove hairpin and raise lever from pin. Remove two retaining screws and washers from cupped low speed adjustment cover at upper end of housing and withdraw cover and gasket. Support housing in vise, and using a special wrench provided for this purpose remove high-speed spring retainer nut, then remove retainer and spring assembly from housing. Remove low-speed spring cap, spring and spring seat from plunger. Compress the spring assembly in a vise, loosen the lock-nut and remove the low-speed adjusting screw from the high-speed spring plunger.

Remove vertical shaft, operating lever and upper ball bearing as an assembly from the housing as follows: Dislodge the two small welch plugs from each side of lower end of housing to expose taper pin through hub of yoke and drive pin from place with small punch and hammer. Remove lockscrew, plain washer and lockwasher at top of upper ball bearing. Lift shaft, operating lever and upper ball bearing out through top of housing. Then yoke will slip off lower end of shaft and shaft from lower roller bearing.

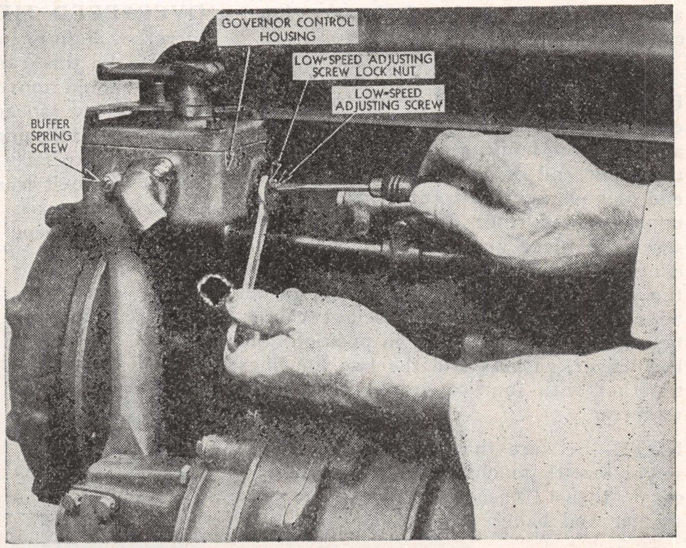
Should the roller bearing assembly at lower end of vertical shaft need replacing, which is rarely necessary, drive bearing assembly down through bottom of housing, using long rod down through top of control housing.

Disassembling Weight and Housing: Before removing any part from the weight housing assembly, the unit should be thoroughly washed in gasoline, dried with compressed air, and then inspected for worn, damaged, or binding parts. If all parts are in good working order, disassembly will be unnecessary. If bearings only need replacing, then removal of weights from the carrier will not be necessary. When complete disassembly is essential, the various steps are as follows: Support the governor weight housing in a vise and remove bearing cap by driving a punch through cap and prying from place.

NOTE—Do not drive punch too far through cap so end of punch will damage ball bearing beneath cap.



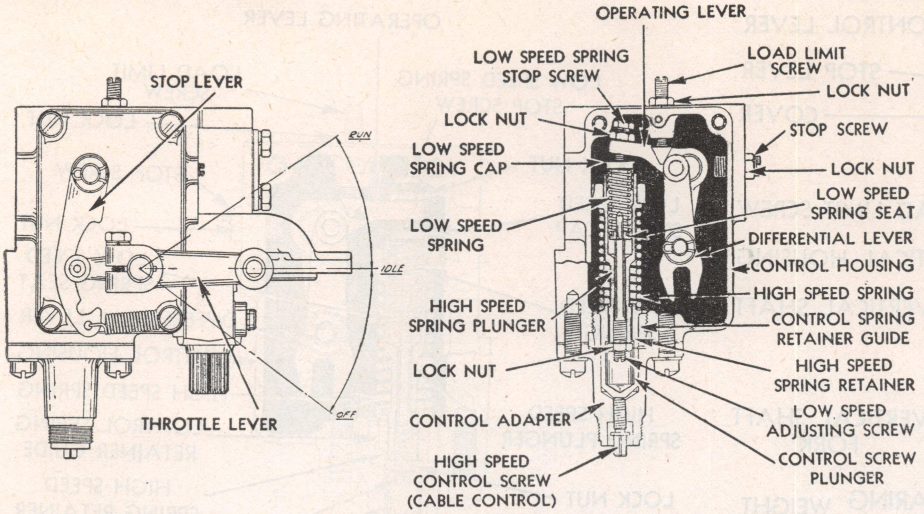
Adjusting governor low speed spring plunger stop screw.



Mechanical governor low speed adjustment.

Straighten lip on lockwasher and remove lock screw from outer end of weight carrier shaft. Using special tool, screw threaded end of tool into tapped hole at end of weight carrier shaft, and holding housing assembly in one hand, remove shaft from bearing by lightly tapping weight against head of tool. This operation may also be performed in arbor press. Slide the thrust ball bearing and riser from the weight carrier shaft.

NOTE—Mark weights and carrier with center punch, also observe position of thin washers between weights, so parts can be replaced in their original locations.



Constant speed mechanical governor springs, control and cover assembly.

Then remove Allen set screws, weight pivot pins and weights from carrier. The governor weight carrier is serviced with the shaft and should not be removed. Dislodge ball bearing lock ring from outer end of housing with sharp pointed tool and jar or press bearing from housing. Usually the bearing is not a tight fit in housing and very little pressure is required for its removal.

Annular ball bearings should be thoroughly cleaned of dirt, blown out with dry air, then lubricated with light engine oil before checking. After such treatment, hold in fingers and revolve slowly for any indication of tight or rough spots. Bearings that do not roll freely should not be used.

Examine all sleeves, pins, shaft journals, and links for wear; also for fits, and, if necessary, dress with crocus cloth for proper fit. The weights should be suspended in their carrier sufficiently free to fall from the extended to the inner position by their own weight, and the suspending pins should not be used if worn more than .002" out of round.

GOVERNOR, ASSEMBLE

The governor may be assembled by reversing the sequence of operations for disassembly. The work will be much simplified by close reference to the following notes. Having thoroughly inspected each part, the governor may be assembled as follows:

Assemble Weights in Housing: Using wood block, tap ball bearing into outer end of weight housing, place shim next to bearing and install snap ring into groove to lock bearing in place. Heeding prick punch marks previously placed on governor weights and carrier, also noting positions of washers between weights, attach weights to carrier and lock each pin with its Allen set screw. Stake Allen screws at two places after replacing. Support serrated end of shaft vertically in vise between copper jaws and slip riser, then thrust bearing, onto upper end of shaft. Drop carrier housing over shaft. Then using block of wood on inner race of ball bearing, drive shaft through bearing tight against shoulder on shaft. Slip lockwasher over lock screw, screw latter into end of shaft and bend over ear of washer to lock in place. Install **new** cap into governor housing over end of shaft to retain oil and protect bearing.

Assemble Control Housing: The vertical shaft, operating lever, and forked lever (yoke) at lower end of shaft are serviced as an assembly only.

NOTE—Levers removed from the shaft may be replaced, but new levers cannot be installed on used shaft, or vice versa, in the field, as it is necessary to drill and ream holes for taper pins with the parts in place.

If operating lever and bearing were removed from vertical operating shaft for replacement of bearing, support lower end of shaft vertically in vise between copper jaws, then tap ball bearing onto shaft. With pivot pin, on operating lever pointing up, align pin hole in operating lever with hole in shaft, then drive lever down tight onto bearing. Drive taper pin in place, locking bearing and lever to shaft. Apply engine oil to the rollers and tap roller bearing assembly in place at lower end of housing for vertical shaft. Insert vertical shaft assembly down through roller bearing. Position the forked lever (yoke) so machined surfaces of forks will bear against ball bearing thrust washer. When lower end of vertical shaft appears through roller bearing, put yoke in position and slide shaft assembly into position and through the yoke. Revolve shaft or yoke to align holes and lock yoke to shaft with taper pin. Lock upper ball bearing from endwise motion with screw, plain washer and lockwasher.

Position differential lever so slotted end **points away from ball bearing at upper end** of vertical shaft, then put lever over pivot pin and lock with plain washer and hair pin.

Next, back off lock nut to within 1/8" of outer end of adjusting screw, then slip **high-speed spring over plunger shims onto** inner end of retainer nut and set nut down on spring. Start adjusting screw into plunger. **Install the low-speed spring seat** on the inner end, and the spring cap on the outer end of the low-speed spring and insert the assembly into the hollow plunger. Using the same tool as was used for removal, screw retainer nut and spring assembly into control housing.

NOTE—Before further governor assembly and to avoid repetition of operations, the governor may be attached to the engine and the low-speed spring plunger stop adjusted. On some installations, difficulty **will be encountered if attempting to** install the control housing assembly when attached to weight housing. Therefore, if a replacement governor as received from stock is to be installed on the engine, the two housings must be separated, but if a governor being rebuilt is to be installed to the engine, the operations may be carried out before the two housings are joined together.

CONSTANT SPEED MECHANICAL GOVERNOR

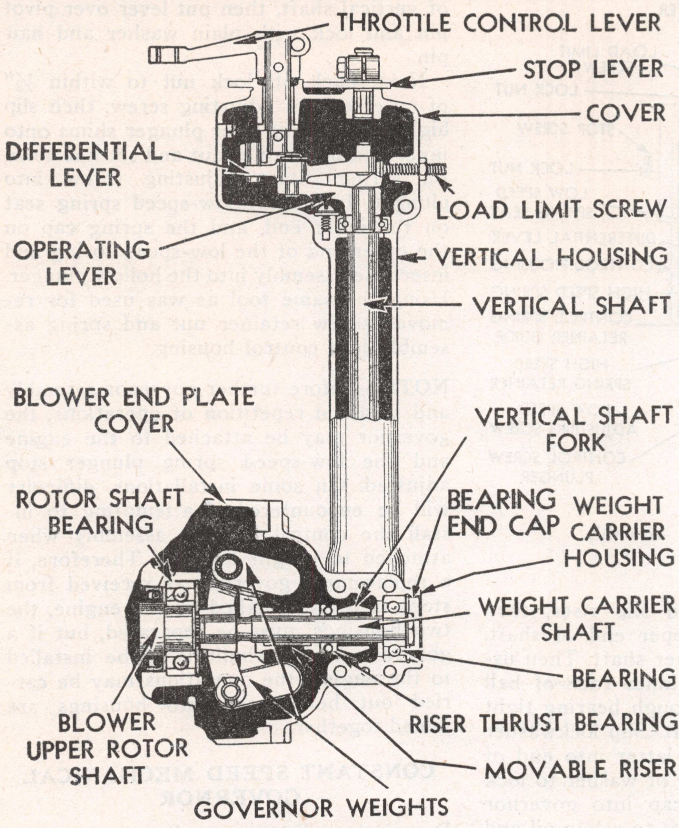
Description: Fundamentally, the constant speed mechanical governor is the same as the limiting speed mechanical type. The **main differences being that the former has** only one set of weights and a close manual regulation of the high speed spring whereby the high speed may be varied within a range of approximately 120 engine R.P.M.; whereas the latter has two sets of weights, and the high speed is fixed by the characteristics of the spring, and no high speed engine changes are possible without internal physical changes within the governor.

To provide free movement for the weights, they are suspended on roller bearings. The bore in the hub of the weight serves as the outer race for the rollers, and the hardened pin as the inner race. A series of 22 rollers are used at each end of the hub with a spacer between the two sets; a plain washer over the pin, and at each end of the weight hub, serves as an outer retainer for the rollers.

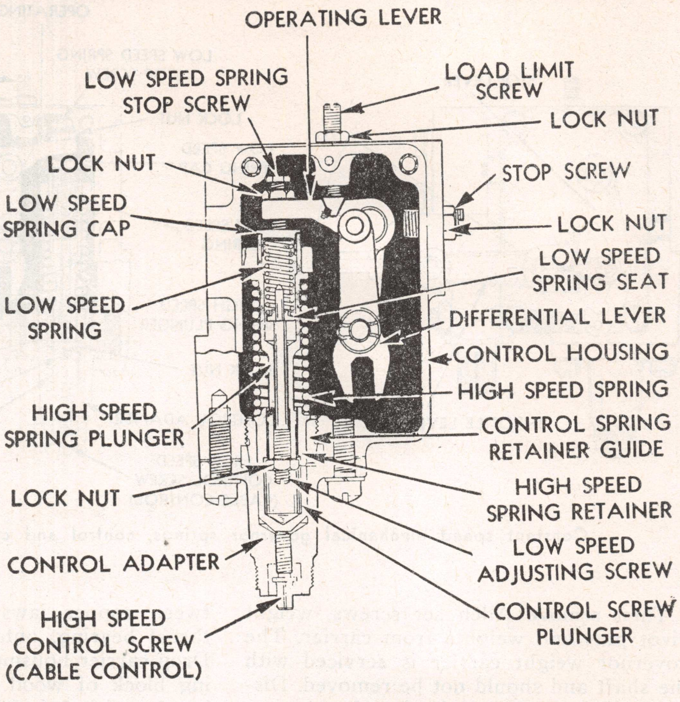
Since there is no intermediate or manually controlled range between high and low engine governor speeds in the constant speed governor, there is no call for two sets of weights. The only requirements for this governor being to control the engine idling speed, and maintain a constant operating speed.

Operation: Since there is no intermediate or manually controlled range in the constant speed governor, the throttle is set in either the low speed or running position for engine operation, and engine control is automatic by the governor for both of these positions.

When the throttle is set in the idling


THROTTLE CONTROL LEVER
STOP LEVER
COVER
DIFFERENTIAL LEVER
LOAD LIMIT SCREW
OPERATING LEVER
VERTICAL HOUSING
VERTICAL SHAFT
BLOWER END PLATE COVER
VERTICAL SHAFT FORK
ROTOR SHAFT BEARING
BEARING END CAP
WEIGHT CARRIER HOUSING
WEIGHT CARRIER SHAFT
BEARING
BLOWER UPPER ROTOR SHAFT
RISER THRUST BEARING
MOVABLE RISER
GOVERNOR WEIGHTS

Constant speed mechanical governor assembly.


OPERATING LEVER
LOW SPEED SPRING STOP SCREW
LOAD LIMIT SCREW
LOCK NUT
LOCK NUT
STOP SCREW
LOW SPEED SPRING CAP
LOCK NUT
LOW SPEED SPRING SEAT
LOW SPEED SPRING
DIFFERENTIAL LEVER
CONTROL HOUSING
HIGH SPEED SPRING
HIGH SPEED SPRING PLUNGER
CONTROL SPRING RETAINER GUIDE
LOCK NUT
HIGH SPEED SPRING RETAINER
LOW SPEED ADJUSTING SCREW
CONTROL ADAPTER
CONTROL SCREW PLUNGER
HIGH SPEED CONTROL SCREW (CABLE CONTROL)

Constant speed governor operating mechanism with low speed spring gap closed.

position, engine control is entirely through the low speed spring, the tension on which may be varied to suit engine requirements. Since low and high speed requirements are met by low and high speed springs respectively, a limit must be established when the low speed spring ceases to function and the high speed spring comes into operation.

The upper limit of the low speed governing range is reached when the low speed spring plunger to high speed spring plunger gap closes. After this condition has been obtained, the engine control is taken over by the high speed spring. This gap may be varied to meet these conditions by means of a screw on the end of the bell crank arm. This adjustment is described later under "Governor Adjustments—Constant Speed."

When the speed of rotation of the weights becomes high enough so that the force on the weights, as transmitted through the riser, the forked lever, the vertical shaft, and the bell crank to the high speed spring, is sufficient to overcome the preload on the high speed spring and again cause motion at the control mechanism, this motion automatically controls the maximum speed.

Service: Before performing any service work or making any adjustments on this governor, refer to the instructions and checks outlined under "Service," for the limiting type governor, which also applies to the constant speed type.

Remove Governor From Engine: The removal of this governor from the engine is the same as for the limiting type, refer therefore, to "Remove Governor from Engine."

Disassemble Mechanical Constant Speed Type Governor: Because of the similarity in design of the constant speed and limiting type mechanical governors, the procedure for disassembly is somewhat similar. The same order of disassembly will be used here and any differences noted below. Before removing any parts from the governor assembly the entire unit should be thoroughly washed in clean gasoline, dried with compressed air, and then inspected carefully for worn, damaged parts, or bind in any of the parts that cannot be corrected without disassembly. Disassembly need be carrier out only far enough to correct those difficulties which interfere with proper governor operation.

Control Housing Cover Disassembly: Owing to the similarity in design of the cover on all three mechanical governors described, refer to "Disassembling Control Housing Cover."

Control Housing Disassembly: With the governor control housing detached from the weight housing, the former may be disassembled as follows:

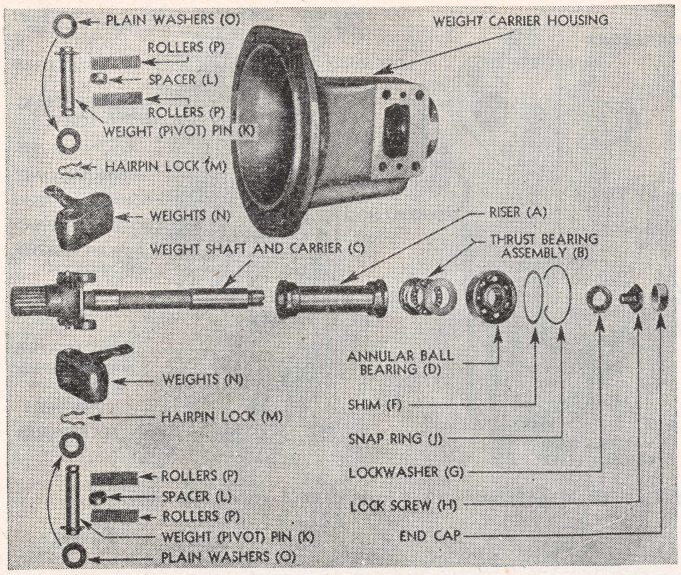
1. Remove hairpin lock and washer from differential lever pivot pin and raise lever from pin.
2. Remove two retaining screws and washers from control adaptor at upper end of housing and withdraw adaptor assembly and gasket.
3. The balance of the operations are the same as for limiting speed governor. Refer, therefore, to "Disassembling Control Housing."

Weight and Housing Disassembly: With the control housing assembly separated from the weight and housing assembly the latter may be disassembled as follows:

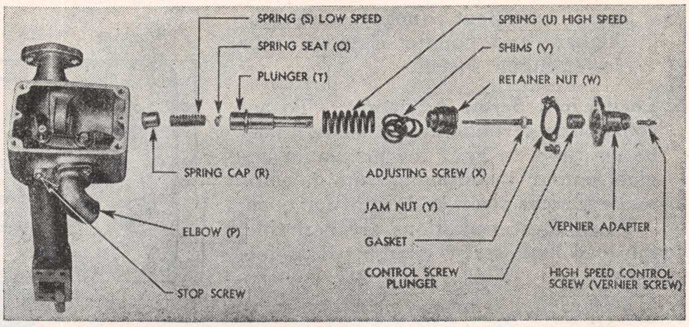
1. Procedure is the same as described for the Limiting Speed Governor under "Disassembling Weight and Housing."
2. Mark weights and carrier with center punch so weights can be replaced in their original locations, then remove hairpin lock from one end of each pin. Hold the weight and carrier assembly over a clean container to catch the rollers inside the weight hubs, and withdraw pins and weights from the carrier.
3. Dislodge bearing lock ring from outer end of housing with sharp-pointed tool, and jar or press bearing from housing. Usually the bearing is not a tight fit in housing and very little pressure is required for removal.

Inspection of Governor Parts: What has been said regarding the inspection of governor parts of the Limiting Speed Governor before those parts are reassembled, applies also to the constant speed governor.

Governor Assembly: The governor may be assembled by reversing the sequence of operations for disassembly. Owing to the similarity in design of the constant speed and



Constant speed mechanical governor weight and housing showing relative position of parts.



Constant speed mechanical governor control housing showing relative position of parts.

the limiting type governors, only those portions of the latter that differ from the former assembly will be discussed in this chapter.

The assembly of this governor will follow the same order as was used on the limiting type, that is:

1. Weight and Housing Assembly.
2. Control Housing Assembly.
3. Control Housing Cover Assembly.

Weight and Housing Assembly: Refer to the illustration and assemble weights, shaft and bearings into housing as follows:

1. Using wood block, tap ball bearing (D) into outer end of weight housing, place shim (F) next to bearing and install snap ring (J) into groove to lock bearing in place.
2. Apply a liberal amount of cup grease to the spacer (L) which is positioned between the two rows of roller bearings inside the weight hubs, and to the rollers (P), and install 22 rollers in each end of the weight hub. Heed the marks previously placed on weights and carrier, position weights (N) between forks of carrier so pivot pin (K) can be dropped into position. Put a plain washer (O) next to hairpin (M) at one end of pin and drop pin through carrier and inside of rollers in weight hub. Put plain washer (O) on free end of pin and lock with hairpin.
3. As balance of the assembly is the same as for the limiting type governor, see "Weight and Housing Assembly."

Control Housing Assembly: Refer to the illustration for relative location of parts in connection with springs and governor control, then follow the instructions under "Control Housing Assembly," for the limiting type governor.

Control Housing Cover Assembly: For instructions relative to servicing this assembly see: "Control Housing Cover Assembly" for limiting speed governor which applies equally as well to this unit.

Governor Adjustments: Five adjustments are necessary on the constant speed governor, as follows:

1. Low speed spring gap adjustment for setting governor linkage.
2. Stop screw adjustment for limiting OFF travel of differential lever.
3. Low speed adjustment for controlling engine idling speed.
4. High speed spring adjustment for controlling engine operating speed.
5. Load Limit Screw adjustment for limiting engine maximum output.

Before attempting any governor adjustments, the following inspections and adjustments should be made:

1. Set valve lash to .008" GO and .010" NO GO.
2. Time injectors according to instructions under "Timing Fuel Injectors."
3. Position injector control racks according to instructions under "Positioning Control Racks."

The five governor adjustments should be made in the order listed, and the following procedure may be used as a guide:

1. Low Speed Spring Gap Adjustment. This adjustment is set at the factory and should require no further change except from parts wear, which takes place slowly. Therefore, unless the adjustment has been tampered with, alterations should not be required. To make this adjustment:

(a) With engine stopped, remove control housing cover and governor link.

(b) Remove adapter from upper end of governor control housing. Loosen lock nut and turn low speed adjusting screw IN until about 1/16" projects from lock nut.

(c) Set throttle lever in idling notch. Turn load limit screw way OUT and tighten lock nut.

(d) Check gap between low speed spring plunger and seat which should measure .170" or exactly 11/64". If gap is not correct, adjust by loosening lock nut and turning screw until correct gap is obtained. Tighten lock nut, if gap is correct.

(e) Install governor link, being sure link is locked at both ends.

(f) Install governor cover.

(g) If low speed spring gap was changed, the injector control racks must be reset after such change. This is done by repeating "Positioning Control Racks," as already described.

2. Stop Screw Adjustment.

(a) Loosen stop screw lock nut and back screw out until it projects ⅝" beyond nut.

(b) Hold injector control tube to position control racks in NO FUEL position.

(c) Turn stop screw IN until injector racks have moved IN about 1/32" from the extreme NO FUEL position. Tighten lock nut.

(d) Check to see that distance from injector rack collar to injector body is at least 27/32".

3. Low Speed Adjustment. The idling speed on the constant speed governor is not so important as on the limiting speed type and may range, therefore, from 300 to 400 R.P.M. Even though the low speed adjustment is set at the factory before the engine is shipped, it may be desirable, at times, either to raise or lower the idling speed of the engine, in which case the adjustment is made as follows: (The engine should be hot and running while making this adjustment.)

(a) Remove adaptor from upper end of governor control housing, and loosen lock nut on low speed adjusting screw.

(b) Adjust screw IN (clockwise) for higher, and OUT (counter-clockwise) for low speed.

(c) Tighten lock nut and replace vernier adaptor.

4. High Speed Spring Adjustment. The governor is adjusted at the factory for the normal operating speed required by the electric generator, which device is usually driven when the constant speed governor is used. The vernier screw provides an adjustment approximately 60 engine R.P.M. above and below this normal speed.

(a) Adjust by turning hand knob on engine instrument panel clockwise for higher, and counter-clockwise for lower engine speeds.

5. Load Limit Screw Adjustment. To accommodate certain kinds of loads, it may be desirable to limit the maximum engine output by stopping the injector racks at some position short of full open.

When these conditions are desirable, the load limit screw is adjusted as follows:

(a) Start and bring engine up to operating temperature.

(b) Loosen load limit screw lock nut and turn screw way OUT.

(c) Throw the desired load on the engine.

(d) Turn load limit screw IN until speed just starts to drop, then back off slightly on screw until engine is operating at governed speed. Tighten lock nut.

VARIABLE SPEED MECHANICAL GOVERNOR

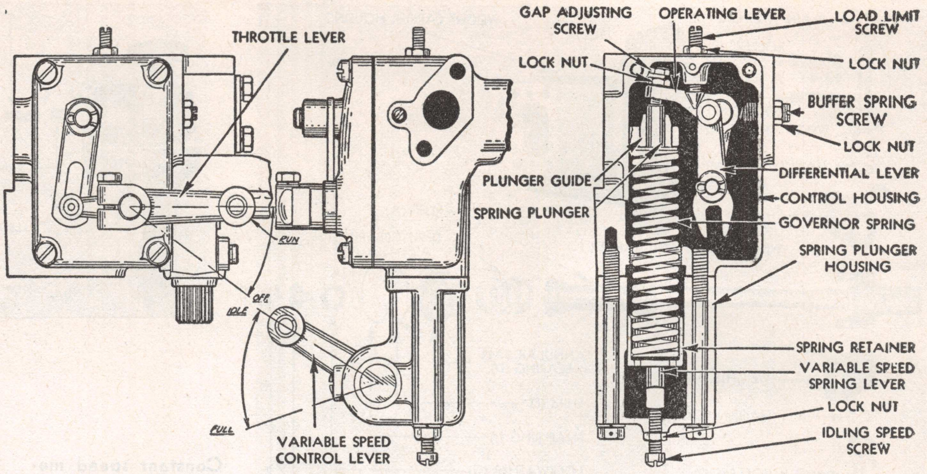
Description: Like the constant speed mechanical governor, the variable speed type has but one set of weights. Unlike the former, however, only one spring is necessary. The governor linkage mechanism consisting of the vertical shaft, its bearings, its allied parts, buffer screw for differential lever and load limit screw are the same for both types.

The plunger at one end of the single spring bears against the operating lever, the opposite end is retained and guided inside a spring retainer which in turn bears against a variable control speed lever.

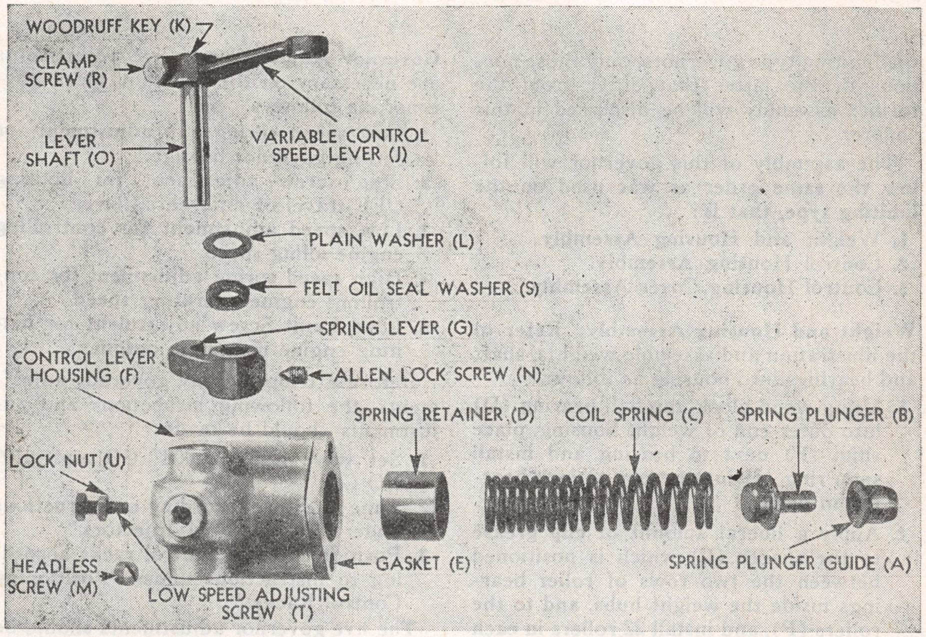
This governor is designed to control the engine at a constant speed at any point within the limitations of the governor spring that the operator may desire. Such control is made possible by the idling screw for the low engine speeds, and imposing more or less tension on the spring by means of the variable speed control lever for higher speeds. The greater the tension on the spring, the higher the engine speed and vice versa.

Lubrication: The lubrication of this governor is exactly the same as for the limiting speed type.

Operation: The operation of the variable speed governor mechanism is similar to that of the constant speed type already described. Two manual controls are provided: the throttle control lever for starting and stopping the engine, and the speed control lever for regulating the operating speed. For starting, the throttle lever is moved to the running position which moves the injector racks to full fuel position. Then, immediately upon starting, the governor moves the injector racks OUT to the position required for idling. The engine is then brought up to any desired operating speed, within the limitations of the spring, by increasing the tension on the spring by means of the speed control lever. As heretofore stated, increasing the tension on the spring raises the governor speed. The engine speed control is entirely automatic from this point on, depending upon spring tension. The engine may be stopped by moving the throttle lever to the OFF position.


THROTTLE LEVER
RUN
OFF
IDLE
FULL
VARIABLE SPEED CONTROL LEVER
GAP ADJUSTING SCREW
OPERATING LEVER
LOAD LIMIT SCREW
LOCK NUT
LOCK NUT
BUFFER SPRING SCREW
LOCK NUT
PLUNGER GUIDE
DIFFERENTIAL LEVER
SPRING PLUNGER
CONTROL HOUSING
GOVERNOR SPRING
SPRING PLUNGER HOUSING
SPRING RETAINER
VARIABLE SPEED SPRING LEVER
LOCK NUT
IDLING SPEED SCREW

Variable speed mechanical governor spring control and cover assembly.


WOODRUFF KEY (K)
CLAMP SCREW (R)
LEVER SHAFT (O)
VARIABLE CONTROL SPEED LEVER (J)
PLAIN WASHER (L)
FELT OIL SEAL WASHER (S)
SPRING LEVER (G)
CONTROL LEVER HOUSING (F)
ALLEN LOCK SCREW (N)
SPRING RETAINER (D)
COIL SPRING (C)
SPRING PLUNGER (B)
LOCK NUT (U)
GASKET (E)
SPRING PLUNGER GUIDE (A)
HEADLESS SCREW (M)
LOW SPEED ADJUSTING SCREW (T)

Variable speed governor control housing spring and lever showing relative position of parts.

Service: The remarks made relative to "Service" on the Limiting Speed Governor, apply equally as well to the variable speed governor. They should, therefore, be carefully reviewed before attempting any governor adjustments or repairs.

Remove Governor From Engine: Removal of governor from the engine is the same as for the previous two types of mechanical governors discussed in this section.

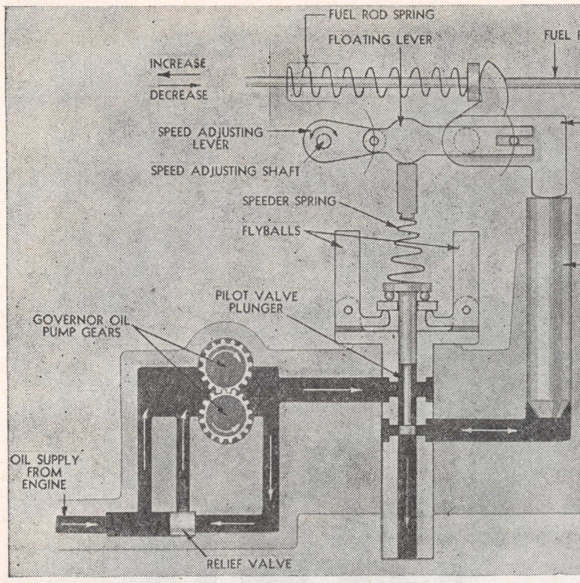
Disassemble Governor: The similarity in design of the variable speed governor to the other two mechanical governors discussed above obviates the necessity of complete tear down operations here. The one sub-assembly which differs slightly from the two previous types is the spring housing and lever assembly. Procedure for disassembly of this sub-assembly is as follows:

1. With the spring housing and lever assembly removed from the governor control housing, loosen the control lever clamp screw and slip lever from shaft. Also, remove Woodruff key.

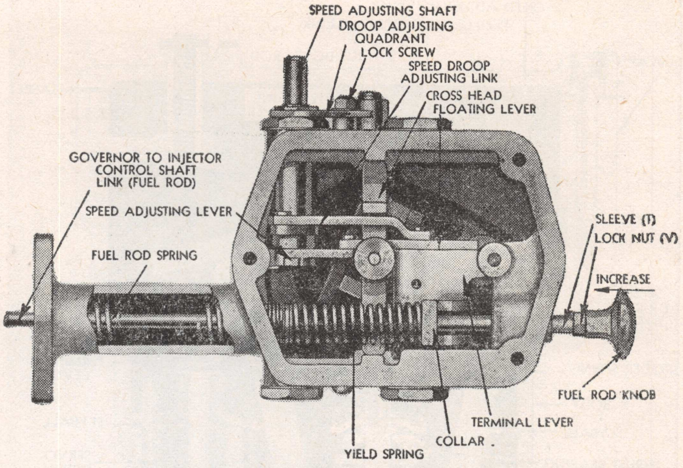
2. Slip plain washer and felt oil seal off lever end of shaft.

3. Remove headless screw from housing then by means of a 3/32 Allen wrench through opening from which screw was removed, back out Allen screw.

4. Pull shaft endwise from housing thus releasing the spring lever from shaft.


FUEL ROD SPRING
FLOATING LEVER
FUEL ROD
INCREASE
DECREASE
TERMINAL LEVER
SPEED ADJUSTING LEVER
SPEED ADJUSTING SHAFT
SPEEDER SPRING
FLYBALLS
SERVO PISTON
PILOT VALVE PLUNGER
GOVERNOR OIL PUMP GEARS
OIL SUPPLY FROM ENGINE
RELIEF VALVE

Schematic drawing showing working principle of hydraulic governor.


SPEED ADJUSTING SHAFT
DROOP ADJUSTING QUADRANT LOCK SCREW
SPEED DROOP ADJUSTING LINK
CROSS HEAD FLOATING LEVER
GOVERNOR TO INJECTOR CONTROL SHAFT LINK (FUEL ROD)
SPEED ADJUSTING LEVER
FUEL ROD SPRING
SLEEVE (T)
LOCK NUT (V)
INCREASE
FUEL ROD KNOB
TERMINAL LEVER
COLLAR
YIELD SPRING

Top view of hydraulic governor assembly.

Governor Assembly: Barring the spring housing and lever assembly, the governor assembly is the same as for the constant speed mechanical governor.

To assemble the spring and housing and lever assembly on this variable speed governor, refer to the illustration for relative location of parts and use the following outline as a guide:

1. Support control lever housing (F) in bench vise and place spring lever (G) in position through opening at flange so that arm on lever points toward opening and lever shaft (O) can slip through hub of lever.
2. Apply some engine oil to shaft journals, and with end of shaft for key pointing out, put shaft (O) in position, so Allen lock screw (N) will enter bevel seat in shaft. Lock screw tight. Install headless screw (M).
3. Crowd felt oil seal washer (S) into counter-bore of housing at lever end of shaft and set plain washer (L) next to felt.
4. Crowd plain washer down tight against felt and place Woodruff key (K) in shaft.
5. Position speed control lever (J) with offset at outer end of lever away from housing, and slip lever over end of shaft tight against plain washer. Tighten clamp screw (R).
6. Attach Control Lever Housing to Control Housing, as follows:
   - (a) With cover removed from control housing, put spring plunger (B) inside spring plunger guide (A) and install in bracket of housing with small diameter of plunger next to adjusting screw of bell crank.
   - (b) Slip loosely wound end of coil spring (C) over end of plunger with opposite end protruding from housing.
   - (c) Lubricate and place spring retainer (D) inside of control lever housing with hollow portion facing finished bolting flange.
   - (d) Shellac a gasket (E) to bolting flange of control lever housing and slide housing assembly into position against control housing with spring entering spring retainer. Secure with two cap screws and lockwashers.
   - (e) Pour about ½ pint of engine oil over governor mechanism.
   - (f) Replace governor cover and gasket and make sure that throttle control lever to differential lever pin is assembled in the differential lever slot.

Governor Adjustments: Three adjustments are necessary on the variable speed mechanical governor, as follows:

1. Spring plunger gap adjustment for setting governor linkage.
2. Low speed adjustment for controlling idling speed.
3. Buffer spring adjustment for limiting OFF travel of differential lever.

NOTE—Before any governor adjustments are attempted the following engine inspections and adjustments should be made:

- (a) Set valve lash.
- (b) Time injectors.
- (c) Position injector control racks.

1. Spring Plunger Gap Adjustment.

- (a) With engine stopped, remove control housing cover assembly.
- (b) Set speed control lever for about ½ speed.
- (c) Check clearance between spring plunger shoulder and seat, which should measure from .010" to .020".
- (d) If clearance is correct, install control housing cover and proceed to adjust idle and buffer screws. If adjustment is required, loosen the gap adjusting screw lock nut and turn screw to obtain proper clearance. Tighten lock nut.
- (e) If adjustment was made, the injector racks must be repositioned as follows:
  - (1) Place throttle lever in running position.
  - (2) Set speed control lever at about ½ speed.
  - (3) Turn out buffer screw until it projects ⅝" from side of control housing.
  - (4) Carry out operations under "Positioning Control Racks."

2. Low Speed Adjustment.

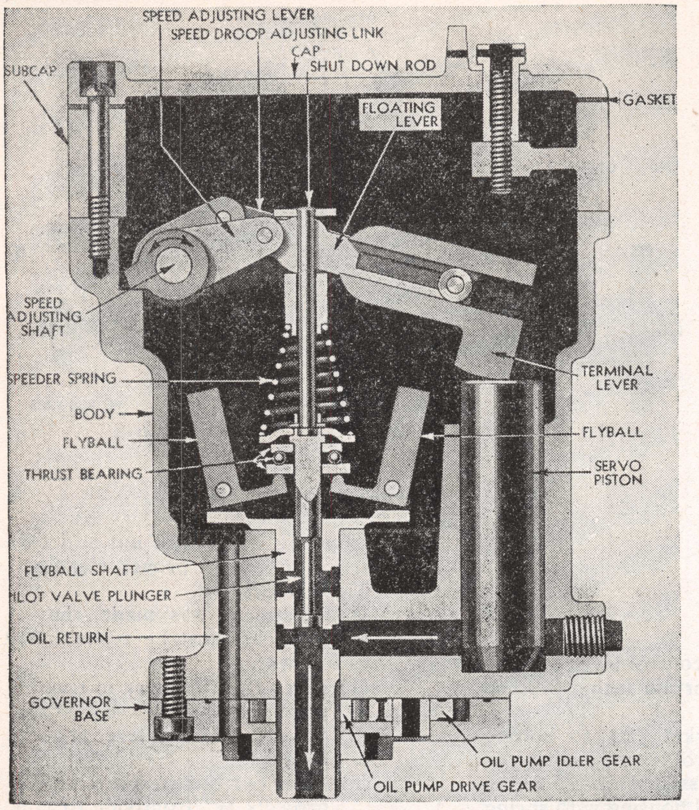
- (a) Back out buffer spring screw until it projects ⅝" beyond lock nut.
- (b) With speed control lever in idling position start engine.
- (c) Loosen idling screw lock nut at end of speed control lever housing and adjust screw until engine speed is approximately 425 R.P.M. Turning screw IN (clockwise) raises, and OUT (counter-clockwise) lowers engine speed. Tighten lock nut.

3. Buffer Spring Adjustment. Turn in buffer spring until engine idles at 430 to 450 R.P.M.

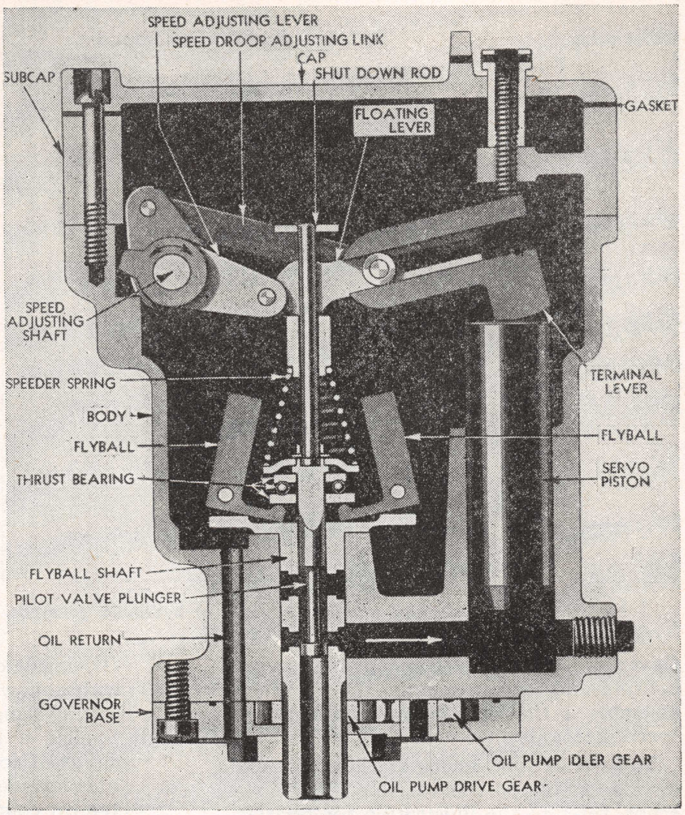
HYDRAULIC GOVERNOR

Description: The governor is the hydraulic type with speed droop stabilization. The hydraulic feature is brought about by oil from the engine lubricating system being admitted, under pressure, to an auxiliary oil pump in the governor. The auxiliary pump furnishes the necessary oil pressure to actuate the governor mechanism. (See Schematic Diagram.)

In this governor, the fuel is decreased by action of a fuel rod spring and increased by the opposing action of a hydraulic servo cylinder, the admission of oil to which, is controlled by a pilot valve. The pilot valve is controlled by the flyballs of the governor. The flyballs are mounted on a vertical shaft and driven through a pair of miter gears from the upper rotor shaft of the blower


SPEED ADJUSTING LEVER
SPEED DROOP ADJUSTING LINK
CAP
SHUT DOWN ROD
SUBCAP
FLOATING LEVER
GASKET
SPEED ADJUSTING SHAFT
PEEDER SPRING
TERMINAL LEVER
BODY
FLYBALL
FLYBALL
THRUST BEARING
SERVO PISTON
FLYBALL SHAFT
ILOT VALVE PLUNGER
OIL RETURN
GOVERNOR BASE
OIL PUMP IDLER GEAR
OIL PUMP DRIVE GEAR

Position of governor mechanism with hand control knob (on dash) in OFF position—Maximum Droop—Hydraulic Governor.


SPEED ADJUSTING LEVER
SPEED DROOP ADJUSTING LINK
CAP
SHUT DOWN ROD
SUBCAP
FLOATING LEVER
GASKET
SPEED ADJUSTING SHAFT
SPEEDER SPRING
TERMINAL LEVER
BODY
FLYBALL
FLYBALL
THRUST BEARING
SERVO PISTON
FLYBALL SHAFT
PILOT VALVE PLUNGER
OIL RETURN
GOVERNOR BASE
OIL PUMP IDLER GEAR
OIL PUMP DRIVE GEAR

Position of governor mechanism with hand control knob (on dash) in FULL position—Minimum Droop—Hydraulic Governor.

at 1.9375 times engine speed. The centrifugal force of these flyballs in rotation is opposed by a so-called "speeder spring," the compression of which, determines the speed at which the governor will control the engine. The compression on the speeder spring is varied by the hand knob on the dash.

If the engine speed drops below that corresponding to the setting of the speeder spring, the flyballs will fall inward, lower the pilot valve plunger, admit oil to the servo cylinder, raise the piston, and increase the fuel supply. If the engine speed increases above that corresponding to the setting of the speeder spring, the flyballs will fly outward, raise the pilot valve plunger, cut-off the oil supply to the servo cylinder, the servo piston will drop and the fuel supply will be decreased. Under equilibrium conditions, the pilot valve is so positioned that its ports are substantially closed, passing only a minute amount of oil required to supply leakage and maintain the servo piston in a given position.

In order that the governor operation may be stable (that is, without hunting), "speed droop," adjustable in amount, is introduced into the governing system. By speed droop is meant, the characteristic of decreasing speed with increasing load. The desired magnitude of this speed droop varies with engine application, and in this governor, may easily be adjusted to suit conditions as will be described in a later paragraph.

As previously stated, the compression on the speeder spring is governed by the position of the hand knob on the dash. With the hand knob in the "OFF" position, the pilot valve plunger is positively lifted by the **"shut-down" rod, and no fuel can be admitted by the injectors. With the hand** knob in the "FULL" position, the speeder spring is fully compressed or set for maximum engine speed with that particular speeder spring. If the hand knob is set at any position between OFF and FULL (above idling position) the governor will open the injector racks to full fuel position, if necessary, as the engine load is increased, and maintain the engine speed (neglecting droop) for that setting.

Hydraulic governors are furnished for 1200 and 1800 engine R.P.M., also for right and left-hand rotation engines making four different governor type numbers. The chart below shows the governor type number for each individual case.

Governor Type No.	G. M. No.	Engine Speed	Used on Engine Series
SGA-9	3224346	1200 R.P.M.	LA, LB, RA, RB
SGA-10	3224347	1200 R.P.M.	LC, LD, RC, RD
SGA-11	3224348	1800 R.P.M.	LA, LB, RA, RB
SGA-12	3224511	1800 R.P.M.	LC, LD, RC, RD

The engine, as shipped, will have the governor properly mounted and connected to the fuel controlling mechanism. The speed adjusting shaft of the governor will also be properly connected to the governor linkage. After all preliminary instructions have been followed and the engine is ready to start, it may be found that several seconds delay occurs before the governor will operate the rack control shaft to start the engine. This time is required to allow the lubricating oil pump to build up pressure and produce the required supply of oil at the governor. The fact that engine lubricating oil is used to actuate the governor, although responsible for this characteristic, also causes it to function as a safety device in the event of complete lubricating oil failure. If this delay in starting is considered objectionable, the time can be shortened by pressing in on the knob which projects from the rear of the governor. This knob is on the fuel rod, which connects directly to the injector control shaft, and pushing it in takes the control away from the governor. **This last fact should be remembered.** In a similar manner the engine can be stopped, regardless of the governor, by pulling out on the knob. Considerable force must be exerted to do this as spring pressure must be overcome. The knob thus functions as an emergency stopping device for the engine.

The speed droop requirements of the governor will vary with different installations. In general, the engine will run with the least speed droop that will give the desired stabilization (without hunting) over the operating range. In special cases, as when two units are to be paralleled, greater speed droop may be required in order to match units and secure the proper division of load.

The speed droop is adjusted by movement of the slotted quadrant at the side of the governor body. The quadrant is raised to decrease and lowered to increase the speed droop.

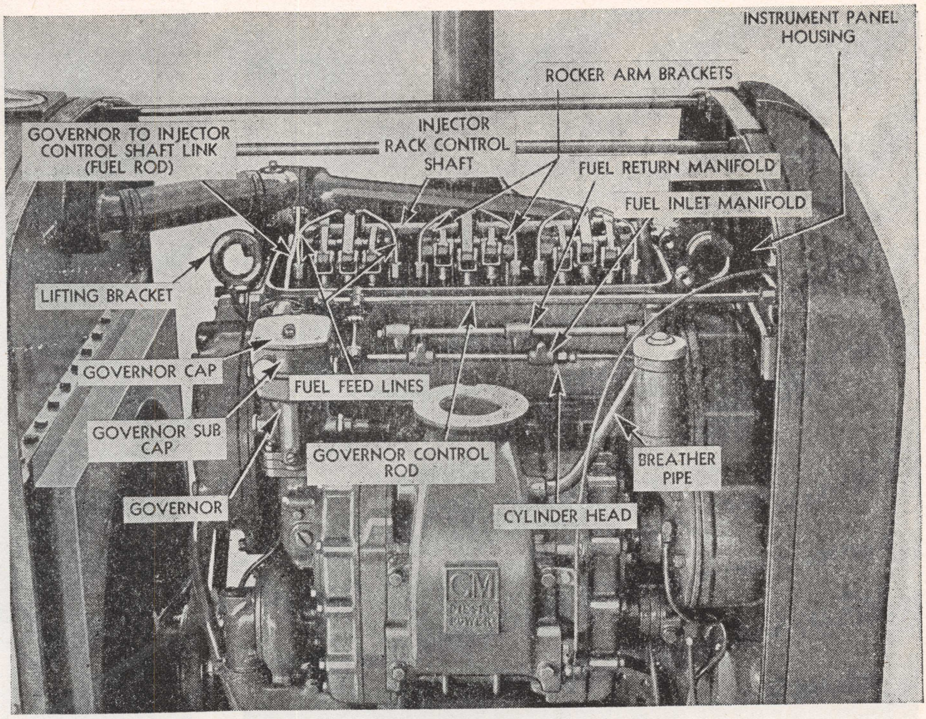
Governor Lubrication: The governor is lubricated by oil introduced into the governor housing past the servo piston and pilot valve plunger, which is broken up into a fog by the governor flyballs. Oil which collects on the floor of the governor, drains into the bevel gear drive beneath the governor. After reaching a certain level in the governor drive housing, the oil returns through the drive gear bearings to the oil reservoir in the blower housing, thence to the engine oil pan.

Service: What has been said regarding engine condition vs. governor operation in connection with the mechanical governor "Under Governor Service," applies also to the hydraulic governor.

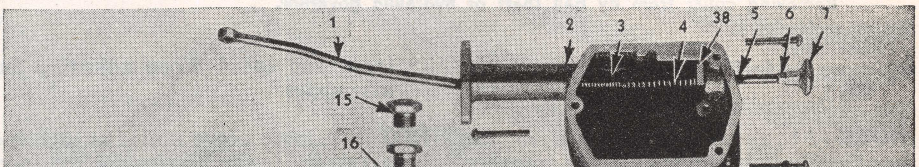
Inasmuch as the hydraulic governor employs a bevel gear drive, whereas such a feature is unnecessary on the mechanical governor, some additional checks, in addition to the ones referred to above, should be carried out before drawing any hasty conclusions on supposedly faulty governor operation. These additional checks apply to the hydraulic governor only. If neither load nor engine irregularities are found to be the cause of the speed variations, it may be either in the governor or the drive. If the speed changes in regular oscillations (a hunt), gradually increase the speed droop of the governor as above described until the hunt ceases. If the hunt cannot be eliminated by this method, the governor may be at fault. If the speed variations are erratic but small in magnitude, the fault may lie in the governor drive. Excessive back-lash in the coupling or the miter drive gears, or too tight meshing of the latter, may cause this condition. If, for any reason, such as worn blower rotor bearings or rubbing of the rotors on the housing, or the load on the flexible coupling between the blower and the engine varies erratically, this variation will be transmitted to the governor as a speed change, and, it in turn, will attempt to compensate for this by changing the fuel shaft position. No amount of adjustment or other work on the governor can correct this condition.

If the speed variations are large and erratic, and unaffected (except, perhaps, in magnitude) by changes of speed droop adjustment, or if the governor fails to control at all, it should be repaired or replaced.

As a last resort, to prove whether the governor or engine is at fault, a master governor may be installed on the engine. If this is done, see that the master governor bears the same type number as the one being removed. The type number is important because of the right- and left-hand rotation, as well as the different size governor weights. (See "Governor Type Numbers.") If checks show the governor to be at fault, it should be removed and either overhauled or replaced.



Hydraulic governor connections to engine.

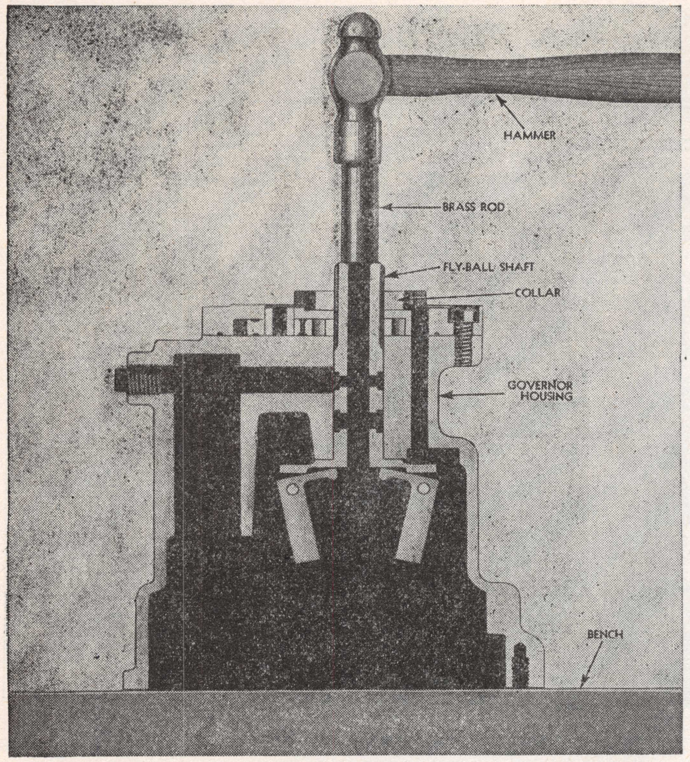


1 GOVERNOR TO INJECTOR CONTROL SHAFT LINK (FUEL ROD)
2 SUBCAP
3 FUEL ROD SPRING
4 YIELD SPRING
5 SLEEVE
6 LOCK NUT
7 FUEL ROD KNOB
8 CAP
9 COLLAR
10 BASE
11 RUBBER SEAL
12 OIL PUMP DRIVE GEAR
13 OIL PUMP DRIVEN GEAR
14 GOVERNOR BODY
15 PLUG
16 TERMINAL LEVER SUPPORT
17 FLYBALL SHAFT
18 THRUST BEARING
19 PILOT VALVE PLUNGER
20 SPEEDER SPRING
21 SHUT DOWN ROD
22 GUIDE CROSS HEAD
23 RELIEF VALVE ASSEMBLY
24 TERMINAL LEVER
25 SPEED ADJUSTING SHAFT
26 SERVO PISTON
27 FLOATING LEVER
28 SPEED DROOP ADJUSTING LINK
29 SPEED ADJUSTING SHAFT SLEEVE
30 SPACER
31 DROOP ADJUSTING QUADRANT
32 SEAL
33 WASHER
34 LOCK SCREW WASHER
35 SHAFT LOCK RING
36 LOCK SCREW
37 SQUARE SLEEVE
38 COLLAR

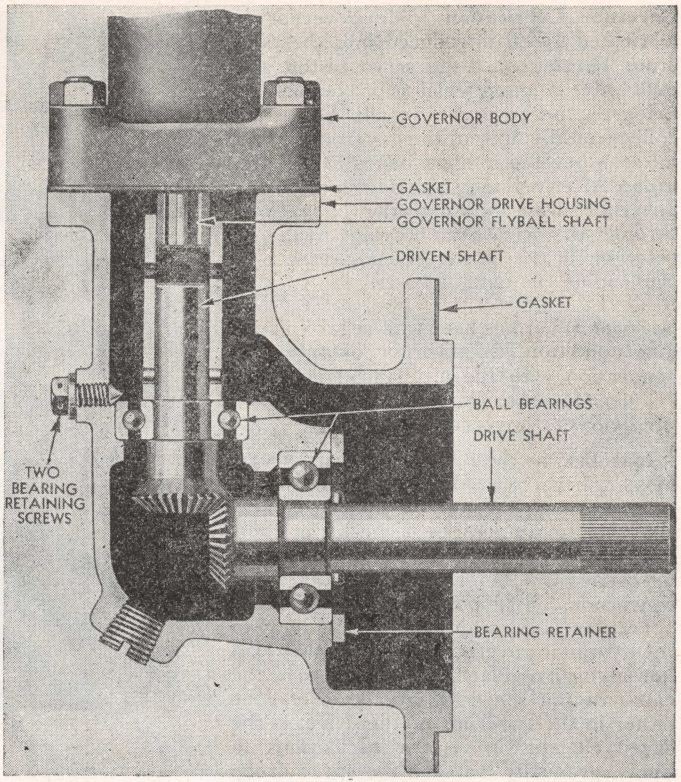
Layout of hydraulic governor showing relative position of parts.

Remove Governor From Engine: In case of major repairs or a governor change, the unit may be removed from the engine as follows:

1. Remove valve rocker cover and the clevis pin which attaches the fuel rod to the injector control rack shaft lever.
2. Disconnect the governor linkage from the speed adjusting shaft, and the oil line to the governor.
3. Remove two capscrews that attach the governor sub-cap to the cylinder head.
4. Remove the four capscrews that attach the governor to the drive assembly and carefully lift the governor vertically away from the drive coupling and with-



Removing collar from fly ball shaft of hydraulic governor.



Hydraulic governor drive assembly.

draw the fuel rod from hole in cylinder head.

NOTE—At all times use care in the handling and setting down of the governor to avoid striking the end of the drive shaft a sharp blow which might move the thrust collar, pressed thereon, and result in excessive lost motion vertically.

Disassemble Governor: After removal from engine the governor may be disassembled as follows:

1. Loosen three screws and remove cap and sub-cap from governor body.

NOTE—The cap alone cannot be removed from the sub-cap without removing the load limit lock nut. This nut or the load limit screw should not be tampered with, as they are set and sealed at assembly. There will be no need for removing the cap from the sub-cap, as there are no parts to cause trouble in this assembly.

2. Back out the terminal lever supporting screw at the side of the governor body, and remove the lever and the bushing from the stud at the outer end of the speed droop adjusting link.
3. Remove the droop lock screw washer and spacer at the side of governor body.
4. Remove plug at front of governor body so speed adjusting shaft can be pushed from position.
5. Remove lever from outer end of speed adjusting shaft, then tap outer end of shaft with wood block thus dislodging lock wire washer, and droop adjusting quadrant. Push shaft from position and remove floating lever, speed adjusting **lever, and speed droop adjusting link assemblies.**

NOTE—A loose sleeve slotted at each end, is carried inside the bearing for the speed adjusting shaft; the droop adjusting quadrant is carried at the outer, and the droop adjusting link at the inner slotted ends of this sleeve. There will be no need for removing this sleeve if it rotates freely in the bearing.

6. Remove the cross head, shut down rod, speeder spring, thrust bearing, and pilot valve plunger as an assembly from the governor body. If occasion requires, to change the speeder spring or the pilot valve plunger, the shut down rod may be removed from the plunger assembly by driving the pin from the top of the plunger.
7. Remove the servo piston from the governor body.
8. Rest the governor body on a bench bottom-end up, and using soft bar on lower end flyball shaft, drive shaft through collar.
9. Remove the three fillister head screws and the governor base, including oil pump gears, from the governor body. Be careful not to damage rubber seal imbedded in groove of governor base.
10. Loosen and remove the relief valve assembly and copper gasket from side of governor body.

NOTE—No attempt should be made to disassemble the relief valve assembly. If the relief valve is stuck or otherwise inoperative, the entire assembly should be replaced.

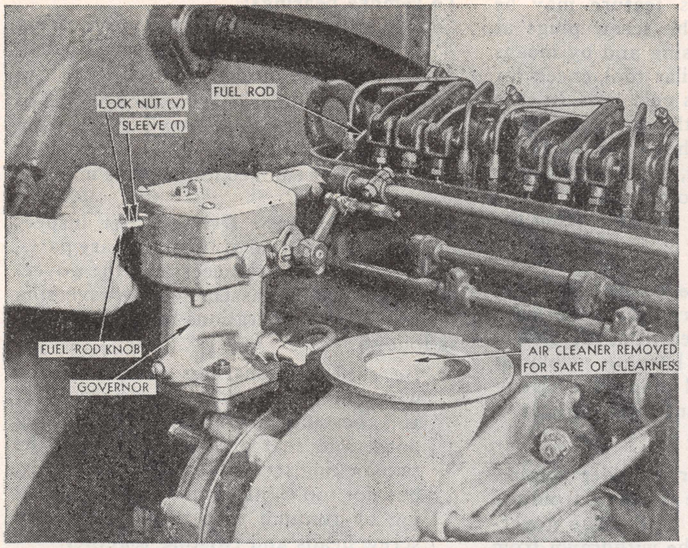
Inspection: Before reassembling the governor, wash all parts in clean gasoline and carefully inspect for wear.

The servo piston should move freely in the cylinder, but the clearance between piston and cylinder should not be excessive. The pilot valve plunger should move freely in the governor flyball shaft. If the plunger has become damaged or scratched on the outside surface, it may be dressed off with crocus cloth. If crocus cloth is used the sharp edges of the cut-off, at the lower end of the plunger, should not be rounded.

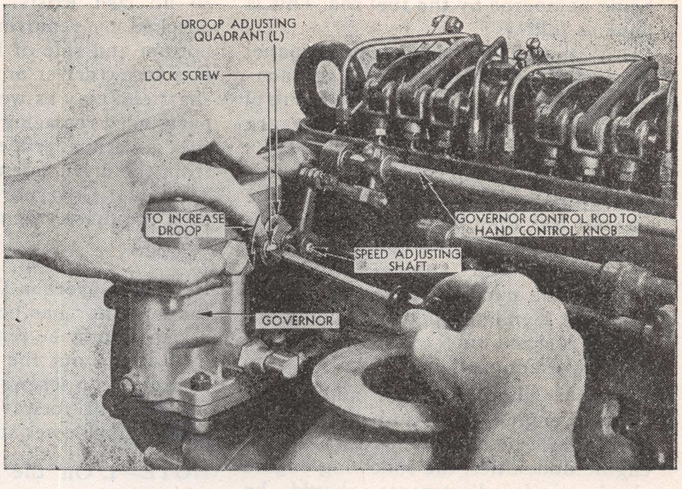
The governor weight shaft should rotate freely in the governor body when the governor base, including the oil pump, is installed. Bind might occur in the governor weight shaft either from slight misalignment of the governor base with the governor body, or from the collar, rubbing against the governor base at lower end of the flyball shaft. This latter condition may be corrected by tapping the lower end of the governor shaft with a block of wood. The collar should be pressed onto the shaft just far enough to provide free shaft movement without shaft end play.

The flyballs should work freely on their supporting pins for satisfactory governor action. The cross-head should move freely in the ways, and all joints and bearings in connection with the floating lever, speed droop adjusting link, and speed adjusting shaft, should move freely when in place.

Governor Assembly: All parts having been cleaned and inspected, the governor may be assembled. As the various moving parts are assembled, dip in clean gasoline (if cloth is used, beware of lint) and lubricate with engine oil to insure free movement.



Fuel rod adjustment—Hydraulic governor.


DROOP ADJUSTING QUADRANT (L)
LOCK SCREW
TO INCREASE DROOP
GOVERNOR CONTROL ROD TO HAND CONTROL KNOB
SPEED ADJUSTING SHAFT
GOVERNOR

Speed-droop adjustment—Hydraulic governor.

Furthermore, after the governor has been completely assembled, apply a liberal amount of good clean engine oil over all the moving parts of the governor; thus insuring initial lubrication.

The governor may be re-assembled in the following manner and refer to the Layout of Governor Parts illustration:

1. Support governor body in bench vise and install the relief valve assembly (23) at the side of the governor housing, being sure the copper gasket is in place under head of screw and that the assembly is tight against gasket.
2. Replace the two oil pump gears (12 and 13) in the governor base (either side up) wipe the adjoining surfaces of base and governor body clean, see that neoprene seal ring is in place in base and not damaged; and, holding base and gears face up, set body onto base with dowels in base registering with holes in body. Temporarily, slide flyball shaft (17) down through body and base, to align the two pieces, then replace the three fillister head screws through base and draw up evenly. Revolve the flyball shaft during the tightening process to make sure shaft revolves freely.
3. With flyball and shaft assembly down in governor body, support piece of ½" rod in bench vise. With upper end of flyball shaft resting on rod install collar (9) over end of shaft and tap into position with convenient hollow sleeve and hammer. The collar must not be driven too far onto shaft, neither should end play exist. The shaft should turn freely.
4. Moisten surface with oil and drop servo piston (26) into place, cone end down.
5. Being sure the ball thrust bearing (18) is in place on pilot valve plunger (19), with large washer next to flyballs, slide cross head (22) and plunger assembly into place with guide at top of cross head at same side of governor body as the speed adjusting shaft is installed. After installing, slide cross head up and down with fingers to insure free movement in ways.
6. See that sleeve (29) is in place inside of speed adjusting shaft bearing, then put droop adjusting link (28) in position, with inner end of link over slotted end of sleeve, and side of link riding on lug of cross head. Put speed adjusting lever (27) up against link, with stud at outer end of link in slot of floating lever. With link and lever held in these positions, slide the speed adjusting shaft (25) through the two pieces and bearing, with flattened portion of shaft head engaging slot of speed adjusting lever and undercut at outer end of shaft, for lever lock screw, pointing down.
7. The droop adjusting quadrant (31) engages the slotted end of the loose sleeve (29) so as to actuate the speed droop adjusting link, at opposite end of sleeve. The quadrant can be located in only one position on the sleeve and get full travel of the adjusting link. With link placed for minimum droop, locate quadrant so lock screw (36) is at lower end of slot.
8. Holding shaft from backing out, replace washer (32) over outer end of shaft and slide lock wire (35) into groove over end of shaft. Hold spacer between governor body and adjusting quadrant and put plain washer (33), lockwasher (34), and lock screw (36) in place to hold quadrant. Replace lever at outer end of speed adjusting shaft.
9. Replace plug (15), in governor body.
10. Replace the sleeve (37) on stud at outer end of adjusting link (28), then slide terminal lever (24) into place, with sleeve on link sliding in slot of lever. Replace the terminal lever supporting screw (16) holding lever in place.
11. Push the shut-down knob (7) way in so that the fork on the terminal lever straddles the fuel rod (1) and lays back of the collar (38) on the fuel rod; then locate the cap (8), sub-cap (2), and fuel rod assembly in position at top of governor body. Install the three screws holding cap and sub-cap in place.

Attach Governor to Engine: After the governor has been completely reassembled and the governor drive checked and loosely attached to the engine, the governor may be attached. This should be done with care to avoid forcing into position, as follows:

1. Using a standard gasket between governor base and drive housing, also paper gasket at each face of governor control rod bracket at forward end of control rod and positioned between governor sub-cap and cylinder head, put governor in position with fuel rod through hole in gaskets, bracket and cylinder head.
2. Bolt governor and drive housing together, then rock governor and drive assembly to see that the two attaching screws at cylinder head can be started into threads without forcing and that governor sub-cap, bracket and gaskets make tight joint to cylinder head without cramping. If so, draw up cap screws at this point and tighten retaining screws between governor drive and blower.
3. Remove the three screws holding governor cap in place. Slide cover sidewise and pour about ½ pint of engine oil over governor operating mechanism.
4. Connect fuel rod to injector rack control shaft lever.
5. Connect governor linkage to speed adjusting shaft, being sure to put cotter pins in place. Connect oil line to governor.

NOTE—This linkage connects governor speed adjusting shaft to the control rod. The control rod in turn carries a knob at the instrument panel which indicates OFF and FULL throttle positions. The levers on shaft and control rod should be so positioned that injectors are in the full OFF position when knob at dash on control rod is in the OFF position.

6. Check to see if fuel rod adjustment is such that injector racks can be returned entirely to the OFF position without

being hampered by the fuel rod. This is done as follows:

(a) With fuel knob on instrument panel in OFF position and fuel rod connected to injector rack control shaft lever, measure the distance between the injector body and the shoulder of the collar on the injector rack. This distance should be not less than 27/32". If distance is less than this amount **do not attempt to start engine,** as injectors may be partially open and engine must then be stopped by pulling out on fuel rod knob to throw governor out of action.

7. After attaching governor and before starting engine, to be sure that governor will not be condemned for possible engine difficulties, the following engine checks and adjustments should be made unless perchance such are known to be correct.
   (a) Check valve lash to .008" GO .010" NO GO.
   (b) Time injectors as directed under "Time Injectors." Start engine for governor adjustments given below:

HYDRAULIC GOVERNOR DRIVE

Description: As will be seen from illustration, the hydraulic governor drive consists of a combined horizontal drive shaft and bevel gear and a combined vertical driven shaft and bevel gear; both mounted on ball bearings and retained inside a cast iron housing.

For the three and four cylinder engines, the drive shaft is mounted on one ball bearing, and on two bearings for the six cylinder. The driven shaft is mounted on one ball bearing for all three engines.

Drive to the horizontal shaft is by means of serrations on inner end of the shaft to mating serrations inside the upper rotor shaft of the blower. By the same method the governor flyball shaft is driven off the vertical shaft by means of splines inside a sleeve pressed on and pinned to the vertical shaft.

The bearing or bearings on the horizontal shaft are positioned by a removable retainer, and on the vertical shaft by two lock screws. The housing flange at the drive shaft is gasketed and bolted to the front blower end plate, while the governor proper is gasketed and bolted to the flange at opening for the driven shaft.

Lubrication: Gears and bearings of the governor drive assembly are lubricated by drain back from the governor proper which spills over the moving parts and then drains into the blower end cover compartment.

Service: If the governor and drive have had considerable use and the governor fails to control the engine speed properly, the fault may lie in either the governor or the drive. To function properly the back lash in the bevel gear drive should not exceed .003", and .002" is more desirable. On the other hand, the gear teeth must not bottom so no lash exists. This feature may be checked by removing the screw plugs at bottom and side of housing and by means of a screw driver or similar tool, check for shaft end play as well as gear lash. In case parts need replacing in the governor drive, the governor proper should be removed from the drive assembly, as directed under "Remove Governor from Engine," and then the drive assembly removed from the blower.

Remove Governor Drive Assembly: After the governor has been removed, the drive assembly may be removed from the blower by backing out the six housing to blower retaining cap screws and pulling the assembly straight forward until drive shaft is free of the blower shaft.

NOTE—1. On the four cylinder engine, the water pump must be removed from the blower end plate cover before the governor drive assembly can be withdrawn from position.

NOTE—2. The special wrench for removing fuel pump may be used to advantage in removing rear retaining cap screw between governor drive housing and cylinder block.

The gasket between the two members can usually be preserved if care is exercised in the withdrawal.

Disassembly of Governor Drive: To disassemble the governor drive:

1. Remove screws from drive shaft bearing retainer.
2. Clamp serrated end of drive shaft between brass jaws in bench vise, tap housing with block of wood and remove shaft and bearing assembly.

NOTE—Some of the earlier design governor drives used a spacer to retain the ball bearing for the driven shaft. This spacer may be slipped from upper end of housing. Two lock screws were later substituted for the spacer.

3. Remove two cone pointed lock screws from vertical driven shaft and bearing assembly from housing by inverting housing and tapping on bench at governor bolting flange.

Inspection: After disassembly wash parts in clean gasoline before inspecting.

Examine gear teeth for rough marks, chipping, or scoring. Any one of these conditions will render the gears useless for further use.

After washing and blowing out with dry air, revolve the bearings slowly by hand for rough spots. Bearing should roll freely and smoothly. Slight end play is not objectionable in single row annular ball bearings, in fact, they are built with that characteristic.

If inspection shows bearings to be satisfactory, lubricate each one with engine oil preparatory for assembly. If bearings are found to be unsatisfactory for further use, as is rarely the case, they must be removed from the shafts and new bearing substituted.

To remove bearings:

(a) Knock out pin holding inner bearing race on drive shaft or sleeve holding inner race on driven shaft.

(b) Support inner bearing race on bed of arbor press and crowd shaft from race. The bearings from either shaft may be removed in the same manner.

Assemble Governor Drive: After inspection and substitution of the necessary parts, if substitutions were necessary, the governor drive may be assembled by reversing the sequence of operations for disassembly, as follows:

1. Be sure ball bearings are lubricated with engine oil, then set driven shaft and bearing assembly with bearing down into seat of housing. Install the two locking screws and draw up evenly, but not too tight, then lock from turning by running wire through holes in screw heads and twisting together.
2. Bear in mind that drive shaft for the three and four cylinder governor drive is supported on one bearing only. The six cylinder on two bearings. With this difference in mind, lightly tap drive shaft and bearing assembly into bearing seats of housing, and lock in place by installing screws and lockwasher for bearing retainer.

After assembly, support drive shaft between copper jaws of bench vise, remove inspection plugs at bottom and side of housing and check end movement of shaft assemblies, also back lash of gears. There should be no end movement of shafts, and desired back lash is .002" with a maximum of .003". Replace inspection plug.

Attach Governor Drive to Engine: The governor drive assembly may be attached to the front blower end plate cover by reversing the sequence of operations for removal. Bear in mind during this assembly that on the four cylinder engine the governor drive must be attached before the water pump is bolted in position. With this difference in mind, shellac a gasket to housing flange at connection to blower and slide assembly straight into position so that serrations on drive shaft enter mating serrations on blower upper rotor shaft. Using the six cap screws and lockwashers, turn attaching screws finger tight only.

NOTE—The special wrench for removing fuel pump, may be used to advantage in removing and replacing rear retaining cap screw between govenor drive housing and cylinder block.

After governor drive assembly has been installed, attach governor to housing and engine as described under "Attach Governor to Engine."

Governor Adjustments: The hydraulic governor has two adjustments:

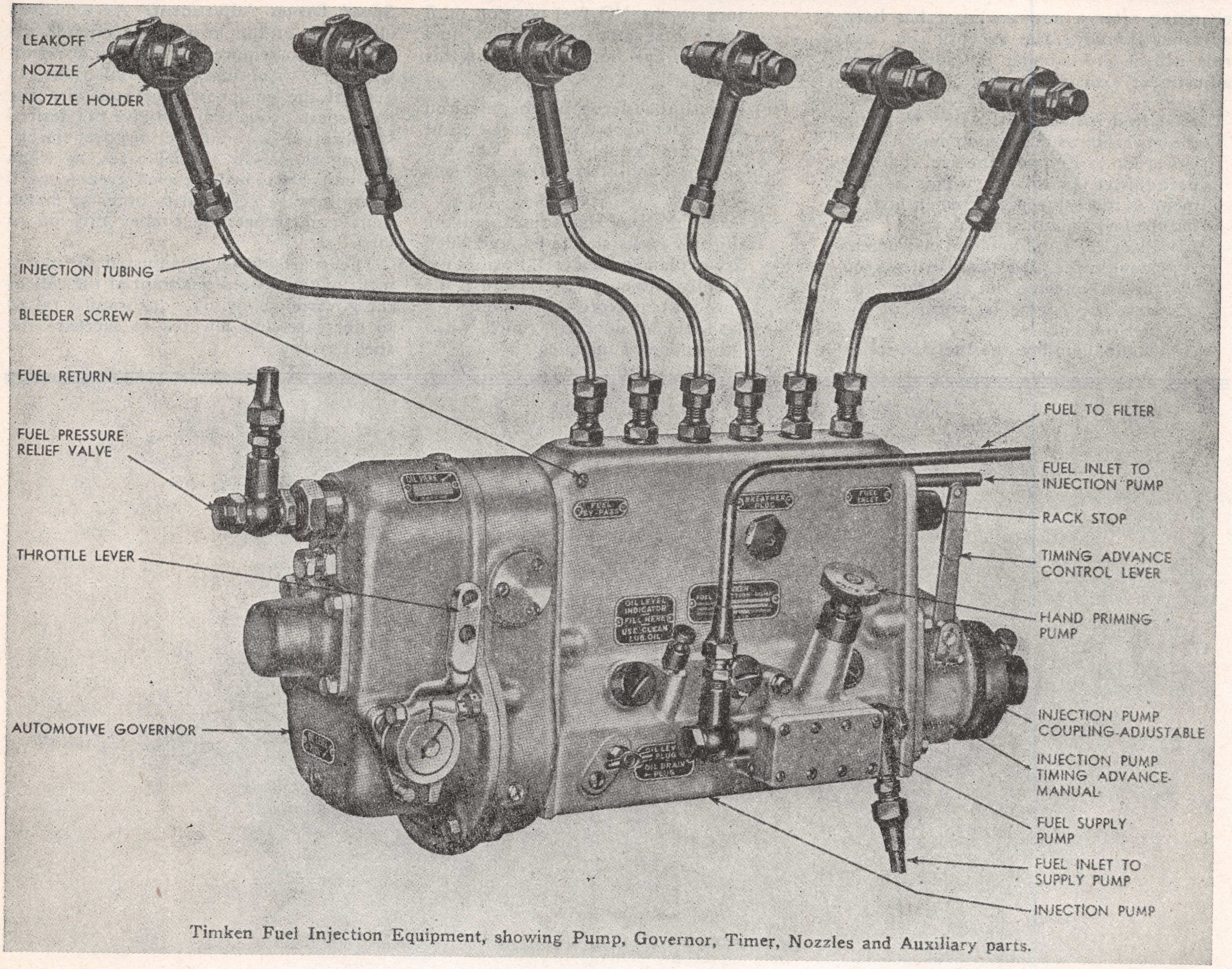
(a) Fuel rod adjustment.
(b) Speed droop adjustment.

Both of these adjustments should be made whenever a new governor is mounted on the engine and will probably rarely need changing after a new governor has been adjusted initially. The exception to this rule will be given under the speed droop adjustment explained below:

1. **Fuel Rod Adjustment.** After installing the governor as directed under "Attach Governor to Engine," the fuel rod may be adjusted as follows: (This adjustment is rarely necessary when installing the original governor.)
   (a) Place the hand knob on instrument panel in the OFF position (to keep the servo piston out of action) and start the engine by means of the fuel rod knob.
   (b) Gradually allow the fuel rod to return to the NO fuel position until the engine stops, then allow fuel rod to travel out 1/16" beyond this point.
   (c) Adjust the sleeve on the fuel rod to this valve by turning lock nut and outer knob. Tighten lock nut against knob after making the adjustment.
   (d) After the fuel rod adjustment the injector racks should be positioned as explained under "Positioning Control Racks," then adjust the speed droop. Note that valves were lashed and injectors timed when governor was installed.

Speed Droop Adjustment: As explained elsewhere in the governor section: "the speed droop requirements of the governor will vary with different installations. In general the engine will be run with the least speed droop that will give the desired stabilization (without hunting) over the operating range. In special cases, as when two units are to be paralleled, greater speed droop may be required in order to match units and secure the proper division of load."

The speed droop is adjusted by movement of the slotted quadrant at the side of the governor body. The quadrant is raised to decrease and lowered to increase the speed droop


LEAKOFF
NOZZLE
NOZZLE HOLDER
INJECTION TUBING
BLEEDER SCREW
FUEL RETURN
FUEL PRESSURE RELIEF VALVE
THROTTLE LEVER
AUTOMOTIVE GOVERNOR
FUEL TO FILTER
FUEL INLET TO INJECTION PUMP
RACK STOP
TIMING ADVANCE CONTROL LEVER
HAND PRIMING PUMP
INJECTION PUMP COUPLING-ADJUSTABLE
INJECTION PUMP TIMING ADVANCE-MANUAL
FUEL SUPPLY PUMP
FUEL INLET TO SUPPLY PUMP
INJECTION PUMP

Timken Fuel Injection Equipment, showing Pump, Governor, Timer, Nozzles and Auxiliary parts.

Timken fuel injection equipment.

TIMKEN

The Timken Fuel Injection Pumps for Diesel engines are multiple unit, integral camshaft pumps. Two sizes are available, one with a plunger diameter range of 4 mm. to 9 mm.; the other with a plunger diameter range of 5 mm. to 11 mm. Both units are made for engines of from one to eight cylinders.

The small size, or model "A" using the 4 mm. to 9 mm. plunger range is designed for use on Diesel engines up to approximately 150 horsepower, and operating at speeds up to 4,000 revolutions per minute. The larger or model "B" with the 5 mm. to 11 mm. plunger range is for use on engines from 110 to 250 horsepower, at speeds up to 3,000 revolutions per minute.

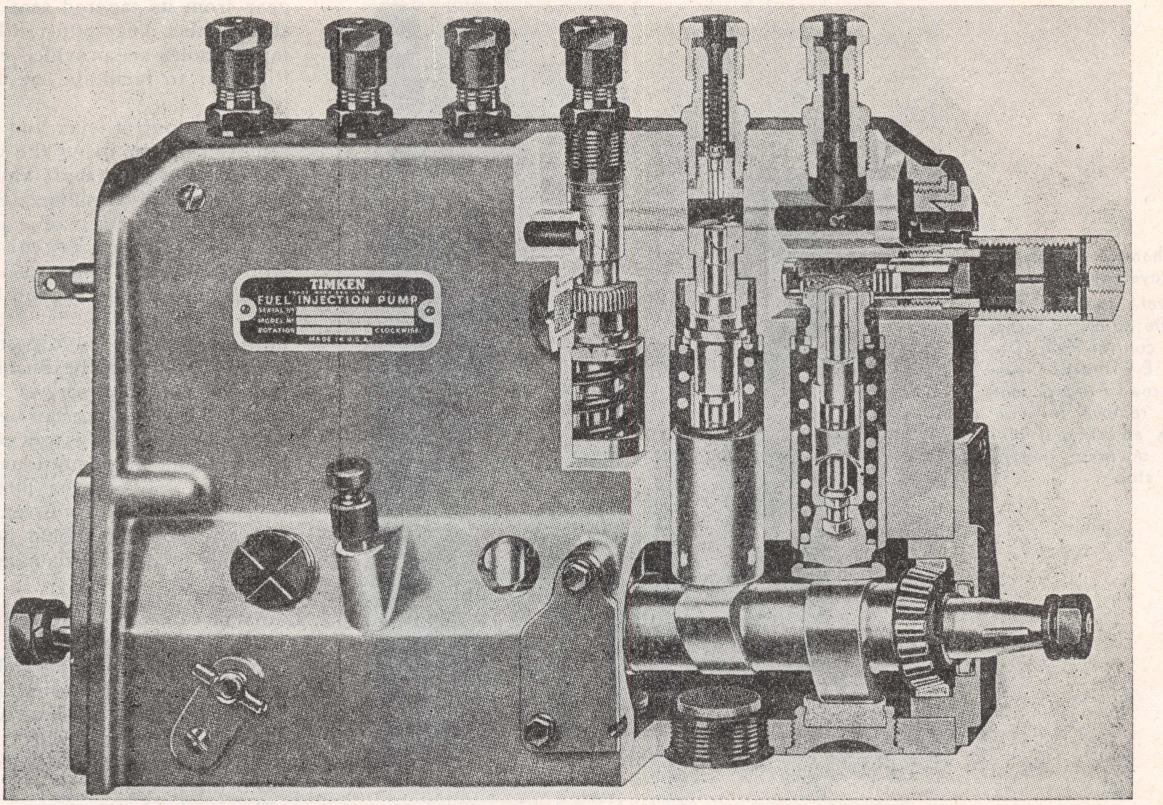
OPERATING PRINCIPLE

The Timken pump is a constant velocity, cam-operated, helical plunger design, the camshaft being mounted on single-row Timken Bearings. The delivery speed of the fuel entering the combustion chamber of the engine is maintained constant at a speed adapted to the rate of combustion, thereby increasing the efficiency and fuel economy of the engine. The metering is adjusted and sealed at the factory. The deceleration of the motion comes late in the stroke, which permits the use of a lighter spring and eases the spring load between the tappet and the cam.

Fuel is delivered to the Timken pump by means of a special pump in the feed line, which is connected to the fuel tank. A full charge of oil enters the cylinder when the plunger is in the lowest position. Delivery of fuel to the engine starts as soon as the plunger covers the inlet port. It ends when the upper helical edge of the annular groove in the plunger opens the overflow or by-pass port on the opposite side of the pump cylinder wall, releasing the pressure in the discharge line. The effective delivery stroke of the plunger or throttle position may be varied by turning the plunger in its cylinder to change the point of the delivery stroke at which the overflow port is uncovered.

The plungers may be adjusted to vary the amount of fuel delivered by means of a simple and positive method. A control rod extends horizontally along the rear face of the pump, meshing with precision cut gears on the upper members of the pairs of plunger control sleeves. The upper or driving sleeve for each plunger may be rotated on its barrel. This upper sleeve is tongue and slot connected with the lower sleeve, which fits on the plunger. As the upper sleeve is rotated on the barrel, the lower sleeve rotates the plunger, which changes the position of the helix with respect to the relief port.

Surrounding these sleeves are light helical springs, which serve to retract the plungers. The tappet cup, which is the automotive barrel type, is so designed as to ride on the cam and spin in operation, distributing the wear evenly over the entire surface. The design of the tappet and lower spring collar does not provide for an adjustment between the plunger and cam. The injection timing depends entirely on the accuracy of the parts. The entire



Timken fuel injection pump.

assembly is made to Timken precision standards and is not subject to field adjustment.

To adjust the individual metering sleeves on the plungers, the control rod is provided with a series of detachable rack sections which mesh with the gears of the metering or driving sleeves. These are adjusted longitudinally on the control rod and locked in position by means of two horizontally spaced parallel screws with conical ends. The space between the two screws is less than the space between the conical recesses in the movable sections, thus enabling the sections to be moved slightly as the screws are tightened and loosened. Provision is made at the back of the pump housing to set these rack sections, which should only be done at the factory or by an authorized service man, and the back opening is made deliberately to discourage attempted adjustments in the field by mechanics who are not familiar with the delicate mechanism of these pumps. This construction provides a method of metering adjustment which assures the delivery of identically the same amount of fuel to each cylinder of the engine.

A special stop is provided in connection with the control rod, which controls the metering sleeves, whereby the maximum amount of fuel delivered to the engine may be definitely limited. At one end of the control rod a knurled nut controlling the stop is provided by means of which the maximum amount of fuel can be limited according to the altitude at which the engine is operating. A series of cotter pin holes are drilled through this nut, the space between each hole representing the change required in adjustment for a thousand-foot change in altitude.

In the event that it should become necessary to prime the Timken pump, provision has been made to do so without endangering the precise adjustment. Priming is accomplished by operating the hand supply pump to bring the oil from the tank to the injection pump. The injection pump, when fuel is present, can also be operated to advantage by inserting a screwdriver or priming lever under each tappet. Since the force is applied under the tappet, there is no possibility of distorting the plunger or other close-fitting parts.

Injection Pump Lubrication: When the fuel injection pump is first put into service, or after an overhauling, and the lubricating oil has been drained, it will be necessary to fill the pump base with the same oil as is used in the engine crankcase. It can be filled through the fuel injection pump oil level gauge hole and should be filled to the mark on the gauge rod. It is also recommended that the oil be drained from the pump base and refilled with clean oil to the proper level at each time the oil in the engine crankcase is changed.

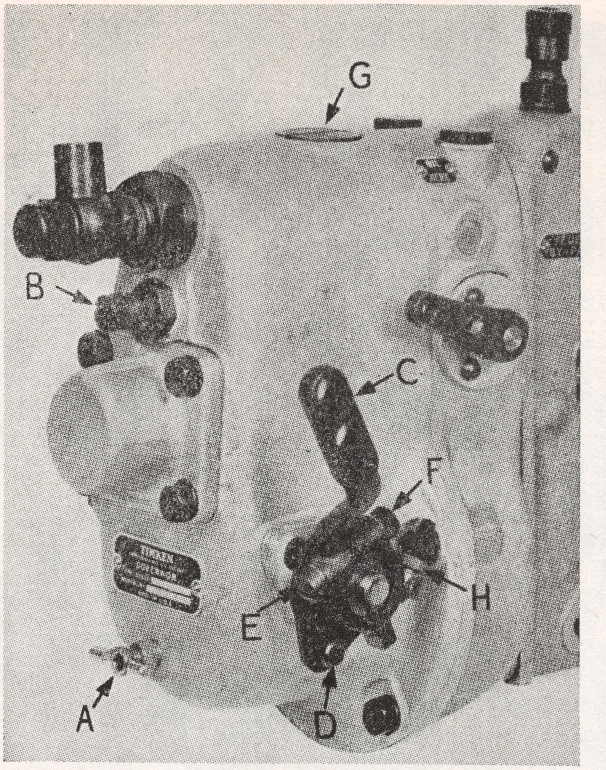
MECHANICAL AUTOMOTIVE GOVERNORS

The Timken Mechanical Automotive Governor is designed for integral attachment to the "B" size fuel injection pump. If normal adjustments fail to give satisfactory governor performance or if governor fails mechanically, the governor itself can be repaired or replaced by following the instructions given below.

Daily Maintenance: The governor oil level should be checked by means of the oil level trycock. Keep filled to level of trycock with clean new lubricating oil of same grade and brand as used in engine crankcase.

Replacement: The replacement of a Timken governor should not be attempted unless proper tools and a clean place to work are available. The injection pump and governor assembly should be removed from the engine before such work is attempted. Follow the instructions below for replacing the governor. Be sure to keep hands, tools and equipment clean at all times.

1. Drain oil from the governor.
2. Remove the four screws and the pinion shaft bearing cap. Remove the central idling spring (this spring is piloted in the pinion shaft bearing cap) through the hole in the housing for the pinion bearing cap. Removal of the cap exposes the pinion shaft bearing and the high speed spring washer and retainer. Attach the high speed spring compressor tool to the governor housing and compress the high speed spring and withdraw the horseshoe washer and then release pressure on springs. The high speed spring or springs may now be withdrawn through the hole in the housing. On earlier models a pin had been used instead of the horseshoe type washer.
3. Remove the idle adjusting screw, locknut and idle spring.



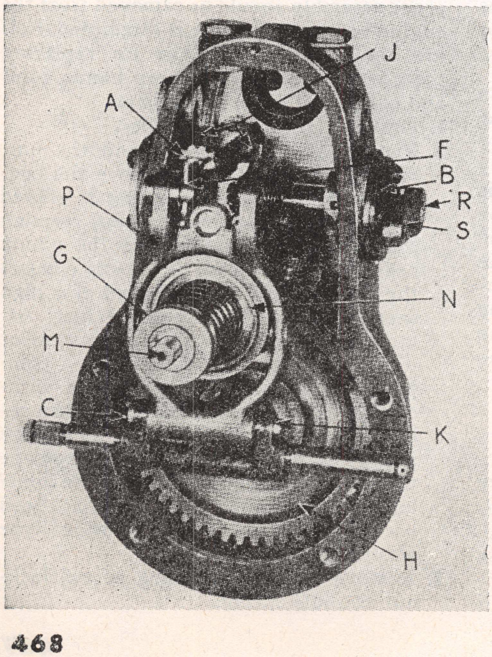
Timken mechanical automotive governor.

A—Oil level trycock. B—Governor idle adjusting screw. C—Throttle control lever. D—Idle stop. E—Throttle lever adjusting screw. F—Lock nut. G—Plug to remove for control rod link adjustment. H—High speed governor throttle stop.

4. Remove the lock nut from the control lever clamping screw and remove the throttle lever adjusting screw and then remove the throttle control lever. Remove the snap ring and then remove control lever hub and key. Remove the control lever stop plate and also the eccentric shaft cap. Remove the corresponding cap on the opposite side of the housing and allow the eccentric shaft to rest on the bottom of the bore in the housing. This exposes the cotter pin. Remove this pin and then withdraw the eccentric shaft pin from the opposite side.
5. Remove the four cap screws and the large fuel inlet pipe nut and washer which hold the rear governor housing to the front housing. The rear housing can now be removed, exposing the internal parts of the governor as shown in the illustration.
6. Remove the clevis pin and withdraw the yoke and the thrust sleeve assembly. The pinion shaft assembly can now be withdrawn. The control rod connecting link is removed by removing the clevis pin. Remove the nut and washer from the governor drive gear and then pull the gear from its tapered seat on the camshaft with a gear puller. (Two 5/16"-18 tapped holes are provided in the face of this gear to facilitate the use of a puller.)
7. The stop control lever and shaft can be removed by removing the cotter at the inside end of the shaft and pulling the shaft from the bushing. (Some models have a snap ring instead of a cotter.) The stop control lever is fastened to the shaft with a taper pin and can be readily removed if desired. The bushing for the stop control lever can readily be removed by removing the screws in the outside flange of the bushing.
8. Remove the four screws and the fuel pipe and the housing can be pulled away from the pump. This governor housing is piloted in the pump housing and contains the cup for the pump camshaft bearing and also an oil retainer; therefore the housing should be withdrawn carefully so as not to damage these parts.

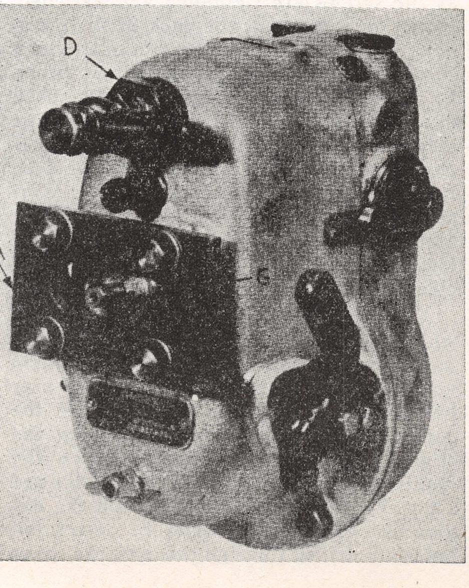
Reassembly:

1. Install camshaft bearing outer race or cup in the governor housing with the same amount of shims behind the cup as was in the old housing. Install the oil retainer in the housing with the thin lip of the leather toward the governor. The pinion shaft bearing cup is pressed into the housing.
2. Place new front governor housing in place on end of injection pump with new gasket in place between the governor housing and the pump housing. Insert the 4 screws and tighten carefully. The camshaft must be checked for bearing adjustment if either the pump, the governor front housing or the bearing have been replaced. Rotate the camshaft several times while tapping or pushing camshaft in one direction and measure distance from the end of the camshaft to the end of the housing with a micrometer. Repeat with camshaft pushed in opposite direction. If camshaft is tight and binds or if end play exceeds



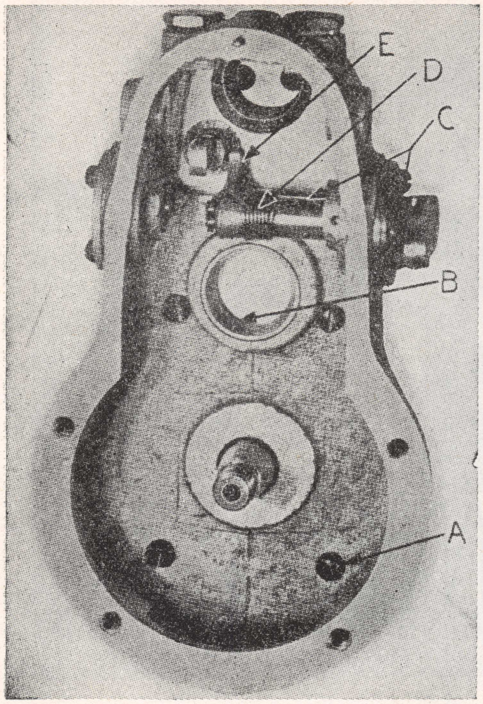
Internal parts of Timken mechanical automotive governor.

A—Star wheel adjuster. B—Shaft bushing. C—Eccentric shaft pin. F—Clevis pin. G—High speed spring washer and retainer. H—Governor drive gear. J—Clevis pin. M—Pinion shaft. N—Thrust sleeve. P—Yoke. R—Stop control shaft. S—Stop control lever.



Timken mechanical automotive governor.

A—High speed spring compressor tool. D—Fuel pipe. G—Horseshoe washer.



Timken mechanical automotive governor.

A—Front governor housing to pump attaching screws. B—Pinion shaft bearing cup. C—Stop lever mechanism. D—Internal lever return spring. E—Internal lever.

.004", remove governor housing and add or remove proper amount of shims from behind bearing cup to give .001" to .004" end play of camshaft when assembled. Tighten screws securely and peen a small amount of the governor housing metal into the screw slots after bearing is adjusted properly.

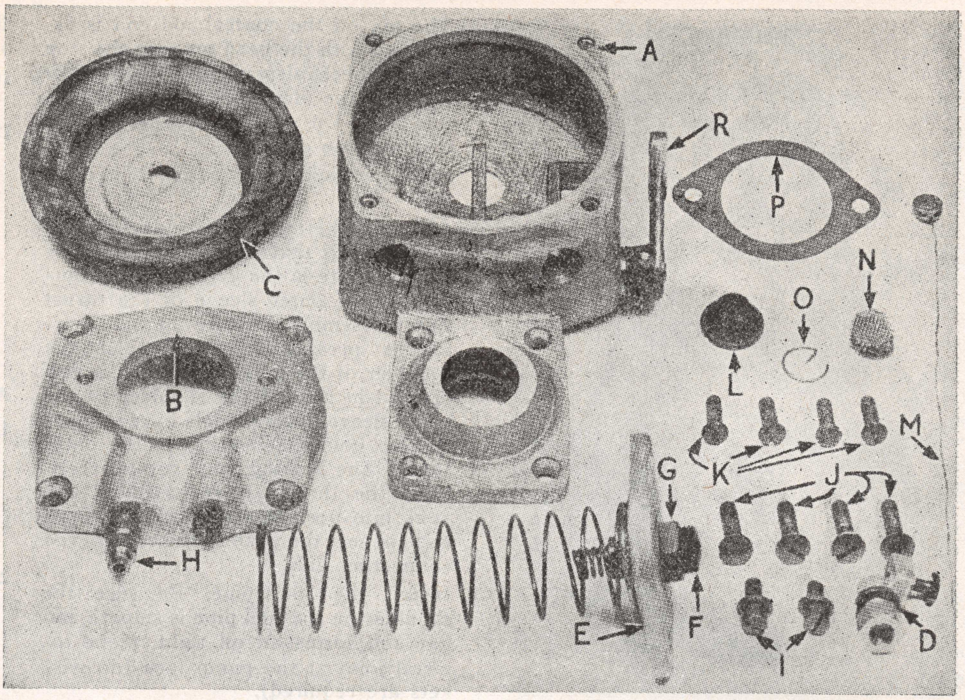
3. Be sure Welch plugs are tight in the housing.
4. Reassemble the stop lever mechanism in the governor housing. Be sure the spring will return the internal lever so that it rests against the housing. It is advisable to replace the shaft fitted with snap rings and also the bushing with the plain leather and washer seal as found on some models with the shaft fitted with a cotter and the type bushing that uses the standard commercial oil retainer assembly. Also install cover and gasket on boss on opposite side of housing
5. Place Woodruff key in camshaft and install governor drive gear on camshaft. Be sure to use proper nut (Metric thread) and lock washer and tighten securely.
6. Replace the control rod connecting link. The link must be assembled to the control rod with the spring which locks the adjustment of the star wheel, toward the bottom. The link should also be assembled with the right hand thread of the link toward the pump. Late models have different size pins to insure proper assembly. The average normal assembled length of this link is 3¼" from center of pin to center of pin. The pin on the control rod end is assembled with the head towards the stop control mechanism so that the internal lever of the stop control operates on this head. The collar is used on the end that has the cotter.
7. Place the pinion shaft assembly in position.
8. Assemble the thrust sleeve assembly in the yoke so that the two pins in the yoke operate in the groove on the outside of the outer sleeve of the thrust sleeve assembly. Be sure the ball bearing is pressed tightly against the shoulder of the inner sleeve and is also pressed in against the shoulder of the outer sleeve. Late models have a snap-ring to hold the bearing in the outer sleeve. The bearing must rotate freely. Slide the thrust sleeve assembly and yoke into position on the pinion shaft and connect the yoke to the control rod connecting link.
9. Install the fuel pipe. Be sure the shoulder on the fuel pipe is smooth and flat and forms an oil tight, metal-to-metal joint at the pump face (no gaskets are required).
10. Install the rear housing. Be sure the face of the governor housings are flat and free of nicks and that the gasket is in position. Install the washer and nut on the fuel pipe.
11. Insert the eccentric shaft through the side of the housing and connect it to the yoke with the eccentric shaft pin. Be sure to use the cotter.
12. Assemble the eccentric shaft cap and also the corresponding cap on the opposite side of the governor. It is advisable to replace the old style cap having a plain leather washer and steel cup with the new style cap which uses a standard commercial type oil retainer.
13. Reassemble the control lever stop plate, control lever hub and key control lever, adjusting screw, and snap ring in their original positions.
14. Slide high speed springs and spring washers on the pinion shaft and install high speed spring retainer pin or washer by means of special spring compressor tool. Then slide pinion shaft bearing on the shaft.
15. Place the central idling spring in the bore in the pinion shaft bearing cap and attach the bearing cap to the governor housing. The free end of the central idling spring seats in the recess in the thrust sleeve outer ring.

IMPORTANT—The spring must be long enough to be compressed about 1/16" to 3/32" when assembled in the governor. Add sufficient shims between the rear pinion bearing and the high speed spring washer so that the pinion bearing cap with the pinion bearing cap gasket in place, will not contact the governor housing. Pull up the screws finger tight and measure the amount of clearance between the pinion bearing cap and the governor housing with a feeler gauge. Remove this measured amount of shims and also an additional .005" shim to give the proper shaft end play. Tighten and lock the screws.

16. Install idle spring, drain plug, oil level plug, etc.
17. Fill the governor to proper level with clean lubricating oil and check and adjust it for proper governor operation. To adjust properly the reassembled governor and injection pump assembly, it must be installed on the engine. Be sure the pump is timed carefully and correctly. Be sure no dirt gets into either the injection pump or the governor.

Adjustment:

1. Adjust the throttle lever by means of screw so that the key in the shaft is approximately 20 degrees to the right of vertical (i.e. towards pump housing) when the control lever is against the idle stop pin.
2. Move the throttle lever towards full throttle until full movement of the control rod toward full throttle is obtained. The control rod stop must be in place and properly set to limit the control rod travel to the requirements of the engine. This can be observed by removing the breather plug on the pump and making sure the pinion of the unit exposed at the breather plug cannot be moved further toward full throttle. A small screwdriver can be used to check movement of pinion but this must be done carefully so as not to damage the pinion or the metal sleeve around the pinion. Adjust the control lever stop screw to stop the control lever at this point.
3. Run the engine and move throttle lever slowly toward full throttle and observe pinion at breather plug hole to see if it moves with throttle or if it lags behind. Adjust control lever screw to reduce lag to a minimum. If there is an appreciable lag between movement of throttle lever and movement of pinion, check central idling spring to be sure it is seated properly in the thrust sleeve and that it has approximately 1/16" to 3/32" deflection with the weights closed. Adjust the idle screw to obtain approximate proper idle speed. Speed up the engine and close throttle suddenly to determine whether engine will stall. If engine stalls, lengthen control rod link a notch or two at a time through the plug until engine does not stall.
4. Open throttle and check no-load top speed of engine. If speed is incorrect, adjust high speed spring as described in "Replacement—item two." If engine returns to idle slowly when throttle is closed, the control rod connecting link is too long and should be shortened slightly. Too long a link may also permit engine to run away. To adjust link, remove the plug and gasket at the top of the governor housing and with a screwdriver reach in and adjust the length of the link by rotating the star wheel of the control rod connecting link. Facing the pump at the governor end, clockwise rotation of the star wheel shortens the



Timken vacuum governor 418D

A—Rear housing. B—Front housing. C—Diaphragm. D—Diaphragm and pump control rod connecting link. E—Idle and high speed spring mounting. F—Idle spring adjusting screw. G—Lock nut. H—Flexible vacuum tube fitting. I—Spring mounting assembly to front governor housing attaching screws. J—Front and rear housing attaching screws. K—Housing to injection pump attaching screws. L—Housing to pump locating screw. M—Wire seal for screws. N—Governor breather hole filter. O—Filter retainer snap ring. P—Spring mounting assembly gasket. R—Governor shut-off lever.

length of the link and counter clockwise lengthens it. Always be sure the star wheel is turned so that the spring snaps into one of the notches.

5. Recheck idle speed after making top speed adjustments.
6. Check stop lever to be sure it shuts off the pump.

TIMKEN VACUUM GOVERNOR 418 D

The Timken Vacuum Governor is a simple, easily maintained governing unit which is used for automotive use. The illustration shows the details of a Timken Vacuum Governor.

Remove Vacuum Governor From Injection Pump:

1. Remove four screws holding front and rear halves of governor housing together and lay front half aside. High speed spring comes out also.
2. Remove single nut in center of diaphragm plate which attaches diaphragm to connecting link. Remove diaphragm. Hold disc part of diaphragm with fingers so as not to twist rack.
3. Remove nut holding pump coupling flange to injection pump cam shaft. Pull coupling with wheel puller.
4. Remove connecting link from injection pump control rod.
5. Remove 4 screws holding rear governor housing to injection pump end plate. Remove single large screw, holding rear governor housing to injection pump. Take off rear governor housing. Be careful not to lose shims between governor housing and injection pump.

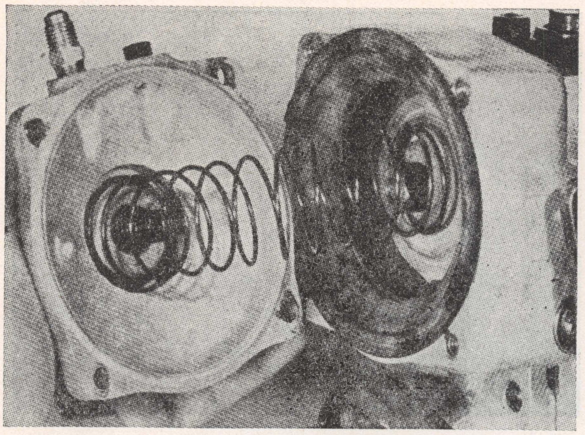
Install Vacuum Governor On Injection Pump:

1. Dismantle vacuum governor as received so that front housing, rear housing, spring mounting assembly, diaphragm and connecting link are all separate.
2. Mount new rear governor housing on injection pump and start the four screws which hold governor housing to the injection pump end plate. Start the large screw to locate housing correctly. Tighten four small screws first and with a thin feeler blade, determine if the top portion of the governor housing is laying flat against the end of the pump housing. If not, a flat shim should be placed between the two housings to be certain that the governor is not distorted. (.010" shim usually necessary.) When properly shimmed, tighten housing to injection pump with all five screws. Peen a small amount of housing material into screw slots to prevent loosening.
3. Pull injection pump control rod out as far as possible and attach new connecting link in hole in end.
4. Install pump coupling flange on pump camshaft. Be sure taper surfaces are clean. Be sure Woodruff key is in place. Watch when inserting coupling that dust seal felts are not damaged. Be sure lock washer is in place. Tighten nut firmly.
5. Attach new diaphragm to new connecting link, holding diaphragm with fingers so as not to twist pump control rod. Tighten nut securely. Be careful not to puncture diaphragm.
6. Press diaphragm evenly against face of rear governor housing. Rotate diaphragm slightly counter clockwise (to remove all drag from control rod due to connecting link overhang) and while holding in this position, put front governor housing in place and tighten down with four screws evenly. Pump control rod should be shoved into injection pump as far as possible while doing this.

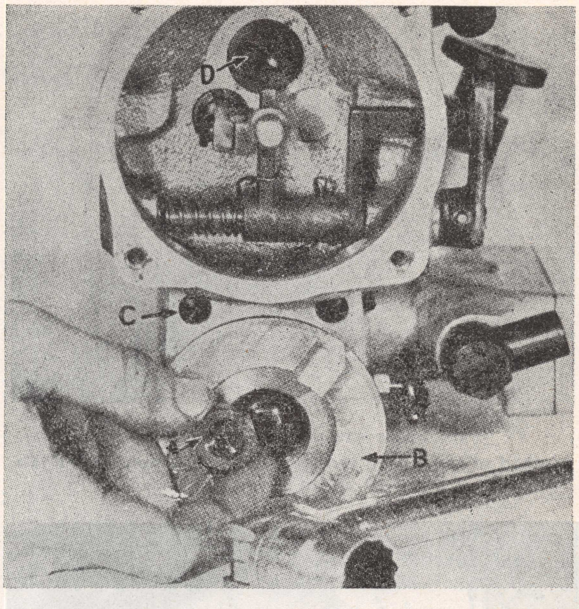
   When screws are tight, diaphragm should be clamped firmly and evenly between the two halves of the housing, and control rod of injection pump should move freely. Test by pushing diaphragm inward with fingers and outward with governor shut-off lever. If diaphragm does not move freely the housing clamping screws must be loosened and the diaphragm so turned that it will not bind the pump control rod.
7. Place spring mounting assembly in place in front governor housing and tighten down with two screws. Be sure gasket is in place between spring assembly flange and front governor housing. Both high speed and idle springs should be in place when spring assembly is installed. Take care not to cramp or cock high speed spring.
8. Check all screws for tightness and peen small amount of housing material into slots to prevent shaking loose.

Remove Injection Pump From Engine:

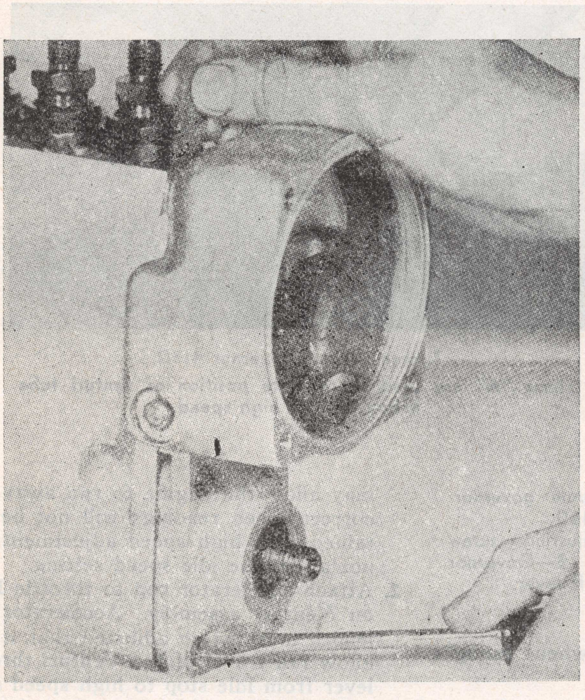
1. Complete injection pump and governor assembly must be removed from engine. Wash thoroughly with fuel oil before removing (Use brush and compressed air if available). Before removing any fuel lines, be sure they and their fittings are absolutely clean.
2. Disconnect all high and low pressure fuel lines from injection and supply pump. Disconnect shut-off lever control wire. Remove flexible vacuum line from governor.
3. Remove injection pump cam case inspection plug under pumping unit nearest drive coupling. Crank over engine until the cam lobe for this unit is in raised vertical position. (This can be seen through inspection hole.) Leave engine in this position through all subsequent operations until pump is again installed on engine. If this cam lobe position is



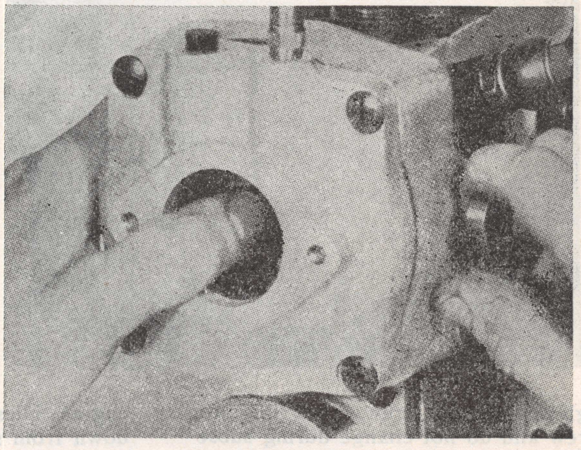
Timken vacuum governor 418D.
Showing front and rear housing separated.



Timken vacuum governor 418D.
A—Pump coupling flange nut. B—Pump coupling flange. C—Housing to pump end plate attaching screws. D—Housing to pump locating screw.



Timken vacuum governor 418D.
Method of determining whether top of governor housing is flat against pump housing.



Timken vacuum governor 418D.
Push diaphragm inward and governor shut-off lever outward to see if pump control rod moves freely.

carefully noted, then cam lobe can be set in exactly the same position when pump is reinstalled and a tedious timing operation avoided. Do not loosen adjustable coupling clamp screws.

4. Loosen pump mounting bracket or pump hold down screws. (Hold down screws preferably if all of them can be reached without removing bracket.) Remove complete pump and governor assembly from engine. Wash with clean oil after removal.

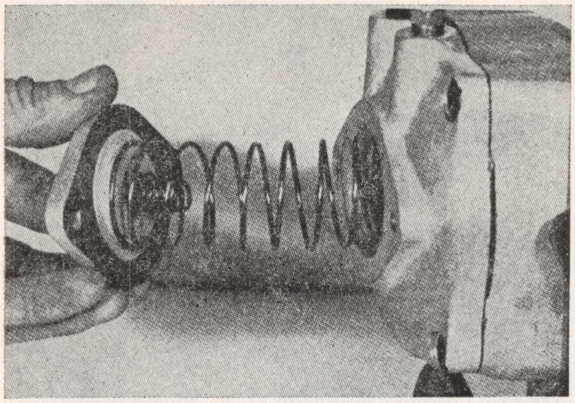
Install Injection Pump On Engine: If engine has been left with crankshaft as set in paragraph three of instructions above, then pump can be easily installed as explained below. If engine position has been changed, see the instructions for timing as described further on.

1. Rotate injection pump coupling until cam lobe (for pumping unit nearest to coupling) is in vertical raised position, as it was when pump and governor assembly was removed.
2. Mount injection pump assembly on engine. If pump camshaft and engine crankshaft are in same position as when pump was removed, the two halves of the coupling will line up and slip together easily. When pump mounting bracket has been left on pump, no lining up will be necessary. If pump was removed from mounting bracket it must be lined up so that coupling will run true and free before tightening down on bracket.
3. Attach all high and low pressure fuel lines to injection and supply pump. Be sure these lines and fittings are clean and that all joints are tight.
4. Attach flexible vacuum tube from Venturi to governor. Be sure tube fittings are tight.
5. Attach governor—shut-off lever control wire. Check for proper action of dash control and full range of shut-off lever movement.
6. Open bleeder cock on injection pump and pump with hand priming pump till clear fuel flows from this fitting.
7. Start engine and let air clear out of high pressure lines. Check for air at bleeder cock on injection pump housing.

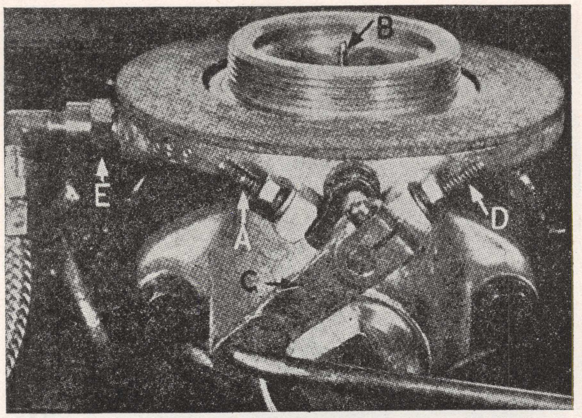
VACUUM GOVERNOR ADJUSTMENTS

Idle Adjustment:

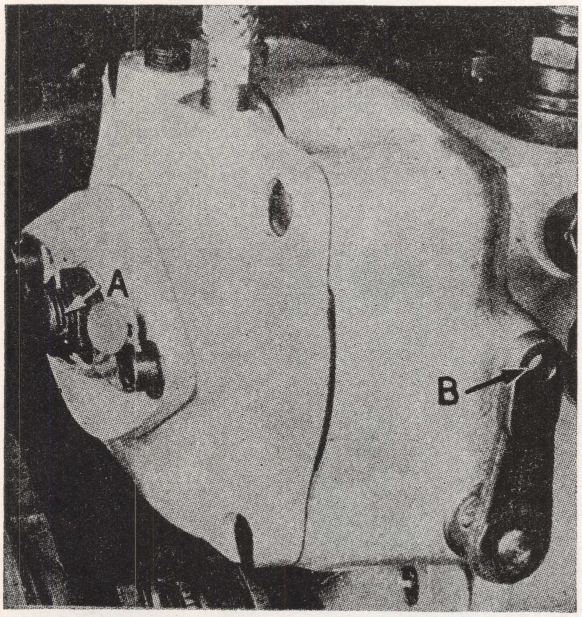
1. Remove engine air cleaner and adjust high speed stop screw on Venturi assembly so that butterfly valve is exactly vertical when throttle lever is held against



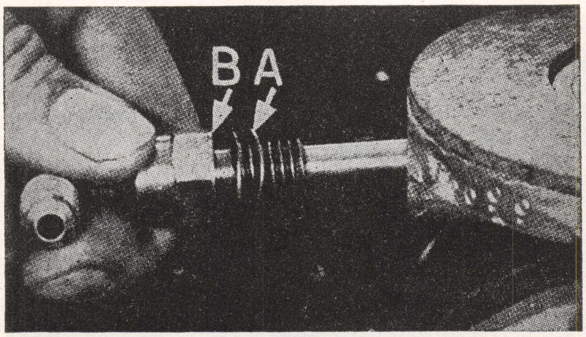
Timken vacuum governor 418D
Method of assembling spring mounting assembly. Install idle and high speed spring as shown.



Timken vacuum governor 418D.
A—High speed stop screw. B—Butterfly valve. C—Throttle lever. D—Idle stop screw. E—Venturi tube fitting.



Timken vacuum governor 418D.
A—Idle adjusting screw and spring. B—Governor shut-off lever.



Timken vacuum governor 418D.
Shims "A" are used to regulate position of venturi tube fitting "B" for high speed.

high speed stop screw. Lock this stop screw and do not change during subsequent governor adjustments.

2. Replace air cleaner on engine. All governor adjustments must be made with air cleaner in place. Be sure all tubing connections between governor and Venturi are tight.
3. Start engine and warm up.
4. Set throttle lever in approximately engine idling position.
5. Screw in adjustable idle spring in governor until engine idles smoothly.
6. Set idling adjustment stop screw on Venturi assembly so that with throttle lever held against it, engine will idle at approximately 500 R. P. M. Check this with tachometer. (Check engine manufacturers recommended idle speed.) Idle stop screw on Venturi controls speed only.
7. Back out idle spring adjustment screw until engine just begins to surge. Open throttle momentarily till engine picks up some speed, then bring back to idle stop quickly. If engine surges at idle, screw in the idle spring adjustment screw until surge is just stopped. Repeat check until engine idles smoothly when brought down from speed.

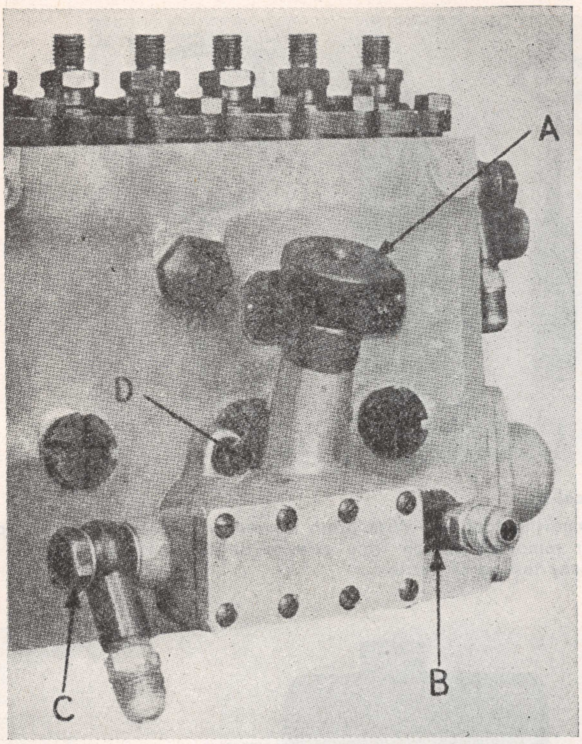
High Speed Adjustment:

1. Watching tachometer closely, open throttle wide and see if engine tends to exceed top speed recommended by equipment manufacturer. If it does, shut down immediately and adjust Venturi tube fitting to hold top engine speed to recommended R. P. M. This is done by stopping the engine and moving Venturi tube fitting farther into the Venturi housing. The position is regulated by shims under the shoulder of the fitting. If top speed is not high enough, the fitting should be moved out of the Venturi housing by adding shims. In case the recommended top no-load speed is so low that it cannot be held by adjusting the Venturi tube fitting, then the high speed stop screw should be loosened and adjusted to give the proper speed.

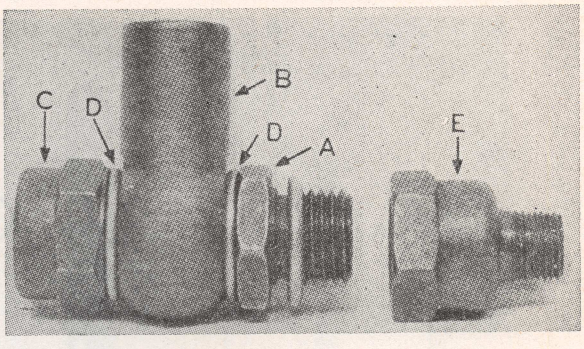
   After each fitting change, be sure all vacuum tube connections between governor and Venturi assembly are tight before restarting engine. A loose fitting may allow the engine to run away and correct speed readings will not be obtained. The high speed adjustment will not affect the idle speed setting.
2. Attach accelerator rod to throttle lever on Venturi assembly. Accelerator rod length must be so adjusted that it will allow full travel of the Venturi throttle lever from idle stop to high speed stop.
3. Attach control wire to governor shut-off lever. Make sure the shut-off control on dash has sufficient travel so that when not in use (Pushed in) it will not hold governor shut-off lever in such a position as to interfere with the operation of the governor. Check to see that control on dash will actually stop engine.

FUEL SUPPLY PUMPS 49D & 54D

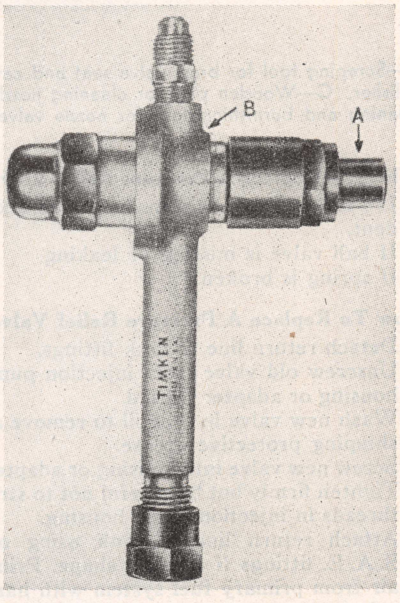
The Timken Fuel Transfer Pump consists of both a mechanically operated piston type pump (driven by one of the lobes on the injection pump camshaft) and a separate hand operable plunger type priming pump. The hand priming pump is positive in operation regardless of the engine cycle or position of the injection pump camshaft. The mechanically operated transfer pump serves through a suitable arrangement of piston and valves, to draw fuel from the main supply tank, through suitable primary filters, and delivers this fuel, through the final filter located between the transfer



Timken fuel supply pumps 49D and 54D.
A—Priming pump. B—Pump inlet fitting. C—Pump outlet fitting. D—Supply pump attaching screws.



Timken pressure relief valve.
A—Valve body. B—Swivel outlet fitting. C—End Cap. D—Gaskets. E—Relief valve adapter.



Typical Timken fuel injection nozzle and holder assembly.
A—Fuel injection nozzle. B—Nozzle holder.

pump and the injection pump, to the injection pump.

Dirt sometimes gets imbedded in the transfer pump valves and reduces its efficiency if not actually causing the pump to cease working. Remove valve and clean or replace. The springs of these same valves sometimes break. Replace when this trouble is found. Use only genuine parts in replacement as substitutes may cause considerable damage.

Maintenance:

1. If hand priming pump handle is of "screw down" type, be sure this is kept turned down tightly by hand when not in use. (Never use a wrench.)
2. Check supply line fittings and face plate screws often for tightness. Replace any cracked or spread gaskets with new parts.

Check For Correct Operation: If supply pump is suspected of operating improperly check as follows:

1. Check fuel supply system for clogged final filter, adequate fuel supply, obstructed fuel lines, air leaks or air lock.
2. Loosen supply pump outlet fitting. Using hand priming pump, see if fuel can be pumped through supply pump and out of this loosened fitting. If a flow of fuel is obtained, the supply pump valves are operating satisfactorily. Tighten down priming pump handle.
3. Turn engine over with starter. If fuel flows from loosened outlet fitting, the mechanical supply pump plunger, spring and tappet are in good condition. Tighten outlet fitting.

Should the supply pump fail to pass one of the above tests, it can be assumed to be faulty and should be replaced following instructions given below.

Replacement: Timken Supply Pumps are easily replaceable as complete units should they become worn or inoperative. Be sure to keep hands, tools and equipment **clean** when changing any injection equipment unit. Follow instructions carefully:

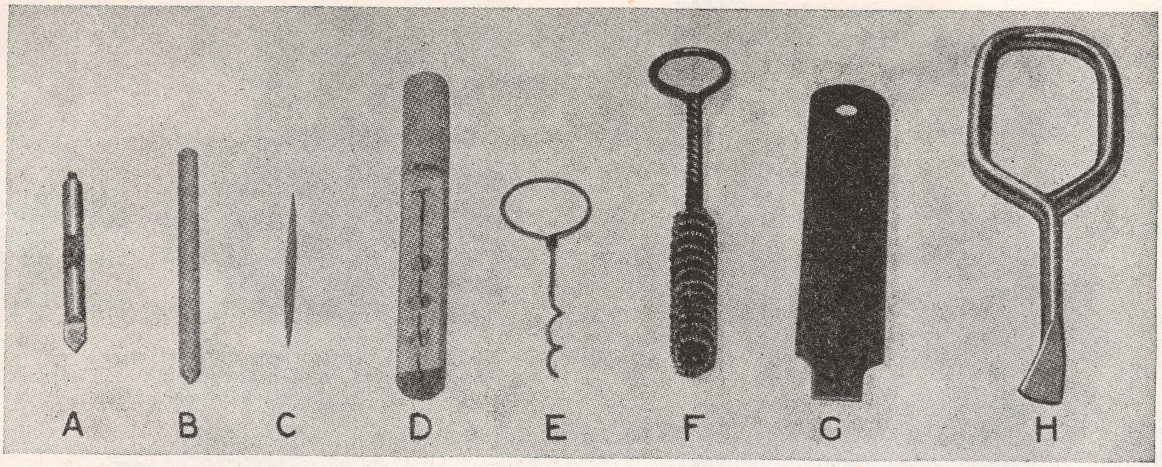
1. Shut off fuel supply at tank.
2. Wash off outside of injection pump, supply pump and all lines and fittings carefully with clean fuel oil.
3. Unscrew inlet and outlet fitting screws from the supply pump and remove inlet and outlet lines.
4. Unscrew the three hexagon head attaching screws from the supply pump mounting flange and remove supply pump from its mounting hole in the injection pump housing. Watch supply pump tappet carefully to be sure it does not drop out of the supply pump housing. Remove old mounting flange gasket if torn or damaged.
5. Place new gasket on supply pump mounting flange (use oil or grease to hold in place).
6. Check new supply pump and its tappet thoroughly for dirt or dust and wash with fuel oil if necessary. Do not disassemble.
7. Insert new supply pump in mounting hole and fasten to pump with three hexagon head mounting screws. (Be sure each screw has flat and lock washer under head.)
8. Replace inlet and outlet lines. These must be perfectly clean and free from dirt or metal chips. Use new gaskets and tighten fittings firmly.
9. Open main supply line valve at fuel tank.
10. With hand priming pump start fuel through supply pump and prime all air from fuel supply system and injection pump fuel passages.

PRESSURE RELIEF VALVE

The Pressure Relief Valve or "Check Valve" is a simple unit designed to hold the primary fuel supply in the injection pump manifold at a constant pressure. It also permits the return to the fuel supply tank of any excess fuel supplied to the injection pump by the supply pump.

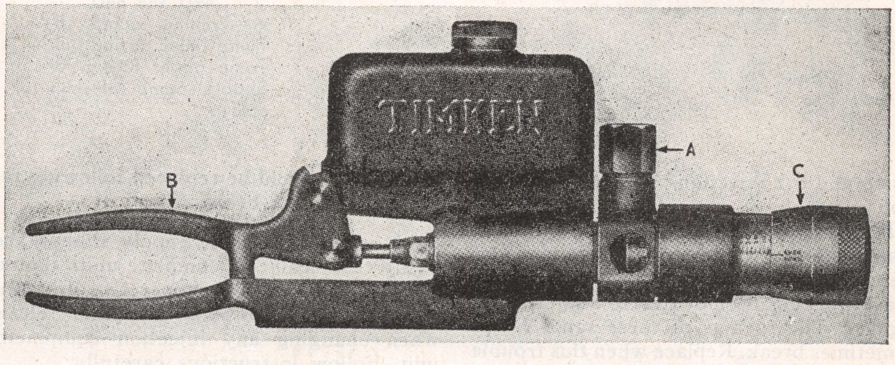
This relief valve consists of a body containing a simple ball check valve which is held on its seat by a helical spring. The spring is retained in the body by a snap ring. The body also supports the swivel outlet fitting which is held in place by an end cap and is sealed by two gaskets, one on each side of the fitting.

The relief valve body is threaded at one end so that it may be screwed into the mounting hole in the injection pump or into a special relief valve adapter which is used in some cases.



Timken nozzle cleaning tool kit.

A—Scraping tool for brass valve seat and cavity. B—Wooden valve seat polisher. C—Wooden pick for cleaning nozzle orifice hole. D—Wooden cleaning and burnishing tool for nozzle valve and pintle. E—Edge type filter removing tool. F—Wire brush for removing carbon. G—Scraping tool for removing carbon from exterior of nozzle body. H—Tool for emergency testing of nozzles.



Timken hand-operated test pump.

A—High pressure adapter fitting. B—Pumping handle. C—Dial for reading nozzle opening pressure.

When To Replace A Pressure Relief Valve:

1. If valve body is broken due to an accident.
2. If ball valve is missing or leaking.
3. If spring is broken.

How To Replace A Pressure Relief Valve:

1. Detach return line to tank fittings.
2. Unscrew old valve from injection pump housing or adapter if used.
3. Wash new valve in fuel oil to remove all shipping protective grease.
4. Screw new valve into housing or adapter. Tighten firmly but be careful not to strip threads in injection pump housing.
5. Attach return line to tank using old S. A. E. fittings if in good shape. Prime air from primary fuel system with hand priming pump.
6. Run engine and check for leaks in new fittings or relief valve gaskets.

FUEL INJECTION NOZZLE AND HOLDER ASSEMBLY

Timken fuel injection nozzles and holder assemblies are precision built parts. As an assembled unit, the injection nozzle and holder assembly forms one of the most important parts of the complete fuel injection system.

The function of these units is to admit, to the combustion chamber of the engine, the charges of fuel, metered, timed, and delivered to them under pressure, by the injection pump. They must regulate the fuel pressure and control the atomization and character of the spray so that the fuel will be properly distributed in the engine's combustion chamber.

Checking: In normal operation, Timken injection nozzle and holder assemblies should require checking only at the regular overhaul periods of the engine. Abnormal conditions such as dirty fuel, an over-heated engine, or an excessively acid fuel may make more frequent servicing necessary.

Loss of power, excessive dark smoke, poor idling, irregular fuel knocks, a rough running engine or excessive flow of fuel from the nozzle leak-off are some of the things that may indicate improperly operating nozzles. Broken tappets in the injection pump are usually caused by clogged or faulty nozzles.

Faulty nozzles are easily located in an engine by loosening in turn each fuel line connection nut at the pump and by listening closely as each nozzle is cut out. The one responsible for the missing, knocking, or roughness of the engine can readily be detected. Should a faulty nozzle assembly be found it should be removed from the engine and repaired or replaced with a new unit.

TIMKEN HAND-OPERATED TEST PUMP

The hand-operated test pump is available for use by injection equipment service stations, equipment dealers and operators. With it the nozzle opening pressure can be correctly set, the fuel spray checked for proper shape and character, and the nozzle checked for dribble or leakage.

FLYWHEEL TIMING MARKS

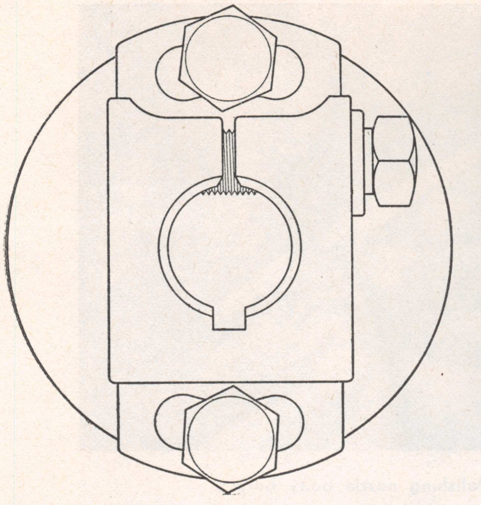
All engine flywheels have a line marked D.C. or T.C. (meaning Top Center or Dead Center) and from this line are graduations designating one or two degrees of crankshaft travel, usually marked from ten (10) to forty (40) degrees with numerals.

FUEL PUMP TIMING AND COUPLING MARKS

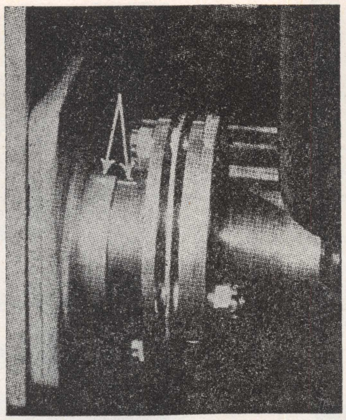
When the scribe marks on the fuel pump end plate and coupling hub are in line as shown in illustration, it will represent port closing position. Any change in engine timing should be made by readjusting the Oldham pump coupling position which has one of the driving members slotted so that the clamp screws can be loosened to permit a certain amount of adjustment of timing by means of the slots in the coupling flange. In doing this, however, care should be used for each mark represents six flywheel degrees.

TIMING FUEL PUMP TO ENGINE BY COUPLING MARKS

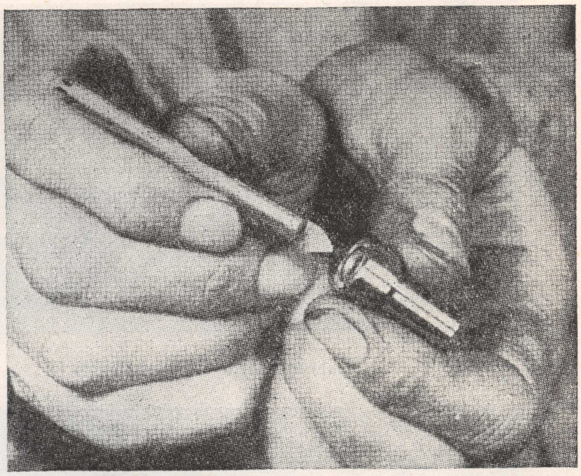
When engines are shipped from the factory the couplings are marked for fuel injection pump timing as shown in the illustration. Before removal of fuel pump assembly from the engine, these markings should be carefully checked and if dim or obliterated should be re-marked so that reassembly can be more easily, quickly, and surely made.



Oldham coupling design.
Showing slots which permit fuel pump timing to be advanced or retarded.



Fuel pump coupling timing marks.



Scraping valve seat in nozzle body.

To re-assemble the pump assembly to the engine, the following procedure should be followed:

1. Spot engine number 1 piston before top center.
2. Install pump assembly on engine—tightening all attaching screws but leaving rear half of coupling loose from front half so pump shaft can be rotated while the drive shaft remains stationary.
3. Rotate rear half of coupling until the heavy mark on it coincides with the heavy mark on the front half of coupling.
4. Install and tighten the attaching bolts which connect the two coupling halves. Make sure the marks are lined up perfectly and the attaching screws or bolts are tight.
5. Install all fuel piping.
6. Prime fuel lines as described further on.
7. Start engine.

If a timing device is employed the coupling marks should be lined up when the timing arm level is in the advance position.

TIMING FUEL PUMP TO ENGINE BY FLOW METHOD

All flywheels have a line marked D.C. (Dead Center) and from this line are graduations designating each one or two degrees of crankshaft travel, usually each ten (10) to (40) degrees are marked with numbers.

1. Spotting Flywheel:

(a) Rotate flywheel by means of hand crank until DC mark appears in timing hole in bellhousing. Be sure number 1 piston is just completing the compression stroke and beginning the expansion which can be determined by observing that the number 6 cylinder exhaust valve is nearly closed.

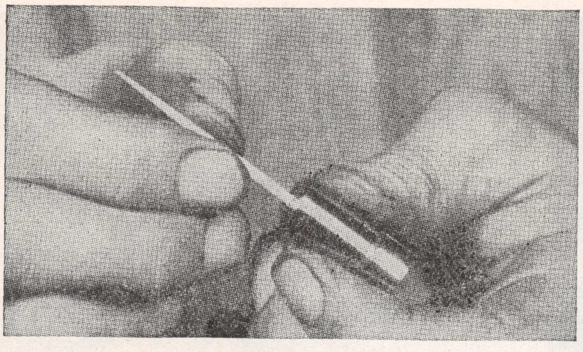
(b) Rotate engine in direction of degree graduation marks—which is counter engine-wise—until the desired graduation mark is directly in line with the mark in the center of the timing hole in the bellhousing.

2. Install pump assembly, tightening all attaching screws but leaving the rear half of coupling loose from front half so pump shaft can be rotated while the drive shaft remains stationary.
3. Connect all fuel suction and discharge pipes from fuel tank to pump. Install all fuel lines except to number 1 cylinder.
4. With governor lever in wide open or full load position prime pump as explained further on.
5. Put governor lever in stop position and remove pump delivery valve holder from number 1 pump plunger, then remove delivery valve and spring but not the seat. Replace delivery valve holder finger tight.
6. Put governor lever in wide open or full load position. Fuel now should rush out of the delivery valve holder. Rotate pump shaft over the top and away from the engine by means of the rear half of coupling until fuel flow stops. If fuel did not flow when governor lever was first opened, rotate shaft until it does then back to where it is just off.
7. Very carefully rotate shaft until fuel just barely flows then back to point where flow is just barely shut off. Repeat this two or three times until a movement of less than 1/64" on the circumference of the coupling is the difference between fuel flowing and not flowing. This determines where the pump plunger just closes the fuel port and begins the period of building up pressure in the lines and nozzles so that injection can start. It is important that this adjustment be extremely accurate.
8. With capscrews provided, connect the front and rear half of the coupling together. Be sure these screws are tight so no slippage can occur and yet do not strip the threads. Also observe if any slight movement which might occur while tightening the screws has started the fuel flowing again from the delivery valve holder. When these screws are tight no fuel should flow. The fuel pump is now timed to close the ports at the proper point. After this is set at the exact position of port closure for No. 1 cylinder ("flow" method), then one more check should be made to be certain that the pump is set correctly. Being careful not to move the engine or pump shafts, remove the No. 1 inspection plug and insert a clean screw driver under the No. 1 plunger tappet. With the screw driver, and holding throttle "wide open," raise the tappet, and the No. 1 plunger, slowly. If it rises a short distance, approximately 3/16 of an inch, then allows the fuel again to flow through the ports and out of the top of the high pressure fitting, the pump setting is on the correct phase. Be sure to hold the throttle lever in **wide-open** position during all timing and checking adjustments.
9. Put governor lever in stop position again. Remove delivery valve holder and replace the delivery valve and spring. Install delivery valve holder, tightening firmly. Be careful not to get any dirt, water, or any other foreign matter in or on any of these parts.
10. Connect fuel line to pump number 1 cylinder. Prime fuel lines, being sure the fuel pump strainer and all lines are full of fuel—with no air.
11. Start engine, which may run slightly uneven for a few minutes, but if it continues, stop and recheck timing position carefully.
12. After engine is operating smoothly and has been properly warmed up, stop engine.
13. With a light chisel and hammer, enlarge the single scribe mark on the front hub, and put a corresponding mark on the other hub, so that these two parts can be lined up together at any future time without the necessity of flowing the pump.

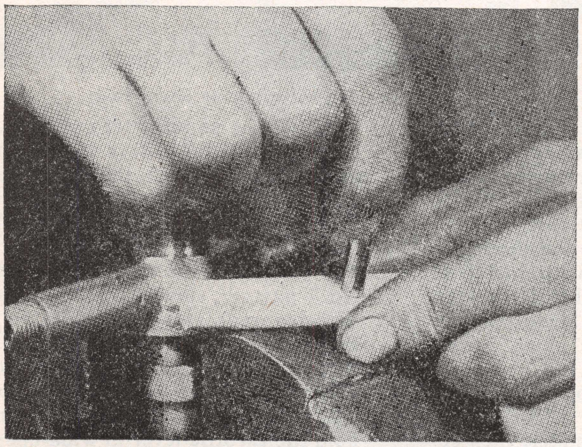
NOTE—When timing device is installed, proceed as with the adjustable coupling except that the timing device arm should be fixed in an advance position.

NOZZLE AND HOLDER ASSEMBLY, REMOVE

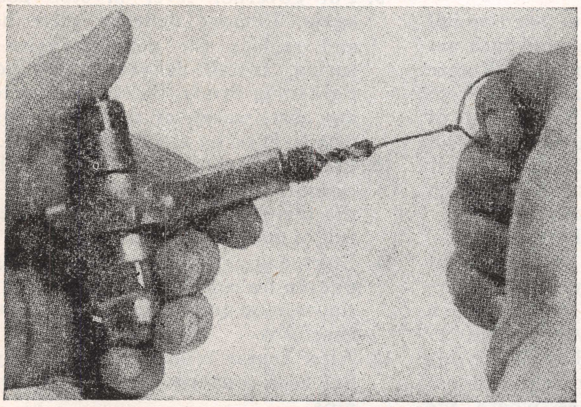
1. Wash holder assembly, injection lines and all surrounding parts of engine thoroughly with fuel oil before removing. Use a brush and compressed air—if available.



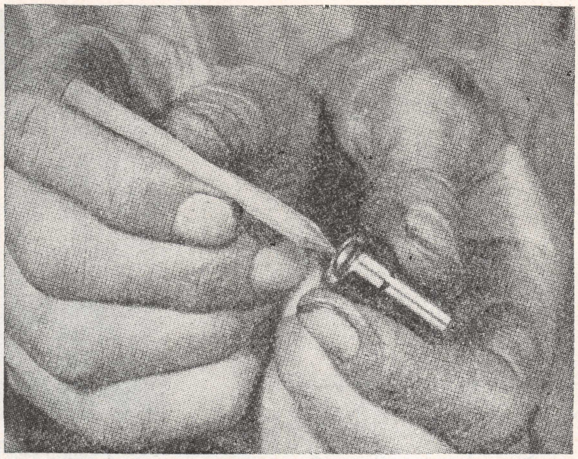
Cleaning nozzle orifice hole.



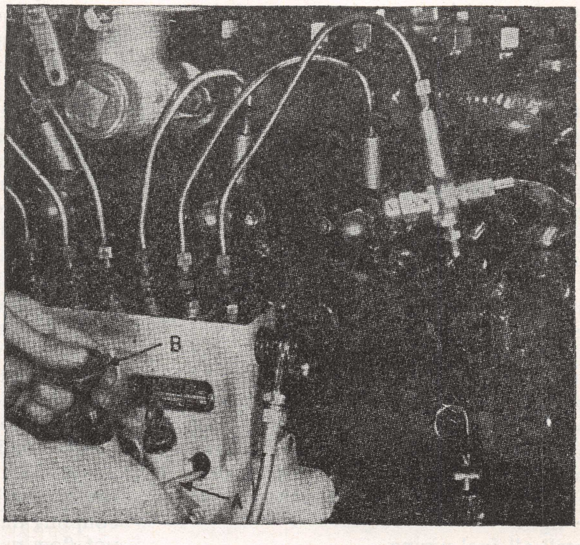
Polishing nozzle valve seat.



Removing edge type filter from stem.



Polishing nozzle body bore.



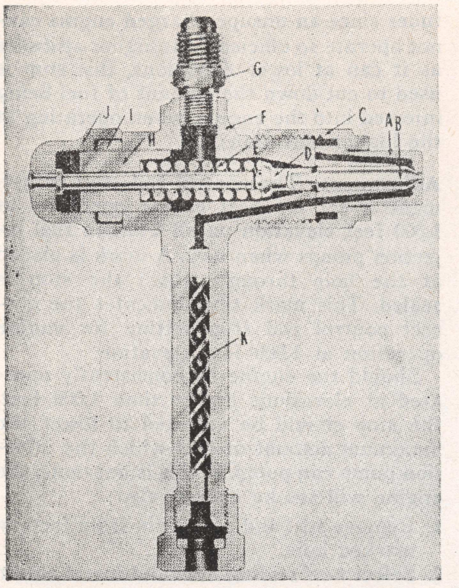
Method of testing nozzle for spray shape and leakage with engine not running.

A—Hand pumping tool inserted under tappet. B—Hand priming pump to keep system supplied with fuel.

2. Detach high pressure and leakoff lines.
3. Loosen clamping nuts and pull assembly from engine. If stuck, rotate whole assembly slightly to break it loose from carbon deposits in mounting hole.
4. Wash complete unit in fuel oil. Wipe all dirt and carbon from exterior with rag.

DISASSEMBLE & CLEAN INJECTION NOZZLE

1. Clamp nozzle holder assembly in vise and remove nozzle retaining nut, after which, remove injection nozzle.
2. Pull nozzle valve from nozzle body and soak both parts in clean fuel oil to soften carbon. Never allow polished surfaces to come in contact with hard metal or abrasives of any kind. Be careful not to drop nozzle parts.
3. Rub exterior of nozzle body with soft (no lint), oil-soaked rag. Scrape off any hard carbon remaining with special scraping tool. Be careful not to touch polished end of nozzle or dig into nozzle orifice hole with scraping tool. Scrape outside turned surfaces only. Brush may also be used in cleaning outside surfaces of nozzle body.
4. Using pointed end of brass valve seat scraping tool, carefully scrape valve seat in nozzle body by inserting tool in body bore, as far as possible, and rotating slowly. Rotate until sure seat has been scraped evenly all around.
5. Reverse tool and repeat scraping process. This end of tool (shaped like small screw driver blade) will scrape all carbon from nozzle body cavity below the seat.
6. With wooden pick tool, clean all carbon from nozzle orifice hole.
7. Slush nozzle body thoroughly in clean fuel oil.
8. Dip wooden valve seat polishing tool in fuel oil and insert pointed end as far as possible into bore of nozzle body. Press against valve seat and rotate. This will polish seat and pick up any remaining carbon particles.
9. Blow out nozzle body with strained compressed air, if available. Slush thoroughly in clean fuel oil and lay on clean sheet of paper.
10. Rub valve and pintle end of nozzle valve with soft oil-soaked rag to remove loose carbon.
11. Dip wooden nozzle pintle cleaning tool in clean fuel oil, insert nozzle valve pintle as far as possible into one of the



Cutaway view of typical Timken screw adjusted nozzle.

A—Nozzle. B—Nozzle valve. C—Nozzle retaining nut. D—Nozzle spring button. E—Nozzle spring. F—Nozzle holder body. G—Leak-off fitting. H—Nozzle spring pressure adjusting screw. I—Adjusting screw lock nut. J—Nozzle holder cap and nozzle valve lift stop pin. K—Filter.

tapered holes, clamp tool together with fingers and rotate valve. Repeat until nozzle valve seat is clean and bright and no carbon remains on pintle.

12. Wash nozzle valve carefully in clean fuel oil. Be sure no dirt or lint remains on it.
13. Insert nozzle valve carefully in nozzle body while holding nozzle body under surface of fuel in open pan of clean fuel oil. Work valve in and out of body, thereby pumping clean fuel through all passages and insuring that no dirt remains in nozzle.
14. Shake nozzle body free of fuel oil (do not wipe with rag) dip valve in clean new lubricating oil and insert in body. Lay nozzle on clean sheet of paper in dust-free spot while holder is being serviced.

NOTE—If nozzle is beyond repair due to erosion of orifice hole or corrosion of valve, it should be replaced with a new nozzle of the same size and type. After unwrapping new nozzle, wash carefully in clean fuel oil and dip in clean lubricating oil before assembly.

NOZZLE HOLDER ASSEMBLY, CLEAN

1. Wash nozzle holder assembly in clean fuel oil, wipe with lint-free rag. Be very careful not to mar or damage polished nozzle seating surface. Leave no lint or grit on this surface. Do not change nozzle spring adjustment.
2. If holder has edge type filter in stem, insert special filter removing tool by screwing into spiral filter element and pulling out. Wash edge filter thoroughly in fuel oil and rinse holder in fuel oil to wash dirt out of stem. Put filter back in stem.
3. Wash assembly in clean fuel oil and lay on sheet of clean paper.
4. Clean out nozzle retaining nut with scraping tool and wire brush. Be sure internal threads and shoulders are clean. Blow out with compressed air, if available. Wash in fuel oil.

NOZZLE AND NOZZLE HOLDER ASSEMBLY, ASSEMBLE

1. Clamp holder assembly in vise.
2. Place nozzle on polished seat in holder. Be sure these mating surfaces are perfectly clean and free from lint.
3. Slip nozzle retaining nut over nozzle and tighten down tightly. Be sure nozzle is not cocked in nut.

NOZZLE AND HOLDER ASSEMBLY, TEST

Testing In Field: When hand test pump and pressure gauge is not available, no attempt should be made to set the nozzle opening pressure. Nozzle and holder assembly may be checked for spray shape and leakage in one or two ways.

(a) Attach nozzle and holder assembly to high pressure line from pump but do not install nozzle in engine. Start engine and run on remaining cylinders. The nozzle being tested can be watched at varying throttle positions as it injects into the open air. Watch for leakage after injection or "dribble." Be sure spray is properly atomized and distributed.

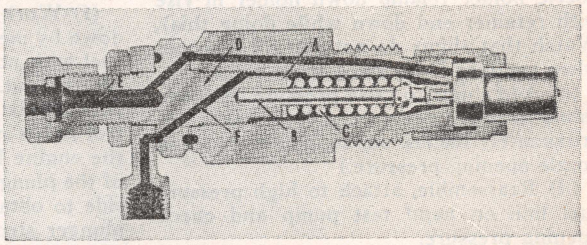
(b) If engine cannot be operated, attach nozzle assembly to high pressure line in open air. Remove inspection plug from under injection pump pumping unit to which nozzle is attached. Insert special hand pumping tool through inspection hole and under the pumping unit tappet. Hold the throttle in "wide open," position and pump by hand. Be sure to keep the injection pump manifold supplied with fuel by means of the hand priming pump. Fuel can thus be pumped through the nozzle and the spray characteristics determined.

Testing In Shop: The hand-operated test pump should be used in the shop as this allows not only a better check on spray characteristics but also allows the nozzle opening pressure to be accurately tested and adjusted. This hand pump is portable and may also be used in the field if desired. It should be clamped firmly to the bench when used in the shop and should be supplied with absolutely clean fuel oil.

Screw the nozzle and holder assembly into the high pressure adapter fitting tightly. A few strokes of the pumping handle will fill the nozzle holder assembly with fuel oil and nozzle will then start to inject. The shape and character of the spray can thus be closely watched.

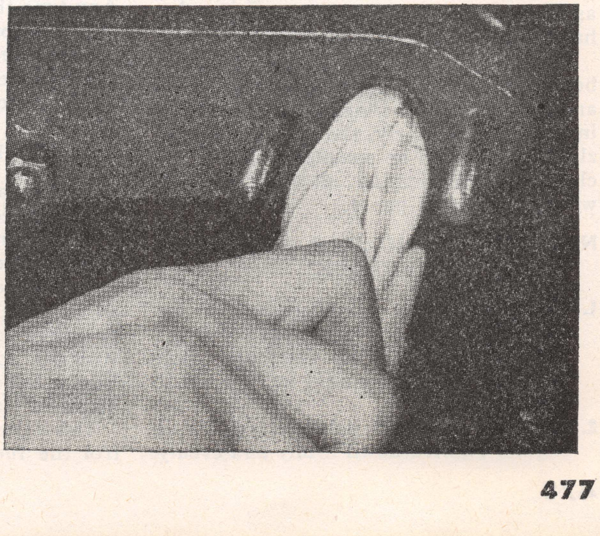
Nozzle opening pressure is read directly on sleeve dial. This sleeve dial regulates the opening pressure of a valve which is built into the hand pump and which exhausts fuel out of a port when it opens. The sleeve dial reads directly in pounds per square inch. By rotating sleeve, while pumping fuel through the nozzle being tested, a point will be reached where the built-in valve will open just before the nozzle opens. If the dial is then rotated slowly so as to increase the pressure on the built-in valve, the point where both valve and nozzle will open simultaneously will be reached. The reading on dial will then be the true opening pressure of the nozzle being tested.

When not checking for nozzle pressure, set dial at some reading higher than the normal nozzle opening pressure so that built-in valve will remain inactive while



Cutaway view of typical Timken shim adjusted nozzle.

A—Adjusting shims. B—Valve lift stop pin. C—Spring. D—Spring retainer. E—High pressure line connection. F—Passage for low pressure leak-off.



Method of cleaning nozzle mounting hole.

nozzle spray characteristics are being checked. If a Timken tester is not available, use any of the standard Nozzle Bench Testers. If nozzle opening pressure is not that recommended by engine manufacturer, the nozzle spring pressure should be adjusted until it is correct.

NOZZLE OPENING PRESSURE, ADJUST

Timken injection nozzle and holder assemblies are of two types: screw adjusted and shim adjusted.

Screw Adjusted Nozzles: The adjusting screw is covered by the nozzle holder cap and is locked in place by lock nut. To adjust nozzle opening pressure, proceed as follows:

(a) Take off nozzle holder cap.

(b) Loosen adjusting screw lock nut.

(c) Turn adjusting screw with screw driver. Turning screw in raises the nozzle opening pressure. Turning the screw out lowers the nozzle opening pressure.

(d) Adjust screw until pressure checks on hand pump test gauge to setting recommended by engine manufacturer.

(e) Tighten adjusting screw lock nut and replace nozzle holder cap. Allow no dirt to enter nozzle holder.

Shim Adjusted Holders: The spring pressure adjusting shims are placed around the valve lift stop pin and are between the spring and the spring retainer part. The spring retainer in the nozzle illustrated also forms the high pressure line connection and contains a passage for low pressure leak-off. To adjust injection nozzle opening pressure with this type of holder assembly, proceed as follows:

(a) Disconnect high pressure fuel lines.

(b) Unscrew nozzle spring retainer from nozzle holder (clamp down holder in vise with retainer end down while doing this). Watch that shims do not slip off stop pin when retainer is removed from holder.

(c) Add shims to raise pressure. Remove shims to lower pressure. (.004" makes approximately 100 lbs. per sq. in. difference in nozzle opening pressure.)

(d) Reassemble, attach to high pressure fuel line on hand test pump and check opening pressure.

(e) Repeat until nozzle opening pressure as recommended by engine manufacturer has been obtained.

When nozzle and holder assemblies have been tested and found to be all right, they are then ready to be installed. If not to be installed immediately, the nozzle and nozzle holder should be completely filled with clean new lubricating oil and carefully wrapped in oiled paper.

NOZZLE AND HOLDER ASSEMBLY, REPLACE

1. Clean out nozzle mounting hole in engine, with soft wooden stick and lint-free rag. Be sure no carbon remains in hole to impair seat of nozzle in hole or to deflect the spray.
2. Install nozzle and holder assembly in engine. Tighten down firmly and evenly. Attach high pressure and nozzle leak-off lines. Be sure these are absolutely clean when attached.

PRIMING FUEL SYSTEM

Air Lock Trouble: Air or gas binding or lock in the fuel injection system is the most general cause of failure to start or hard starting if proper fuel is used. Air binding or lock is caused mainly from leaky fuel lines, check valves, or running out of fuel. Gas binding or lock is caused by heating of fuel to a point higher than that at which the particular fuel used begins to throw off gaseous vapors. To eliminate either of these difficulties, the following procedure should be followed:

Loosen the check valve fitting at the pump and by using the hand priming pump, pull the fuel from the tank and force it through the small filter located between the transfer pump and the injection pump. It is best to leave vent cock on top of filter open until all the air is out of the system up to this point, then close vent cock and pump fuel oil into the injection pump until a solid stream of oil comes through the opening created by loosening the check valve fitting, then tighten this connection. Be sure the engine is in a position other than on the compression and power stroke of number one cylinder, as in this position, the fuel pump cam is in such a position as to render the hand priming feature inoperative.

(a) Place governor stop control lever in wide-open or full-load position.

(b) Be sure stop control is not in shut-off position.

(c) Install nozzle holders firmly in place, if these were removed for any reason.

(d) Loosen fuel line nut at the nozzle holder end.

(e) Remove plug on side of fuel pump.

(f) Work the fuel pump plunger up and down by means of a screwdriver until clear fuel with no air bubbles flows freely, then tighten nut. Continue the same operation with all six lines, being sure the stop control rod is not in "shut off" position. Turn the engine by hand so the fuel pump cam of the plunger being operated is on the low side to obtain full benefit of the complete plunger stroke.

(g) Replace plug on side of fuel pump. Any time this fuel pump inspection plug is removed for any purpose, great care must be exercised to insure its proper replacement as well as to insure against any dirt getting into the fuel pump.

ADJUSTABLE CONTROL ROD STOP

To increase or decrease the quantity of fuel supplied to the engine, the control rod stop adjustment may be turned in or out to secure the desired fuel setting. Care, however, should be used in making any such adjustment, since too much fuel will cause excessive exhaust smoke and become destructive to the engine parts in general. Engine builders usually provide some marking to indicate the proper fuel setting.

This adjustment may also be used to control the fuel adjustment for various altitudes since an unsupercharged engine cannot operate so efficiently at higher altitudes as it can at lower elevations, this stop is used to cut down the amount of fuel being injected into the engine, when operating at the higher elevations.

Adjustment: The control rod stop adjustment is set for best engine operation at 1,000 feet elevation on all Timken fuel injection pumps when new. A mark is placed at the hole through which the stop is sealed. This mark thus indicates the correct control rod stop setting for engine operation at 1,000 feet elevation.

Should the engine be consistently operated at elevations higher than 1,000 feet, the stop should be adjusted to lower the maximum amount of fuel which the injection pump can pump. If this is not done, the engine will smoke excessively.

1. Remove seal and cotter pin from factory marked hole.
2. Select new sealing hole and insert cotter pin. The staggered holes are so arranged that for every 1,000 ft. change in elevation, the seal and cotter pin should be moved one hole. Thus, if engine was at 6,000 ft. elevation, the stop pin would be moved five holes, counting all holes, from the original 1,000 ft. seal hole. Pin should be moved clockwise, looking at end of stop, for increases in elevation.
3. Insert screw driver in slot through which sealing wire and pin formerly passed. Turn stop screw inwardly (clockwise) until the same slot through which the pin originally passed, indexes the pin in its newly selected hole.
4. Seal and pin adjustable stop.

Replacement: If adjustable control rod stop should be damaged or lost, the installation of a new one is a very simple matter. The control rod stop consists of two simple pieces, an outer sleeve and an inner screw. The outer sleeve is screwed on to the threaded portion of the control rod bushing. Tighten this outer sleeve on the bushing threads tightly, then adjust and seal.

If correct stop position is not known, then the engine should be run at full-load and the stop adjusted until the exhaust is almost clear. Then pin and seal the stop.

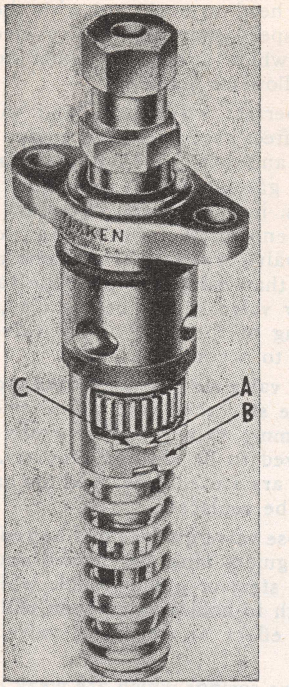
CHECKING AND REPLACING RENEWABLE PUMPING UNIT

The Timken Fuel Injection Pump, with renewable pumping units, provides a simplified method of servicing fuel injection equipment in the field and reduces the cost of its normal maintenance. The pumping units are individually replaceable in the field, on the engine, with stock spare units

Service Checking: Excessive acid or dirt in the fuel, and lack of good lubricating oil in the pump proper, are the common causes of worn or stuck plungers, improperly seating or stuck delivery valves and broken tappet spring. Timken pumping units are easily checked for improper operation as follows:

Worn Plungers:

A. Remove inspection plugs from injection pump.



Timken renewable pumping unit.
Protruding nib "A" must be in center of and vertical to flat surface "B".

B. Replace high pressure line and nut with blind unit. Place throttle in "wide open" position.

C. Insert special Timken hand pumping tool through inspection hole under the tappet and move the tappet up and down. If plunger is not worn, plunger will be very hard to raise. By comparing effort required to lift all plungers it will be possible to tell which plunger, if any, is leaking. Excessive cam case dilution is also an indication of worn plungers or loose plunger barrels.

Stuck Plungers: Check as above. If plungers are stuck, the only resistance to hand pumping felt will be that of the tappet spring.

Broken Tappet Springs: Check as above with "closed" throttle. Lack of resistance to hand pumping lever or failure of tappet to return will indicate a broken spring.

Faulty Delivery Valves Or Broken Valve Spring: Disconnect high pressure line, place throttle in "closed" position, and pump slowly with supply pump hand priming pump. If fuel flows easily from high pressure male fitting, delivery valve can be assumed to have a poor seat, to be stuck, or to have a broken delivery valve spring.

Should the above checks indicate a faulty pumping unit, the unit should be replaced as outlined below. **Keep hands, tools and equipment clean.** Any dirt, lint, or dust allowed to enter the unit or the injection pump while replacement is being made, may result in premature failure of the equipment.

Removal:

1. Thoroughly clean exterior of injection pump with fuel oil.
2. Place throttle in full stop position (Closed throttle). Pumping unit cannot be removed if throttle is in any other position.
3. Loosen fuel supply line from supply pump to injection pump to drain all fuel from injection pump fuel manifold.
4. Remove high pressure injection line tube from unit being removed.
5. Remove the two hexagon hold-down nuts from unit which is to be removed.
6. Lift unit slowly out of injection pump housing. A screw driver may be inserted under the ends of the unit flange to facilitate lifting the unit from its seat. Undercuts are provided at each end of the unit flange for this purpose. Do not force removal of unit. If unit will not come out easily it may be assumed that throttle is not in full-stop position.
7. Check bore of housing for dirt or foreign matter that might interfere with installation of new unit. Cover hole with clean rag.

Installation:

1. Carefully unwrap new Timken Renewable Pumping Unit.
2. Examine unit to be sure metering pinion gear is in proper position. Unit will not enter housing completely unless the protruding nib is in the center of and vertical to the flat surface of the unit body. This is the only position in which the nib will slide through the double tooth space in the control rod of the injection pump. This nib extends from a flat surface which is part of metering pinion gear. Nib should be in proper position when the two flats are brought together by rotating the metering pinion gear. Lint, dirt, or grease should be removed by dipping in clean fuel oil.
3. Throttle lever must be in full-stop position.
4. Insert unit carefully into injection pump housing. Watch oil-resisting gaskets closely to be sure they do not catch or cock in entering housing. New gaskets must be used each time a unit is installed. Be sure nib and flats are on control rod side of pump and that unit flange holes are directly over the studs in pump housing. Press unit gently down until unit flange seats on top of housing. If unit will not enter easily, check throttle position for full-stop setting and unit nib for proper position. If cam for that unit is in lifted position, unit entry will be more difficult and engine should be rotated until cam is in low position. (Cam position may be checked by removal of tappet inspection plug under unit being removed.) Never pound or tap unit to make it enter. This will never be necessary if unit is properly handled and set, and will result in damage to unit.
5. Draw down unit firmly and evenly by means of the two hexagon hold down nuts, alternating from one nut to the other. If nuts are not drawn down evenly, the pump control rod may not operate smoothly.
6. Remove seal from high pressure male fitting on top of unit and replace high pressure injection line tube.
7. Tighten fuel supply line to injection pump, loosen bleeder cock and fill pump fuel manifolds with fuel by means of hand priming pump on supply pump. Pump until clean fuel comes from bleeder cock then tighten cock and lock hand priming pump.
8. Open throttle wide open and start engine. New unit will soon fill injection line and engine will operate smoothly.

No adjustments of any kind are necessary or permissible with Timken Renewable Pumping Unit Injection Pumps.

TUNE UP

Satisfactory performance of the modern high-speed, high-compression gasoline engine of today requires scientific testing equipment in order to restore the engine to the original condition in which it operated when new. In conjunction with this testing equipment, the manufacturer's specifications should be adhered to when making all necessary adjustments in order to obtain smooth performance of the engine with economical results.

At the rear of each Diesel engine chapter will be found useful information concerning Trouble Diagnosis.

The three fundamental divisions of engine tune-up are compression, ignition and carburetion. Since compression does not depend in any way upon ignition and carburetion, it should always be checked first.

COMPRESSION

Before making a compression check, run the engine at a fast idling speed until it is thoroughly warm, in order to allow all the parts affected by compression to expand to their normal operating condition. Remove all the spark plugs and insert a reputable compression gauge in the spark plug hole. Crank the engine with the starter and with the throttle wide open, until the highest reading on the gauge is reached. Repeat the same test on all cylinders. All cylinders should read within 5 to 10 pounds. Should the gauge show a low reading on two adjacent cylinders, a leaky cylinder head gasket is indicated, but, before going any further, tighten down all the cylinder head bolts.

If a cylinder shows a reading of from 10 to 20 pounds below normal, squirt a liberal quantity of oil on top of the piston, being careful not to allow any of the oil to get on the valves, and repeat the compression test. The oil seals the rings, so that a low reading on the first test which remains low on the second test, indicates leaky valves. A low reading on the first test and a normal reading on the second test, indicates a scored cylinder, piston, or poor ring condition.

If the cause of the deficiency is attributed to the valve system, the engine will not idle properly with the vehicle standing still. Although it is difficult to determine the specific cause of the compression leak, the use of a vacuum gauge will help a good deal. Consult the paragraph devoted to vacuum gauge readings further on in this chapter.

Any indication of valve trouble as determined by the vacuum gauge should be followed by the use of the compression gauge, to determine whether there is a slight leak, or a slow-acting valve, that will affect the idling of the engine only and not affect running performance, or whether there is a decided loss in compression that will result in poor engine performance and low gasoline economy.

Vacuum Gauge Readings: When using a vacuum gauge to locate mechanical trouble, make sure that the connection between the gauge and the intake manifold is tight, otherwise the readings will be false.

Start the engine and set the throttle so that the engine idles at a road speed equivalent to from 7 to 10 MPH. The vacuum gauge should show a steady reading of from 17 to 21 inches if the engine is in good condition and the test is being made at from sea level up to about 2,000 feet altitude. Above 2,000 feet elevation the average gauge reading will drop 1 inch per 1,000-foot rise.

A steady reading of from 17 to 21 indicates an engine in good condition which is further indicated by opening and closing the throttle quickly, with the result that the gauge reading should drop to 2 on open throttle and come back to 25 when the throttle closes. However, a reading which shows lower than normal, or about **15 with the needle steady, indicates worn** piston rings, a scored cylinder or piston. This can be determined by opening and closing the throttle which should show a reading of zero at open throttle and come back to about 22 at closed throttle.

With the gauge needle steady at about 10, it generally indicates incorrect valve timing, while a steady reading of about 15 will generally indicate incorrect ignition timing.

Breaker points which are not synchronized properly, or spark plugs with the gaps set too close is indicated generally by the gauge needle drifting slowly between 14 and 16.

Weak valve springs can generally be detected by racing the engine, with the result that the needle will fluctuate back and forth. A sticking valve generally shows on the gauge by its needle dropping occasionally from the normal reading about 4 points. A burned valve, however, will cause the needle to fall back about 5 points each time that particular cylinder functions. Leaking valves also show up in the same manner. A fast vibration of the needle between 14 and 19 approximately, indicates loose valve guides.

A leaky manifold, manifold gasket or carburetor gasket, will generally be indicated by a steady reading of about 3 or 4.

A compression leak between cylinders will usually show up on the gauge by the needle drifting regularly between 5 and 19, while a poor carburetor adjustment will generally cause the needle to move slowly between 12 and 16.

A normal reading when the engine is started, but which soon drops to zero, indicates that the exhaust system is clogged or the muffler is choked.

Valve System Service: A uniform valve tappet adjustment is essential to quiet valve operation and a smooth idling engine. When tappets are not adjusted to the recommended clearances, the valves do not open and close at the proper time. If the tappets are set with insufficient clearance, it reduces the gas charge drawn into the cylinder, with the consequent loss of compression pressure which results in overheating, poor engine performance and poor gasoline mileage. Insufficient clearance will also cause a valve to burn because it reduces the time allowed for the valve head to cool, and with the modern high speed engine, the valves need all the time which a correct tappet adjustment will allow for cooling.

Imperfect valve seats and valve faces will affect every phase of engine performance and will have an important effect upon gasoline economy. When refacing valves, if it has been necessary to grind away enough of the valve head so that the new valve seat strikes the new valve face more than half way up on the valve head, a new valve should be installed, as overheating of the edge of the valve head is likely to occur.

If a valve stem is not scored too badly, it can be smoothed with a fine emery cloth. A gummy valve stem generally must be removed to be cleaned properly. If valve stems are scored or warped too badly, they must be replaced.

Loose valve guides must be replaced and tight guides must be cleaned and reamed. Valve stem or guide trouble which is bad enough to hold a valve open will have the same effect as imperfect valve faces or seats.

Valve springs which are weak or broken must be replaced. Broken valve springs are easily noticeable at idling speed, while weak springs are more evident during high speed operation, which places a limit on top speed performance since they allow the valves to "float" or not follow the cams on the camshaft.

A leak which is caused by a blown cylinder head gasket is noticeable at idle, and indicated by a vacuum gauge, a compression gauge, in the sound of the exhaust, or by its own noise if it is an external leak.

IGNITION

After completing the compression tests and correcting any deficiency which was evident and satisfactory engine performance has not been obtained, the next step is to check the electrical system.

Battery: Since the battery is the source of all electrical energy (unless a magneto is used), its efficiency must first be checked, since starting and idle performance are always poor if the battery and its connections are not up to standard.

A low or defective battery will cause inaccuracies in any tests to the starter, generator or ignition systems. See that the battery terminals are clean and free from corrosion. Warm water, poured slowly over the corroded battery terminals will dissolve the copper sulphate that has been deposited so that it can be brushed off and flushed away easily. The terminals and battery posts should be wiped with a cloth saturated with household ammonia or a solution of water and baking soda. These alkaline solutions will neutralize any acid that may be present on the parts to be cleaned. Do not allow any of the solution to get into the cells of the battery. After the parts have been cleaned thoroughly, they should be given a heavy coating of vaseline or grease to retard further corrosion.

Battery Electrolyte Tests: The electrolyte or battery solution should be tested with a hydrometer. A fully charged battery should register a specific gravity reading on the hydrometer of from 1.270 to 1.290 at 60 degrees F. A gravity reading of 1.150 or below indicates that the battery is entirely discharged.

Whenever a reading of under 1.250 is due to a temporary abnormal demand for current due to the excessive use of lights or starter, the charging rate of the generator should be sufficient to bring the battery up to a fully-charged condition again. If the electrolyte tests below 1.225, the battery should be recharged from an outside source.

The correct level of the battery solution should be maintained according to the recommendations of the manufacturer. If the liquid is too high, it may be forced up and overflow because of the pressure generated within the battery by its "gassing."

Starting Motor Circuit: A voltmeter should be used to determine the condition of the starting motor circuit under actual operation. With the ignition switch turned off, attach the negative voltmeter test lead to the engine for the ground connection, and the positive lead to the starting motor switch, where the cable from the battery fastens, for the positive connection. (This hook-up is used when the negative post of the battery is grounded. Reverse the connections on vehicles where the positive post of the battery is grounded.)

By cranking the engine with the starter, a discharge load will be put on the starting motor circuit. If the starter turns the engine at a good rate of speed, the average voltage reading should be between 4½ and 5 volts (6-volt systems) for a normal operating circuit.

When the starting switch is closed, the starting circuit should crank the engine over for a period of 15 seconds, during which time the normal voltage reading should be 4½ to 5 volts (6-volt systems) without any depreciable drop because of the drain on the battery. If the circuit meets the demands of this test, it indicates that it is in good condition.

Battery Ground Strap: Attach the positive voltmeter test lead to the frame close to the battery, making sure that the connection is secure. Attach the negative lead directly and securely to the grounded battery post (assuming that the negative post of the battery is grounded).

Crank the engine with the starter, which will throw a discharge load across the ground strap. The voltmeter should show a reading of zero, or a very slight indication, if the ground connection is satisfactory. Should the voltmeter show a reading, it indicates a poor ground strap connection and should be cleaned and tightened.

Starting Motor Cable: Attach the negative test lead to the starting motor switch post where the cable from the battery fastens (if the negative post of the battery is grounded), the positive voltmeter test lead should be connected to the positive post of the battery. A discharge load will be thrown through the starting motor cable when the engine is cranked with the starter. If the connections at the battery and the starting switch are satisfactory, the voltmeter will read zero, or a very slight indication. If the voltmeter shows a reading, it indicates a poor connection at the battery or at the starting switch, and should be cleaned and tightened.

Starting Motor Switch: To check the starting switch for high resistance, remove the dust band from the starting motor and connect the positive lead of the voltmeter to the starting switch terminal. The negative lead should be connected to the end of the field coil. Close the starting switch and if the voltmeter reading exceeds ½ volt, the switch is defective.

Engine Ground Strap: Attach the positive lead of the voltmeter to the engine and the negative test lead to the frame. A discharge load will be thrown across the engine ground strap when the engine is cranked with the starter. A zero reading, or a slight indication, should show on the voltmeter if the ground strap is satisfactory, and a loose connection will be indicated if the voltmeter shows a reading. Tighten securely at each connection.

Primary Ignition Circuit: The primary ignition circuit consists of the primary lead wire from the starting switch to the ammeter; the ammeter lead wire to the ignition switch; the lead wire from the ignition switch to the battery connection on the coil; the primary winding of the coil; the lead wire from the distributor connection on the coil to the distributor points; the condenser, and all connections between these various units.

Loose primary circuit connections introduce high resistances into the circuit which will result in hard starting and poor engine performance, therefore, it is important that all connections in the primary ignition circuit be tight to insure a normal supply of current flow.

Ignition Points: Examine the points for burns, pits, dirt and see that they are not sticking on the pivot. Check to see that they are properly spaced and have the correct spring tension. Point spring tension which is too weak or too strong will limit high speed performance, either by the point "floating," which is caused by a weak spring, or "bouncing," which is caused by a spring with too much tension.

Burned or pitted points will prevent accurate spacing and should be replaced. New points, or points that have been dressed, should be cleaned with lacquer thinner or alcohol. Do not use gasoline, kerosene or oil as by doing so, will cause the points to burn rapidly.

Condenser: The condenser should be tested for break-down, leakage, capacity and resistance in series. Use a good tester to perform these operations.

If the condenser cannot stand the break-down test, the engine will not start or run, as the condenser will have practically zero resistance. If the condenser shows less than 2 million ohms resistance, it will in no way affect the engine performance or gasoline economy, but merely indicates that the resistance of the condenser is not up to standard. The capacity test is to determine whether or not the proper condenser has been used.

Secondary Ignition Circuit: The secondary ignition circuit consists of the coil, the high tension coil and spark plug wires, the rotor, the distributor cap and the spark plugs.

Spark Plugs: Spark plugs may be dirty, improperly gapped, have damaged gaskets, burned electrodes or cracked insulators. Make sure that they are the correct plug for the specific engine. However, an engine may be operated at high speeds continuously and may require a colder plug, while another engine of the same make may require a hotter plug if it is operated at low speeds continuously. Spark plug manufacturers provide for these conditions by making plugs with longer insulators for use in cold engines and shorter insulators for hot engines. For normal operation, however, the specifications of the manufacturer should be adhered to and when trouble develops which is caused by abnormal operation of the engine, the plug in the next higher or next lower heat range, depending on whether the engine is operated continuously hot or too cold, will usually correct the trouble.

A cold plug has a shorter insulator than a hot plug in order to allow the heat to travel to the relatively cool cylinder head faster. A plug which is too hot for an engine will develop small blisters on the insulator caused by the extreme heat developed under heavy loads and high speeds. Under these conditions, the tip of the insulator becomes very hot causing the gas to fire prematurely before the spark occurs.

A plug which is too cold for an engine accumulates carbon and oil on its insulator and will eventually develop a short circuit which cuts out the spark.

A spark plug which is correct for an engine will show its insulator to be fairly clean and have a slightly brown or tan color. An insulator in this condition, but shows an accumulation of carbon on the spark plug shell indicates that oil is passing at the piston rings or valves.

Spark plug gaps which are too wide will result in poor top speed performance and will also cause hard starting. Gaps that are set too close, will result in poor idling and low speed performance. Always replace gaskets when replacing the spark plugs as they fail to fulfill their duty when once they are compressed. Be sure the new gaskets are the correct ones for the plugs used as they have to carry the heat away from the plug.

It is important, when replacing spark plugs to be sure they are making a good tight contact, but do not apply too much pressure when installing them as there is danger in changing the gaps.

Ignition Timing: The use of a neon timing light or piston travel gauge should be used to check or set the timing. Timing that is set back as much as 6 degrees from the position of the best setting, will definitely decrease the acceleration and top speed performance.

Centrifugal Spark Advance: Examine for sticking governor weights or weak springs. Sticking governor weights will result in poor acceleration, whereas, weak governor springs will cause a too rapid spark advance, causing the engine to ping, resulting in engine roughness and a decrease in gasoline economy. Sticking governor weights can be cleaned but weak springs must be replaced.

Vacuum Spark Advance: This unit may be inoperative due to a broken diaphragm or spring. To determine whether this condition exists, crank the engine with the starter and hold the choke closed. If the distributor plate will advance and return, the parts are not broken. The plate will not advance if the diaphragm is broken and will not return if the spring is broken.

A leak at the vacuum spark advance connection will allow air to enter the carburetor throat in excess of that considered in the calibration of the carburetor and may result in poor gasoline economy through fixed throttle intermediate speeds, because of incorrect operation of the vacuum spark advance.

If the pig tail leads are broken at any point, or if the distributor housing is worn so that the point plate can shift sidewise as it is oscillated by the vacuum spark advance mechanism, the ignition may be erratic enough to cause flat spots or ignition miss. This condition will usually occur at idle speed or up to 15 MPH. To detect this trouble, disconnect the vacuum line to the distributor. If the trouble disappears, test the pig tail leads, and also, check the groove in the distributor housing where the point plate "floats".

CARBURETION

Since carburetion is dependent in several ways on both compression and ignition, it should always be checked last when tuning the engine. See the CARBURETOR chapter for adjustments and specifications for the unit with which the engine is equipped. However, there are other factors which relate to the carburetor which should be considered and which affect engine performance.

Carburetor Flange: Check the carburetor flange for looseness on the manifold. If one of the flange nuts is loose as little as ½ turn, a sufficient amount of air will enter the intake manifold below the throttle to destroy the engine idle and all engine performance. If a tight fit cannot be obtained by tightening the nuts, install a new gasket but be sure that all of the old gasket has been completely removed.

Air Cleaner: The silencer tube may be misaligned or the cleaner may be restricted with dirt. Either condition will cause a restriction of the flow of air into the carburetor resulting in a partial choking action of the carburetor.

If equipped with an oil bath type cleaner, the flow of air will be restricted if the oil is too high.

Throttle Linkage: If the throttle linkage is adjusted so that the accelerator pedal will strike the floor board before the throttle valve is wide open, it will result in a low top speed.

Gasoline Line: A restriction of the gasoline line will likely result in an apparent vapor lock action or a definite cut-off in the gasoline supply. This can generally be corrected by blowing out the line with compressed air, but in some cases, it may be necessary to replace the line.

Intake Manifold: A deposit of gasoline gum in the intake manifold will restrict the flow of gasoline and air into the engine, affecting all engine performance with a definite loss in power. In some cases, the manifold can be cleaned by using acetone or a half-and-half solution of benzol and denatured alcohol. If this cannot be accomplished, replace the manifold.

Manifold Heat Control: The thermostatic spring (if this type is used) may become disconnected during a tappet adjustment and may not be reinstalled properly. If the control is adjusted to a point where it holds too much heat in the intake manifold, the engine will ping upon acceleration even though the ignition is timed properly, and will show up as an apparent flat spot due to over-expansion of the gas mixture in the intake manifold.

If the control valve is adjusted so that it opens too early, insufficient heat is retained in the intake manifold which will result in slow warm-up, causing poor gasoline economy on short trips.

If the thermostatic spring is allowed to remain disengaged, the entire heat control system is destroyed, causing a decided loss in engine performance and gasoline economy.

A sluggish engine caused by a slow warm-up may be due to an accumulation of carbon in the carburetor heat riser section of the intake manifold. If this condition exists, poor acceleration will be noticed even after the engine is well warmed up. To correct this condition, remove the carburetor, intake manifold, and unbolt the heat control assembly. Place the manifold upside down on the bench and insert a piece of paper in the heat outlet opening of the riser. Ignite the paper and, with a torch, using **oxygen** only, it will be possible to burn and completely oxidize the carbon deposit. Better results will be obtained if part of the opening through which the torch is inserted is covered with a heavy piece of metal after the carbon starts to burn.

CAUTION—Do not put kerosene in the riser to facilitate the burning operation, nor use acetylene, as a cracked manifold or a burned riser may result.

Fuel-Vacuum Pump Diaphragm: When the diaphragm on the vacuum pump is leaking, oil is drawn from the crankcase, causing high oil consumption and ignition miss due to fouled plugs. A small hole in the diaphragm, when first encountered, may be indicated by a partial miss on the two cylinders adjacent to the spot where the vacuum line taps into the manifold. This condition may be checked by the action of the windshield wiper (vacuum-operated type) upon acceleration, with a vacuum gauge, or by disconnecting the line on the manifold side of the vacuum pump to inspect for oil.

TESTING EQUIPMENT

The importance of the testing equipment being maintained in perfect condition cannot be stressed too highly. Long leads of wire between the generator and the battery, which are of too small a gauge, test clips with weak springs, meter connections loose, inaccurate meters, wire which is partly broken at the terminals, batteries with the electrolyte solution too low, improperly charged batteries, and corroded battery terminals should be checked and corrected if satisfactory results are to be obtained from the tests.

After the above points have been checked and corrected, the following standards are recommended in order to obtain the best results in using the equipment.

1. The generator leads should be of No. 10 stranded wire, with voltage drop not to exceed .2 volt from the generator terminal to the battery terminal.
2. The generator lead terminals or test clips should be soldered and should have no broken strands of wire.
3. Starting motor leads should have No. 1 stranded cable with terminals properly soldered. (Do not use test clips.)
4. Meter and shunt connections should be polished and tight. These connections should have soldered terminals on all wires.
5. Where knife switches are used, be sure that both the blades as well as the posts are polished bright. The knife blades must also be aligned with the posts so that a full, tight contact is made when the switch is closed.
6. Cut-out relays which are permanently mounted on the test stand should be checked for proper adjustment and the connections must be tight.
7. Where circuit breaker test holders are used having spring contacts, be sure that the contacts are clean and have enough tension to show no voltage drop.
8. Distributor and coil testing equipment should have all leads of No. 12 stranded wire with soldered terminals or test clips.

9. Ground connections, if made by a wire to the holding stand, should have terminals soldered to the wire with the terminals clamped tightly under a bolt and nut. Ground surfaces should be free from paint or dirt and when units are being tested be sure they are clamped tight.

10. All test batteries should be given a weekly inspection to see that the electrolyte level is correct; that the specific gravity has a reading between 1.225 and 1.275, and the terminals should not show any evidences of corrosion.

If the shop is equipped with a lathe, it should have its centers checked for true running; bearings checked for wear, and tool holders checked for play in feed screws and guide rails. This is important, especially where lathes are used for truing commutators, as finished commutators, when checked with a dial indicator, should not be out of round more than .0005" maximum.

CARTER DOWN-DRAFT

Engine Model	Carburetor Model and Number ①	Carburetor Size, Inches ⑪	Main Venturi Diameter, Inches	Low Speed Jet Tube: Low Speed Jet, Inch or No.	Low Speed Jet Tube: By-Pass Inch or No.	Low Speed Jet Tube: Economizer Jet, Inch or No.	Idle Ports: Upper Port Diameter, Inch or No.	Idle Ports: Lower Port Diameter, Inch or No.	Idle Screw Seat, No.	Vacuum Spark Port, Inch or No.
CHEVROLET										
1936	WI-319S	1¼	1¼	72	56	.054-.056	44	54	52	50-56②
1936	WI-334S	1¼	1¼	72	56	.054-.056	44	54	52	50-56②
1936	WI-335S	1¼	1 1/16	72	56	.051-.053	44	52	52	.0415-.0445
1937	WI-346S	1¼	1¼	72	56	.059-.060	44	52	50	50-56②
1937-38	WI-358S	1¼	1 1/16	72	56	.051-.053	44	52	52	.0415-.0445
1938	WI-391S	1¼	1¼	72	56	.059-.060	44	52	52	.0415-.0445③
1939-40	WI-420S	1¼	1 1/16	70	56	⑤	44	52	52	.040x.125⑥
1939-40	WI-434S	1¼	1 1/16	70	56	.051-.053	44	52	52	.040x.125⑥
1941	WI-483S	1¼	1¼	.035	51	.0545-.0555	44	54	52	.041x.125⑥
1941	WI-492S	1¼	1 1/16	72	56	.0545-.0555	44	⑦	52	.041x.125⑥
STUDEBAKER										
2M2, 2T2	WI-336S	1¼	1¼	70	55	48	⑧	⑧	46	None
J15	WI-357S	1¼	1¼	68	55	.054-.056	⑨	⑨	46	.030x.140⑥
J20, K20	WI-360S	1¼	1¼	70	55	48	⑧	⑧	46	None
J25, K25	WI-361S	1¼	1¼	70	55	48	⑧	⑧	46	None
K10	WI-394S	1¼	1¼	68	55	.054-.056	⑨	⑨	46	.030x.140⑥
K15	WI-395S	1¼	1¼	68	55	.054-.056	⑨	⑨	46	.030x.140⑥
M5, M15	WAI-496S	1¼	1 3/16	64	50	.0755-.0765	⑧	⑧	46	.1005-.1025

① Carburetor number usually stamped on tag attached to carburetor.

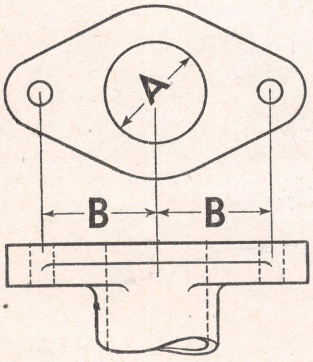
② Round type—smaller figure is the upper port, larger number is the lower port.

③ Late production size, .041″ wide by .125″ long.

④ Next step is power step.

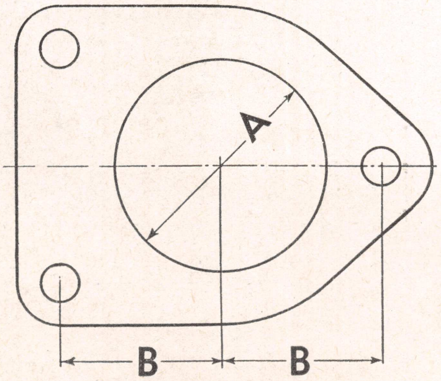
⑤ For 1939 engines, .059″ to .060″: 1940 engines, .062″ to .063″.

STANDARD DIMENSIONS FOR AUTOMOTIVE TYPE CARBURETOR FLANGES



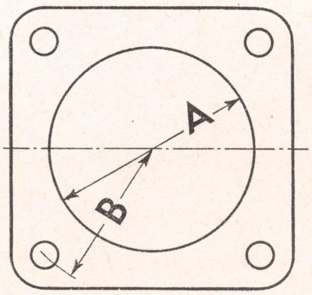
TWO-BOLT FLANGE

Nominal Size, Inch	Dimension A, Inch	Dimension B, Inch
½	13/16	29/32
⅝	13/16	29/32
¾	1-1/16	1-1/8
⅞	1-1/16	1-1/8
1	1-3/16	1-3/16
1¼	1-7/16	1-11/32
1½	1-11/16	1-15/32
1¾	1-15/16	1-21/32
2	2-3/16	.-25/32



THREE-BOLT FLANGE

Nominal Size, Inch	Dimension A, Inch	Dimension B, Inch
¾	15/16	29/32
1	1-1/8	29/32
1¼	1-3/8	1-1/32



FOUR-BOLT SQUARE FLANGE

Nominal Size, Inch	Dimension A, Inch	Dimension B, Inch
2½	2-11/16	2-1/32
3	3-3/16	2-5/16
3½	3-11/16	2-5/8

SPECIFICATIONS

Nozzles			Standard Metering Rod Diameters, Inches					Accelerating Pump System			
Outer Nozzle Discharge Size, Inch	Inner Nozzle Jet Size, Inch	Nozzle Retainer Plug, No. or Inch	First Step, Inch	Second Step, Tapers to—Inch	Third Step, Tapers to—Inch	Power Step, Tapers to—Inch	Metering Rod Jet Size, No. or Inch	Discharge Jet, No.	Intake Check No.	Discharge Check No.	Engine Model
											CHEVROLET
.125	31	None	.069	.056	④	.042	.0955	72	62	40	1936
.125	31	None	.069	.056	④	.042	.0955	72	62	40	1936
40	53	None	.068	.060	.060	.049	.0835	72	62	40	1936
.125	31	None	.069	.058	.058	.044	.094	72	62	40	1937
40	53	None	.067	.063	.061	.052	.0835	72	62	40	1937–38
.125	31	None	.069	.060	.058	.042	.095	72	62	40	1938
.125	31	None	.0675	.057	.050	.040	.095	72	62	40	1939–40
40	53	None	.065	.061	.058	.041	.0835	72	62	40	1939–40
.125	.120	31	.067	.062	.060	.046	.093	72	62	40	1941
.125	.120	53	.0645	.063	.061	.046	.0835	72	62	40	1941
											STUDEBAKER
35	None	None	.069	.063	④	.044	42	72	62	45	2M2, 2T2
35	None	None	.080	.067	④	048	.0935	68	62	45	J15
31	46⑩	None	.0695	④	④	.045	.09525	72	62	45	J20, K20
31	48⑩	None	.070	④	④	.040	.0935	72	62	45	J25, K25
35	None	None	.080	.0675	④	.057	.0935	68	62	45	K10
35	None	None	.080	.0695	④	.045	.0935	68	62	45	K15
44	None	None	.068	.060	④	.043	.098	72	62	32	M5, M15

⑥ Width by length.

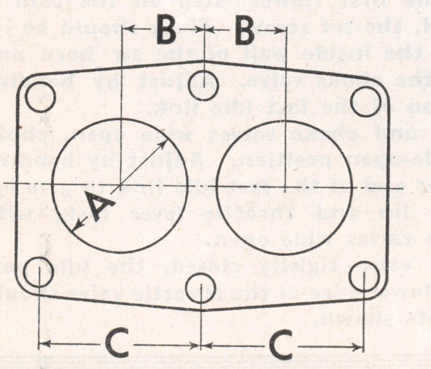
⑦ Early production, No. 52 drill: late production, No. 54 drill.

⑧ Slot type: Length .200″, width .030″.

⑨ Slot type: Length .175″, width .030″.

⑩ Nozzle restriction.

⑪ See illustrations for other flange dimensions.



DUPLEX FLANGE

Nominal Size, Inch	Dimension A, Inch	Dimension B, Inch	Dimension C, Inch
1	1-3/16	23/32	1-1/2
1¼	1-7/16	13/16	1-5/8
1½	1-11/16	15/16	1-27/32
1¾	1-15/16	1-1/16	2-1/16
2	2-3/16	1-3/16	2-3/8

GENERAL INSTRUCTIONS

It is well to remember that any change in carburetor action will usually come gradually. Therefore, if the carburetor operated properly when last used, it is reasonable to assume that some other part of the engine is at fault, and the trouble should be located and corrected before attempting alterations to the carburetor.

Dirt is the great enemy of good carburetion; it not only fills up air and gasoline passages, but it also accelerates the wear of delicate parts. How often a carburetor should be cleaned depends upon the conditions under which it is used. In dusty areas, the carburetor should get more attention than in parts of the country where this condition is not prevalent.

Never use a wire to clean out restrictions in jets as this practice will destroy the calibrations of these parts. Always use compressed air.

The perfect carburetor delivers the proper gasoline and air ratios for all speeds of the particular engine for which it was designed. By proper cleaning and replacing of all worn parts, the carburetor can again function in the original condition, and will then deliver the proper air-fuel ratios as it did when new.

The many other factors which affect performance and economy cannot be changed in any way by the carburetor.

In servicing the carburetor, it is well to divide the unit into its various systems or circuits. These circuits are: float or gasoline level system, low speed system, high speed system, pump or acceleration system and the choke system. By treating each system separately, repairs to the unit are made easier.

When disassembling the carburetor, it is well to have a separate pan for the parts which comprise each circuit. Inspect the unit for its general condition, evidence of previous repair, and relation of parts.

If any of the parts are too tight to remove without mutilating the slots, place the proper size screwdriver in the slot and rap its handle with a hammer. This will loosen the part in its seat so it can be removed. When this is done to jets, it generally changes the size of the metering hole, besides damaging the part.

CARTER DOWN-DRAFT SETTINGS

Engine Model	Carburetor Model and Number	Float Setting, Inch ①	Idle Port Opening, Inch	Vacuum Spark Port Location, Inch ③	Idle Screw Setting, Turns Open ④	Metering Rod Setting Gauge	Accelerating Pump Setting, Inch	Anti-Percolator Setting	Unloader Adjustment	Fast Idle Adjustment	Choke Lock-Out Setting
CHEVROLET											
1936	WI-319S	⅜	.016–.020②	⑦	1–2	T109-25	⑤	None	None	None	None
1936	WI-334S	⅜	.016–.020②	⑦	1–2	T109-25	⑤	None	None	None	None
1936	WI-335S	⅜	.016–.020②	.015–.030	1–2	T109-25	⑤	None	None	None	None
1937	WI-346S	⅜	.034–.038②	⑦	1–2	T109-25	⑤	None	None	None	None
1937–38	WI-358S	⅜	⑥	.015–.030	1–2	T109-25	⑤	None	None	None	None
1938	WI-391S	⅜	.047–.051②	.012–.016	1–2	T109-25	⑤	None	None	None	None
1939–40	WI-420S	½	⑧	.000–.004	1–2	T109-25	⑤	None	None	None	None
1939–40	WI-434S	½	⑧	.000–.004	1–2	T109-25	⑤	None	None	None	None
1941–42	WI-483S	½	.044–.048②	.000–.004	1¼–2¼	T109-25	⑤	None	None	None	None
1941–42	WI-492S	½	.044–.048②	.000–.004	1¼–2¼	T109-25	⑤	None	None	None	None
STUDEBAKER											
2M2, 2T2	WI-336S	⅜	.016–.020②	None	¼–1	T109-25	⑤	None	None	None	None
J 15	WI-357S	⅜	.014–.018②	.008–.014⑨	½–1¼	T109-40	⑤	None	None	None	None
J20, K20	WI-360S	⅝	.016–.020②	None	½–1¼	None	⑤	None	None	None	None
J25, K25	WI-361S	⅝	.016–.020②	None	½–1¼	None	⑤	None	None	None	None
K10	WI-394S	⅜	.014–.018②	.008–.014⑨	½–1¼	T109-40	⑤	None	None	None	None
K15	WI-395S	⅜	.014–.018②	.008–.014⑨	½–1¼	T109-40	⑤	None	None	None	None
M5, M15	WAI-496S	5/16	.010–.014⑯	⑩	½–1½	T109-102	11/64⑪	⑫	⑬	⑭	⑮

① Measure from the end of the float opposite the gasoline intake needle from the top of the float to the machined surface of the bowl cover-- without gasket.

② With the throttle valve tightly closed, the distance between the top of the lower port and the top of the valve should be within the limits shown.

③ Top of spark port should be the dimension shown —above the top edge of the throttle valve.

④ Turn screw OUT for richer mixture and IN for leaner.

⑤ No specified setting other than seasonal: long stroke for winter and short stroke for summer.

⑥ Late production, .048″ to .052″: early production, .012″ to .016″ above top edge of valve.

⑦ Round type—two holes, upper and lower.

⑧ For 1939 units, .047″ to .051″: 1940, .041″ to .045″ above top edge of valve.

⑨ Bottom of spark port should be the dimension shown below the valve.

⑩ Early production, .045″ to .050″: late production, .055″ to .060″ above tope edge of valve.

⑪ Pump plunger travel should be the distance shown for full throttle position.

⑫ With a .030″ wire gauge placed between the throttle valve and the carburetor bore (side opposite port), bend the rocker arm until a clearance of from .005″ to .015″ is established between the rocker arm and the pump arm.

⑬ There should be ¼″ clearance between the lower edge of the choke valve and the inner wall of the air horn, with the throttle valve wide open.

⑭ With fast idle cam held in normal idle position, tighten throttle lever adjusting screw until it JUST seats against the cam. Hold throttle lever closed and pull cam back until the first (lower) step on the cam is AGAINST, NOT ON, the set screw. There should be ⅝″ clearance between the inside wall of the air horn and the lower edge of the choke valve. Adjust by bending at the offset portion of the fast idle link.

⑮ With throttle and choke valves wide open, choke should lock in wide-open position. Adjust by bending the lip at the lower end of the fast idle link to give 1/32″ clearance between lip and throttle lever lock, with throttle and choke valves wide open.

⑯ With throttle valve tightly closed, the idle port opening below the lower edge of the throttle valve should be within the limits shown.

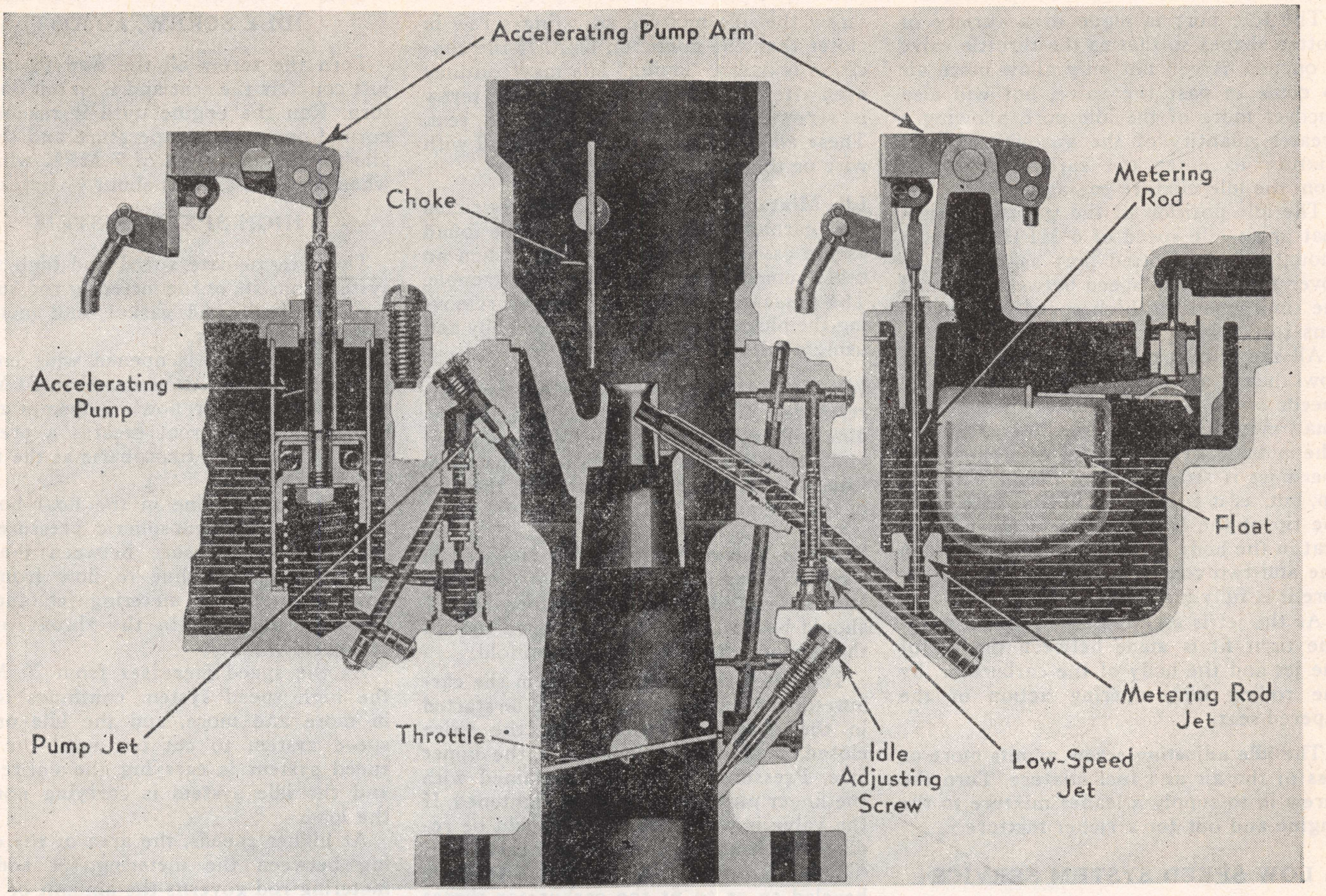
After the parts have been removed, inspect all holes in the casting to be sure they are not restricted. Wash the casting in gasoline with a brush and blow out all the openings with compressed air. Any gum or foreign matter which cannot be removed with gasoline, can generally be removed with lacquer thinner.

A complete check of all parts should be made since, usually a complaint is caused by two or more sources, and by replacing one part will not restore the carburetor to perfect condition. Use new gaskets, since used gaskets are generally compressed and usually will not seal again.

CARTER W-1

FLOAT SYSTEM

Gasoline is forced into the fuel bowl by fuel pump pressure. As the fuel rises to a pre-determined level, it raises the float.



CARTER W-1 DOWNDRAFT. Diagrammatic view.

The float, due to its buoyancy, tends to remain on top of the fuel. Being hinged on the far end of its bracket, the float assembly acts as a lever and pushes the fuel valve needle against the fuel valve seat, thereby shutting off the fuel.

Float height setting is the control for the fuel level in the bowl. This setting must be made with extreme care. If the fuel level is too high, fuel will spill over the discharge nozzle, causing a rich mixture, waste of fuel, and a very rough idle. Lower fuel level will cause a bad flat spot around 18 to 22 m.p.h. A correct float setting will allow the fuel to seek a level in the discharge nozzle about 1/32 of an inch below the top of the tube. To check the float setting, remove the bowl cover and hold float and bowl cover assembly upside down with float hinge end away from you. Consult the CARTER SETTINGS chart for the proper setting. Use either Carter spacing tool or piece of round stock, with guage resting on bowl cover, gasket removed. There should be a hairline of space between gauge and float. To correct this setting bend the lip on the float bracket which contacts the fuel valve.

FLOAT SYSTEM SERVICE

The fuel valve needle will wear from continual pounding against the fuel valve seat. If there is a ridge on the valve, replace both valve and seat, as they are matched and tested at the factory. The float can be punctured, fuel can seep inside the float allowing same to sink. The curved lip on the float bracket, which contacts the fuel valve will wear at the point of contact. If the wear is excessive, it will cock the fuel valve and cause flooding. The float lever pin should slide freely in the float bracket, yet there must be no ridges on the pin and no sign of egg-shaped wear in the float bracket.

The float bowl acts as a reservoir to hold a supply of gasoline throughout the entire range of performance of the engine.

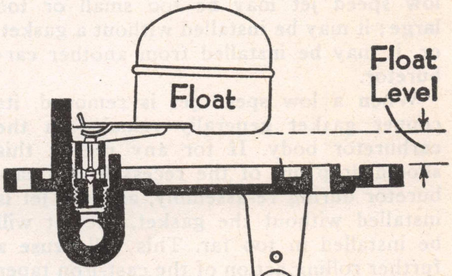
Always check fuel bowl air vent. There must always exist an air pressure on the fuel level to push fuel out of the jets.

Flooding over and stalling engine only when hot, due to percolation, happens on warm days when winter gasoline is still in use. Percolation creates a pressure in the bowl which forces gas out of the nozzle. Use bakelite metering rod disc No. 129-21. Pressure raises bakelite and escapes. Pump pressure should be 2½ to 3½ pounds fuel valve, and seat will hold up to 16 pounds.

LOW SPEED SYSTEM

The idle or low speed circuit completely controls the supply of gasoline during idle and light-load speeds up to approximately 20 MPH and it partially controls the light-load speeds between 20 and 30 MPH.

During idle and low speed operation of the engine, gasoline flows from the float bowl through the idle speed jet to the point where it is combined with a stream of air coming in through the by-pass. The combining of the air and gasoline tends to atomize or break up the gasoline into a vapor.



CARTER W-1. Checking float level.

This mixture of air and gasoline continues on through the economizer until it begins to pass the point where it is further combined with a stream of air coming in through the lower air bleed. This again tends to break up the gasoline particles into a finer vapor. The gasoline and air mixture that flows downward in the passage from the lower air bleed, is still richer than an idle mixture needs to be, but when it mixes with the air which has come past the throttle valve, it forms a combustible mixture of the right proportions for idle speed.

The idle port is made in a variety of slotted shapes so that as the throttle valve is opened, it will not only allow more air to come in past the valve, but will also uncover more of the idle port, allowing a greater quantity of the gasoline and air mixture to enter the carburetor throat from the idle mixture passage.

The idle position of the throttle is such that at an idle speed of 6 MPH, it leaves enough of the slotted port as reserve to cover the range in speed between idle and the time when the high speed system begins to cut in.

All the gasoline flowing from the float bowl during the idle period and at no-load speeds up to 20 MPH, flows through the small metering hole in the low speed jet. The outside of the barrel of a new low speed jet is straight from the base to the tip, but, as it is installed in the carburetor, the tip of the barrel contacts the tapered seat in the body of the carburetor between one and two complete turns of the jet before it is fully installed.

As the jet is screwed into place, a gasoline tight fit is made between the tip of the jet and the body of the carburetor, by the rolling and tapering action of the tapered seat.

The **idle adjusting screw** admits more or less of the air and fuel mixture. Turn the screw in to supply a leaner mixture to the engine and out for a richer mixture.

LOW SPEED SYSTEM SERVICE

Low Speed Jet: Trouble may be due to any of the following: The metering hole in the low speed jet may be too small or too large; it may be installed without a gasket, or, it may be installed from another carburetor.

When a low speed jet is removed, its copper gasket generally remains in the carburetor body. If for any reason this should drop out of the recess in the carburetor during re-assembly, and the jet is installed without the gasket, the jet will be installed in too far. This will cause a further rolling action of the cast-iron taper on the jet. Installing the jet without the gasket will likely cause a gasoline leak at the seat of the jet; and if it is then removed and replaced with a gasket, a space will be left between the tip of the jet and the cast-iron taper. This will allow gasoline to go into the idle passage past the outside tip of the jet without passing through the small metering hole in the side. This will destroy the calibration of the carburetor and will affect gasoline economy. If the metering hole in the side of the jet is too large because of improper cleaning, or if it is clogged so that it cannot be cleaned with compressed air, the jet should be replaced.

By-Pass & Air Bleed Holes: The black carbon deposit which forms in the throats of carburetors may restrict the air bleed holes to such an extent that insufficient air will be supplied to mix the gasoline before it reaches the idle port. This condition will generally be indicated if it is necessary to screw the idle mixture adjusting screw in closer than the minimum limit. If the condition is bad, a "loping" idle may continue even after the idle mixture adjusting screw is screwed entirely in against the seat. These air bleed holes may be cleaned with wire or the proper size drills.

Idle Mixture Passage: A passage restricted with carbon is unusual but it may be found as the cause of an unsteady idle when no other remedy seems to correct the trouble. The passage should be cleaned by removing the plugs from the carburetor body and using a wire and compressed air.

Idle Port: Make sure it is clean and unrestricted. If the port is damaged, the engine will not perform properly at low speed and a new casting will have to be installed. Consult the calibration chart for the size of the idle port.

Throttle Valve: A capital "C" enclosed in a circle is stamped on the face of the valve. When installed in the carburetor, the "C" should be on the side of the valve toward the idle port, and facing the manifold.

To center the valve properly in the carburetor throat, the screws should be started in the shaft, and then, with the valve closed, it should be tapped on the upper side. Pressure should be maintained with the finger until the screws are tightened. If the valve is worn or bent it should be replaced as it affects the idle port relation.

Valves are made with two opposite edges beveled so as to fit the carburetor throat when the valve is closed. Always make sure that the valve is installed correctly as poor performance at low speed will be the result otherwise.

To correct the relation of the throttle valve to the idle port opening, see CARTER SPECIFICATIONS. Throttle valve shims are supplied in two sizes: No. 2-93 is .002" thick and No. 2-94 is .005" thick.

Throttle Shaft & Lever: If the shaft is badly worn it will affect port opening. If the lever is loose on the throttle shaft, the carburetor will idle slow one time and fast another; in both cases, it will have to be replaced. Do not try to tighten a lever that is riveted on the shaft as this will damage other parts of the shaft.

Carburetor Bore: If the carburetor bore is restricted with a carbon deposit, it will make it necessary to open the throttle wider than the specified opening to obtain the proper idle speed. This will uncover more of the slotted idle port than was intended in the calibration of the carburetor, which will result in leaving an insufficient amount of idle port as reserve to cover the period between idle and 20 MPH when the high speed system begins to cut in. This will result in a flat spot. The bore can be cleaned with emery cloth or by scraping.

Idle Adjustment Screw & Spring: The point of the screw must be free of burrs and must also be smooth. The spring must have the proper tension to hold the adjustment.

IDLE SCREW, ADJUST

Turn the screw all the way in until it just contacts the seat and then out one full turn. Run the engine until it reaches its normal operating temperature and set the idle to the equivalent of 7 MPH which is when the idle screw is about ½-turn open.

HIGH SPEED SYSTEM

The intermediate speed and high speed system consists of the metering rod, metering jet, nozzle and gasket, and metering rod spring and disc.

As the throttle is opened wide enough for a speed of a little more than 20 MPH, the velocity of air flowing down through the carburetor throat creates a pressure slightly less than atmospheric at the tip of the main nozzle.

Since the gasoline in the float bowl is acted upon by atmospheric pressure, the difference in pressure between the two points causes gasoline to flow from the bowl, through the metering jet, and out the main nozzle into the throat of the carburetor.

As the speed increases from 20 MPH, the high speed system continues to cut in more and more, and the idle or low speed system to cut out until the high speed system is carrying the entire load and the idle system is carrying none of the load.

At higher speeds, the area of the opening between the metering jet and the metering rod governs the amount of gasoline going into the engine. At top speed, the smallest section of the metering rod is in the jet.

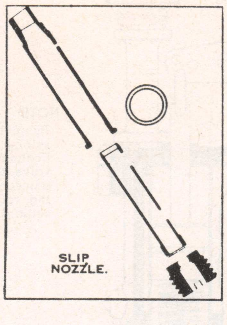
HIGH SPEED SYSTEM SERVICE

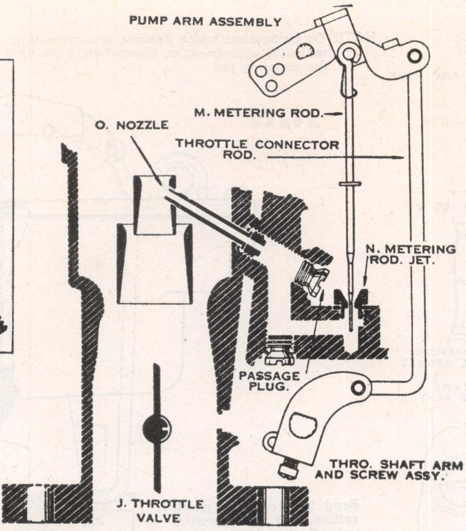
Main Nozzle: When a restricted main nozzle cannot be cleaned with compressed air, or if the hole in the end of the nozzle is too large or is damaged, or if the installation of new gasket will not overcome the leak at the base of the nozzle, a new nozzle and gasket must be installed.

The main nozzle consists of two parts and must be replaced as an assembly. The screw nozzle takes its length from being pressed into the slip nozzle. The thin copper gasket should be assembled against the housing and the slip nozzle must engage its flat surface in the secondary venturi. This assembly is then held in place by the screw nozzle. No gasket should be used between the two nozzles. Never attempt to remove this nozzle without first taking off the choke housing, as bent or broken parts will result.

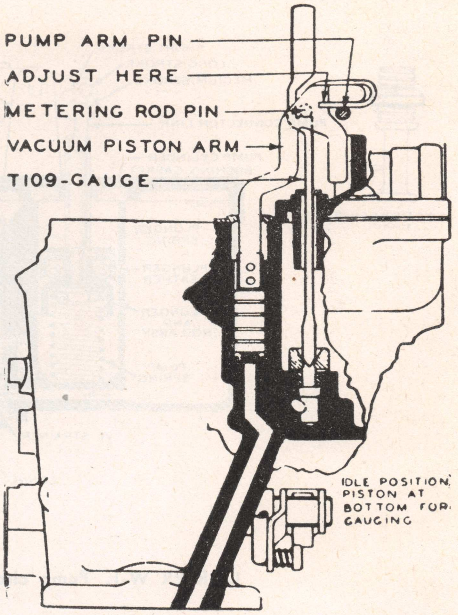
Main Metering Jet: This jet will seldom give trouble in normal service. When air-fuel ratio changes are made with metering rod changes, be sure to check the metering rod jet which is in the unit to see that it is the proper one for the job.

Metering Rod: The metering rod measures all the fuel that passes the discharge nozzle at intermediate and high speeds. While the metering rod jet is a sized orifice, the





CARTER W-1. High speed circuit.



CARTER W-1 VACUMETER DEVICE.
Method of adjusting metering rod.

metering rod is stepped and tapered. As different parts of the rod hang in the jet, the space between the rod and jet is changed. When the thinnest part of the rod (bottom portion) is suspended in the jet, more fuel will pass through than would do so if the wider or upper portion of the rod is in the jet. The correct adjustment of this rod is very important from both performance and economy angle and a Carter metering rod gauge is required to make this adjustment. The correct metering rod gauge number is listed in the CARTER SETTINGS table. Leaner than standard metering rods are available to compensate for special fuel or high altitude operation. Standard metering rod sizes are listed in the CARTER SPECIFICATIONS table. Metering rods should be measured with a micrometer.

METERING ROD SETTING

The metering rod position should be checked when carburetors are serviced or when leaner than standard rods are installed. Consult the CARTER SETTINGS table for the correct gauge to use.

For 1936 and earlier W1 units, back out the throttle adjusting screw so that the throttle valve seats tight. Insert the gauge in place in the metering rod jet. Hold the gauge vertical to insure its seating. The metering rod pin in the pump arm should rest at the bottom of the notch in the gauge with the throttle fully closed and the upper end of the connector rod centering freely in the hole in the pump arm. If it does not center freely, use Tool No. T109-75, and bend the connector rod at the lower end (where it right-angles), so that the top end centers freely in the hole in the pump arm with the throttle fully closed. After replacing the metering rod, spring and disc, lubricate the pump arm with graphite grease.

W-1 VACUMETER TYPE (STUDEBAKER)

For 1937 and later W1 units having a specified pump setting or vacumatic metering rods, it is well to understand the principle of operation.

Under part throttle acceleration and for hard pulling at part throttle, the power mixture is required for a short time. This requirement always coincides with a drop in manifold vacuum. The carburetor meets this demand by allowing the drop in manifold vacuum to permit a spring to move the metering rod to the proper step and give the required richer mixture the instant it is needed, regardless of throttle opening. As soon as the demand is passed, as shown by the rise of manifold vacuum, the metering rod moves down against the pin attached to the pump arm, and it is then controlled mechanically until another such demand arises.

The vacumeter control consists of a small brass piston beneath which is a spring fitted into a cylinder, bored into the carburetor casting. The lower end of the bore has a drilled passage, opening into the carburetor throat below the throttle valve. The vacuum acting upon this piston through this passage holds the piston down and compresses the spring as long as the vacuum is stronger than the spring. The spring under the piston is calibrated to force the piston up to a pre-determined point (not the top of the cylinder) when manifold vacuum drops below 3 inches of mercury. This spring varies in length for different carburetors, and the correct spring must be used. With the manifold vacuum above 3 inches of mercury, the piston is pulled down until the arm to which it is attached, rests on the pin attached to the pump arm. When the piston is down, this pin lifts the metering rod in direct ratio to the throttle opening, without regard to vacuum.

To adjust the metering rod on vacumeter units, insert the gauge in place of the metering rod, seating the tapered end in the metering rod jet. Hold the gauge vertical to insure seating. Bend the link on the step-up piston link so that when the link is pushed down all the way, with the throttle valve seated, the metering rod pin will rest on the shoulder in the notch of the gauge. Remove the gauge, install the metering rod disc and spring. Be sure the metering rod is in the jet. Care must be taken that the piston is clean and dry, shows no wear, and moves freely. Make sure the proper length spring is under the piston; replace this spring whenever the carburetor is overhauled.

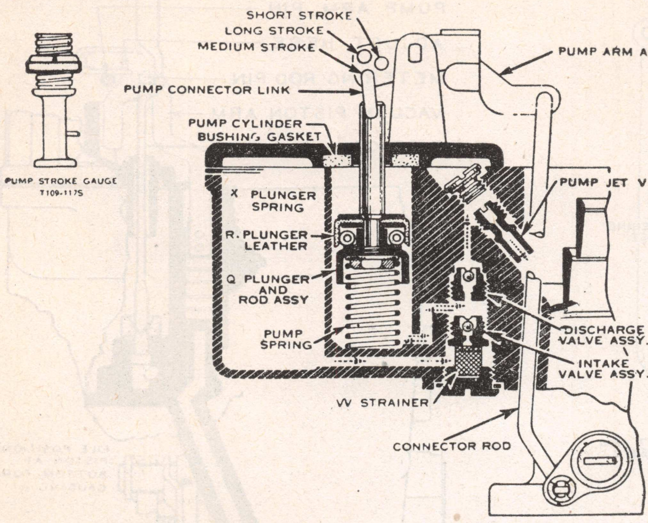
PUMP OR ACCELERATION SYSTEM

The pump system consists of the pump cylinder, pump arm assembly, connector link, pump plunger and rod assembly, plunger leather and spring, intake valve. discharge valve, pump strainer screen, pump disc check valve (Chevrolet), pump jet, connector rod and pump spring.

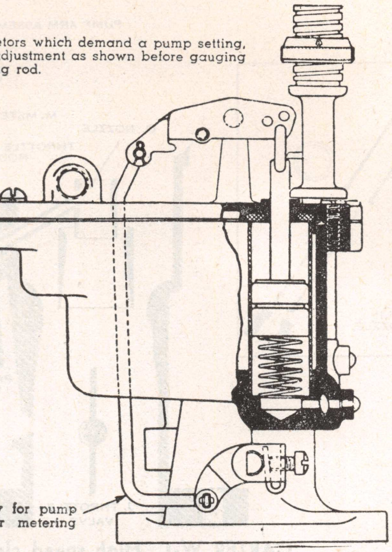
When the pump plunger and leather are first installed in the pump cylinder, a small amount of air is trapped between the piston and the top of the liquid gasoline. As the accelerator pedal is depressed, the pump plunger and leather are forced downward. This compresses the trapped air, forces the gasoline to leave the cylinder, closes the inlet valve, opens the discharge valve, closes the disc check valve (Chevrolet), and discharges gasoline into the carburetor throat.

The discharge is prolonged, since the hole in the tip of the pump jet is small enough to restrict the flow so long as it is being forced out by the pump travel, plus the expending of the trapped air. The prolonging of the pump discharge gives the gasoline in the high speed system sufficient time to flow fast enough to satisfy the demands of the engine.

As the accelerator pedal is allowed to return to its original position, the accelerating pump plunger is lifted upward by the link. This creates a partial vacuum in the pump cylinder, which opens the inlet valve. closes the discharge valve, and draws in a charge of gasoline.



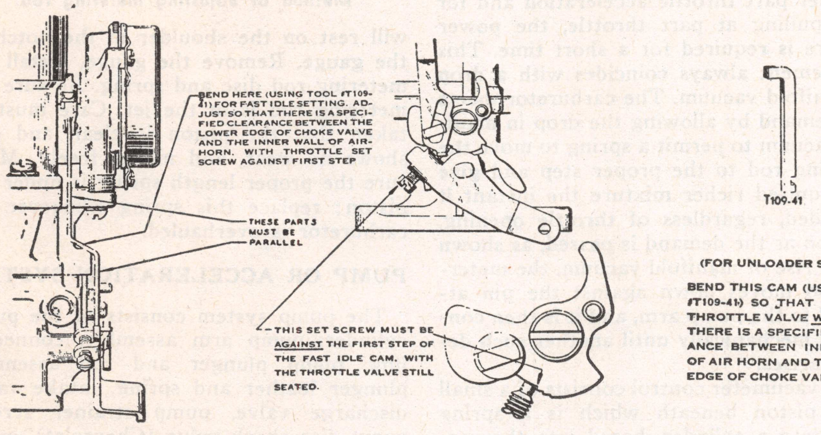
CARTER W-I. Pump circuit.


NOTE: On carburetors which demand a pump setting, make the adjustment as shown before gauging the metering rod.

NOTE:
Pump link must be in the setting specified on specification sheet and throttle valve seated. Make pump adjustment before metering rod or anti-percolator setting

Bend here only for pump setting, not for metering rod adjustment.

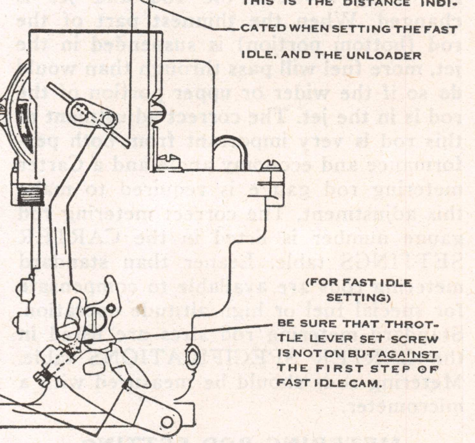
CARTER W-I. Pump adjustment.


BEND HERE (USING TOOL #T109-41) FOR FAST IDLE SETTING. ADJUST SO THAT THERE IS A SPECIFIED CLEARANCE BETWEEN THE LOWER EDGE OF CHOKE VALVE AND THE INNER WALL OF AIR-HORN. WITH THROTTLE SET SCREW AGAINST FIRST STEP

THESE PARTS MUST BE PARALLEL

THIS SET SCREW MUST BE AGAINST THE FIRST STEP OF THE FAST IDLE CAM, WITH THE THROTTLE VALVE STILL SEATED.

CARTER W-I. Fast idle setting.


(FOR UNLOADER SETTING)

BEND THIS CAM (USING TOOL #T109-41) SO THAT WITH THE THROTTLE VALVE WIDE OPEN, THERE IS A SPECIFIED CLEARANCE BETWEEN INNER WALL OF AIR HORN AND THE LOWER EDGE OF CHOKE VALVE.

THIS IS THE DISTANCE INDICATED WHEN SETTING THE FAST IDLE, AND THE UNLOADER

(FOR FAST IDLE SETTING)

BE SURE THAT THROTTLE LEVER SET SCREW IS NOT ON BUT AGAINST THE FIRST STEP OF FAST IDLE CAM.

CARTER W-I. Unloader setting.

Since the discharge valve is below the liquid level of the carburetor, gasoline would be drawn into the throat of the carburetor through the pump jet from the acceleration system, during fixed throttle intermediate speeds and high speeds, if it were not for the pump disc check valve (Chevrolet), or, air bleed to the outside air on other units. This breaks the vacuum of the acceleration system by bleeding in air from the float bowl.

Pump jets are made in three types: One type is vented by means of the disc check valve already referred to; one type is vented directly to the outside air, while some other units are not vented and the carburetor is calibrated accordingly.

PUMP SYSTEM SERVICE

Some carburetors have specified pump settings; consult the CARTER SETTINGS table.

Pump Piston: If the piston is worn or sticks, or if the spring has lost its tension, replace both, as it will affect the action of the pump.

Pump Intake Valve (Ball Check): If the inlet valve leaks, part of the discharge of the pump will be forced out through the valve, back into the gasoline well in the base of the carburetor, thereby causing an insufficient amount of gasoline to be discharged into the throat of the carburetor upon acceleration. If the valve cannot be cleaned so that it works properly, it must be replaced.

Pump Discharge Valve (Ball Check): If this valve leaks, air will be drawn into the pump cylinder on the up stroke of the pump plunger. This gives an insufficient charge of gasoline into the throat of the carburetor upon acceleration, causing a flat spot. If the ball cannot be cleaned so that it works properly, it must be replaced.

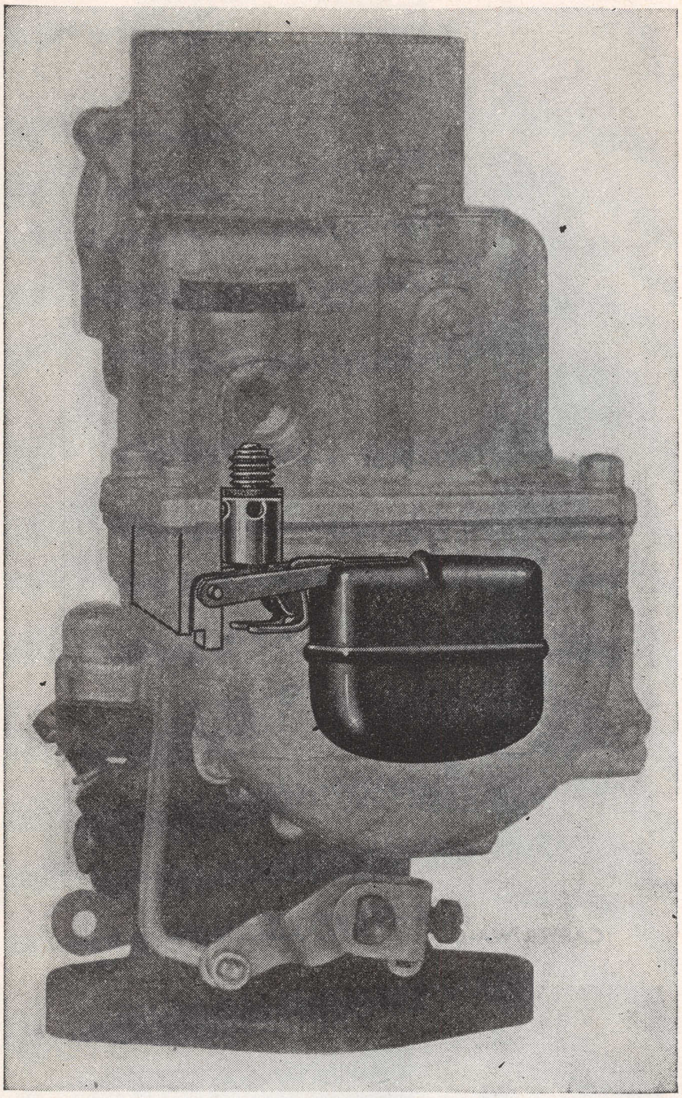
Pump Piston Leather: If the piston leather leaks, the charge of air in the pump cylinder will be lost. Without the compressed air in the cylinder, the charge will not be sufficiently prolonged to allow the gasoline in the high speed system to catch up and a flat spot will result.

A plunger leather can rarely be cleaned or repaired. Since this is a specially treated leather for this use, both the leather and the expanding spring must be replaced.

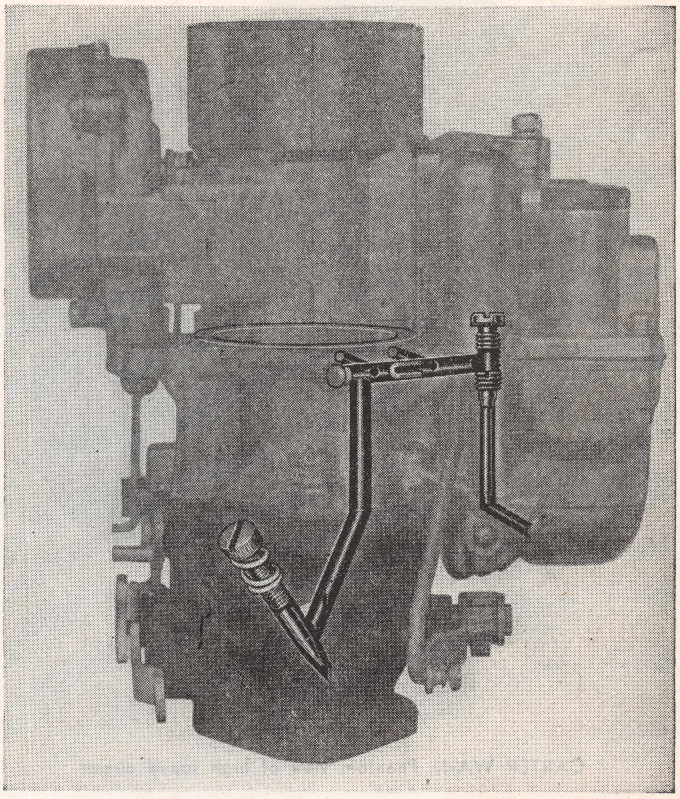
Ball Check Strainer Screen: A restriction will allow an insufficient charge of gasoline to be drawn into the pump cylinder causing a flat spot. The screen can generally be cleaned, but if damaged, it must be replaced.

Accelerating Pump Jet: If the hole in the pump jet is too large, the accelerating charge will be allowed to pass out too fast and will make the mixture too rich, resulting in a stumble on acceleration, or sluggishness. An enlarged jet must be replaced. A jet which is loose on its seat will give the same effect. A jet which is stopped with dirt will result in poor acceleration.

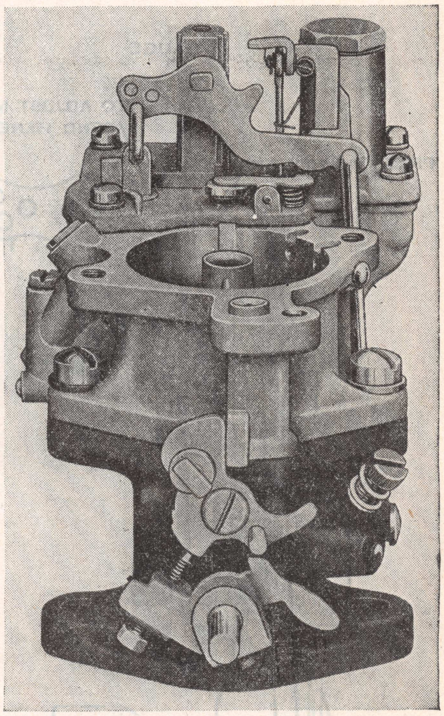
Pump Arm & Counter Shaft Assembly: If the linkage is adjusted to give a heavy charge (long stroke) in hot weather, a flat spot will result because of too great a supply of gasoline. If the linkage is ad-



CARTER WA-1. Float circuit.
Check level as shown for W-1 unit.



CARTER WA-1. Low speed circuit.



CARTER WA-1.
High speed circuit.

justed to give a light charge (short stroke) in cold weather, a flat spot will result because of an insufficient charge of gasoline. The middle setting of the linkage will cover year-around operation in most territories.

Throttle Connector Rod & Throttle Shaft: These parts may be worn, and if so, will cause the throttle valve to be opened by the accelerator pedal before the accelerating pump jet begins to discharge gasoline, resulting in a flat spot. Replace all worn parts, as the operation of the metering rod is also affected.

Disc Check Valve (Where Used): The valve may be stuck open or closed. If the valve does not close properly during the operation of the accelerating pump, part of the gasoline in the pump will be forced back into the float bowl and only a small amount of gasoline will be discharged into the carburetor throat, causing a flat spot.

If, because of gum deposit, the valve sticks closed so that air cannot be bled in above the acceleration system during high speed operation, the accelerating jet will supply gasoline to the carburetor throat during this period, resulting in low gasoline economy.

Carburetors which are not equipped with a disc check valve, but have a vent to the outside atmosphere, should be checked to see that this vent is not clogged. If so, clean it out or the mixture will be too rich at high speed.

Pump Cylinder Bushing Gasket: A damaged or missing gasket floods the pump and causes high pressure, which may result in damaged pump linkage.

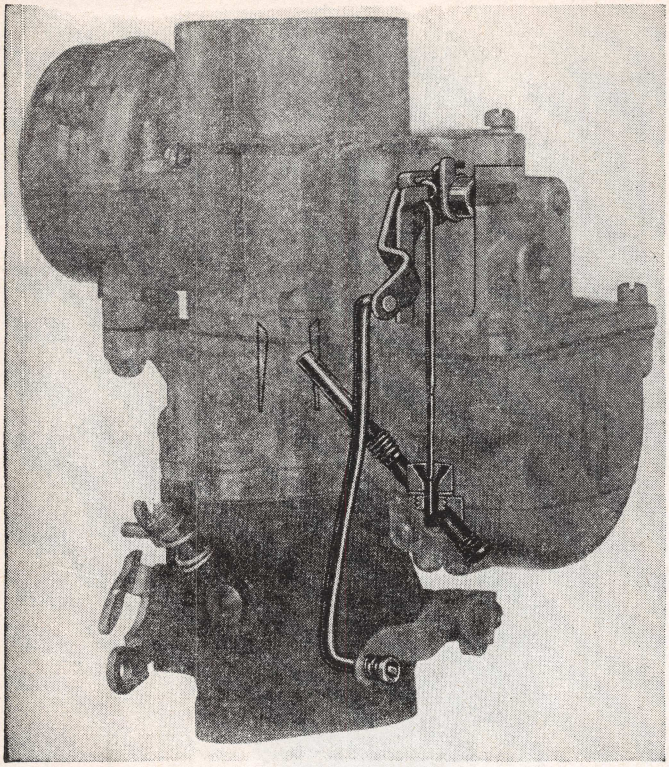
WA

STUDEBAKER M5, M15

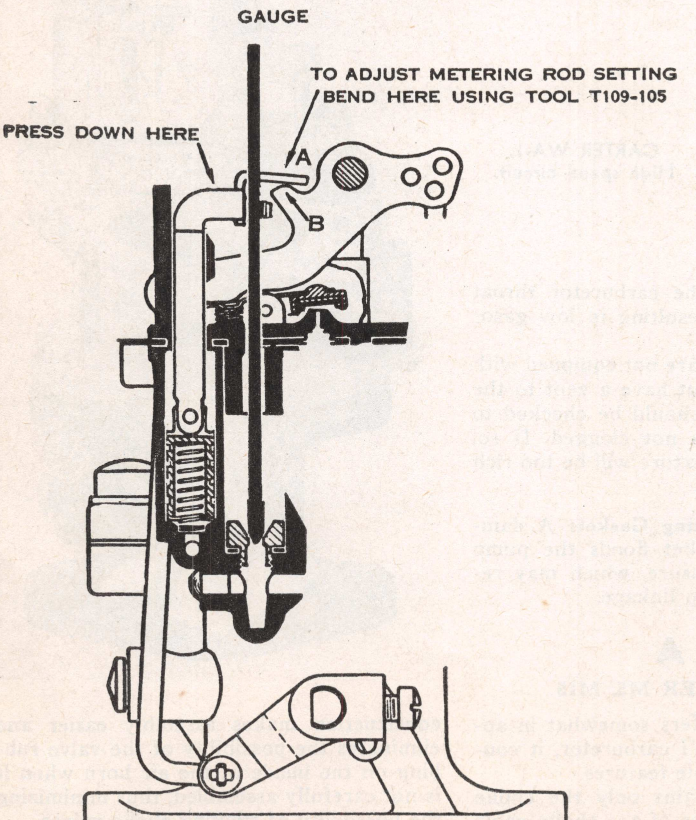
While this unit differs somewhat in appearance from the WI carburetor, it contains all of its desirable features.

The air horn contains only the choke mechanism. The sides of the choke valve are not quite parallel, and there is a ridge in the air horn which acts as a stop for the valve in the wide-open position. This new construction makes assembly easier and eliminates the possibility of the valve rubbing on the inside of the air horn when it is not carefully assembled, thus minimizing the possibility of sticking choke valves.

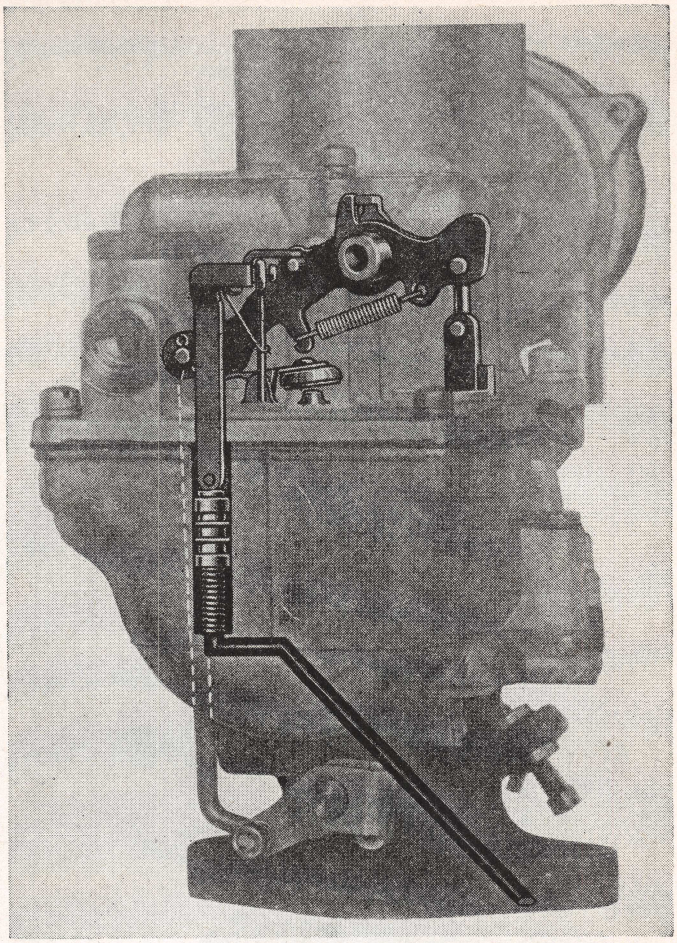
The accelerating pump system consists of a die-cast cylinder in the carburetor body, and intake and outlet ball checks seated in



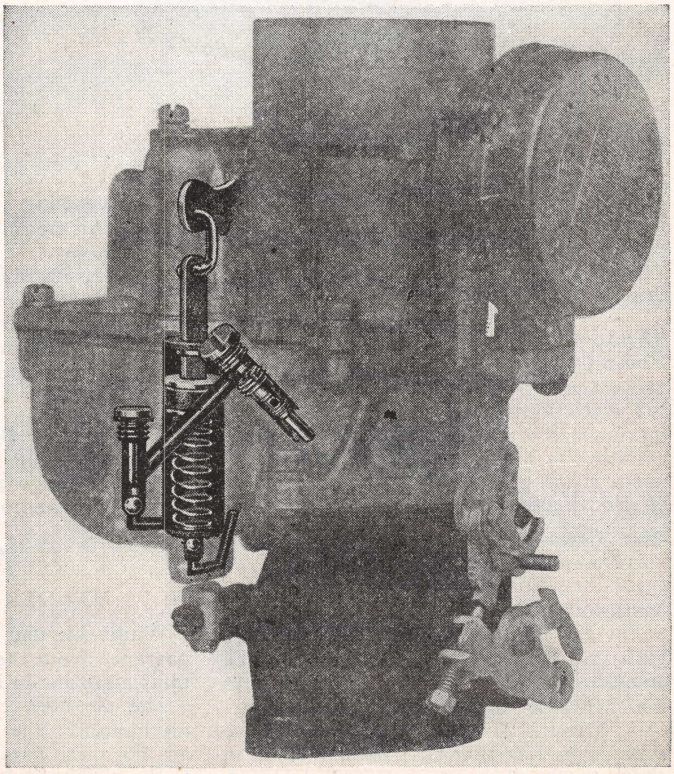
CARTER WA-1. Phantom view of high speed circuit


GAUGE
TO ADJUST METERING ROD SETTING BEND HERE USING TOOL T109-105
PRESS DOWN HERE
A
B

CARTER WA-1. Metering rod setting.



CARTER WA-1. Pump circuit showing vacumeter device.



CARTER WA-1. Pump circuit.

the body. The intake ball is held in place by a screen under the pump spring, and the outlet ball by an extension on the plug above the ball.

The low speed jet is inserted through the top of the float bowl. These details in construction have removed two external screw plugs below the fuel level, leaving only the plug behind the nozzle.

The bowl cover carries the complete anti-percolator and pump arm. The seat of the anti-percolator is cast as a part of the cover, and is located to cover the vertical passage through the body.

The anti-percolator valve is of the saxophone type and is held on its seat by a coiled spring in tension. The anti-percolator cap has a special leather base and a resilient felt pad beneath the leather.

The service instructions which are described in detail for the WI unit apply also to the WA carburetor.

CARTER BB

DOWNDRAFT TYPE

This carburetor is of the plain tube, downdraft type with fixed jets which cover all speed ranges except the idle range, which is controlled by an adjusting needle. The unit is equipped with an adjustable accelerating pump and a fast idle device for the prevention of stalling with a cold engine. The idle needle valve controls the fuel mixture for idle. Turning the adjusting screw clockwise gives a leaner mixture and counter-clockwise, a richer mixture. When adjusting the carburetor, a vacuum gauge may be used and the adjustment should be set at the highest reading of the gauge.

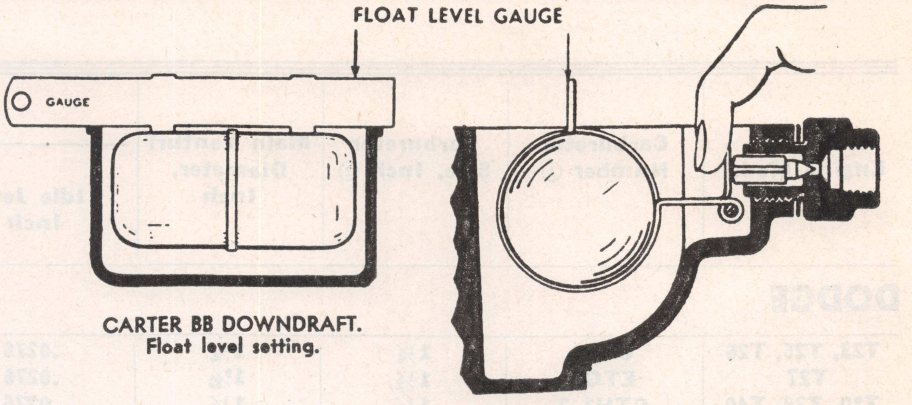
In order to provide the additional fuel required for rapid acceleration, the carburetor is equipped with a pump which supplies an extra charge of fuel momentarily, as the throttle is opened.

Three positions are provided on the accelerator pump lever in order to give a greater or lesser discharge of fuel, depending upon climatic conditions.

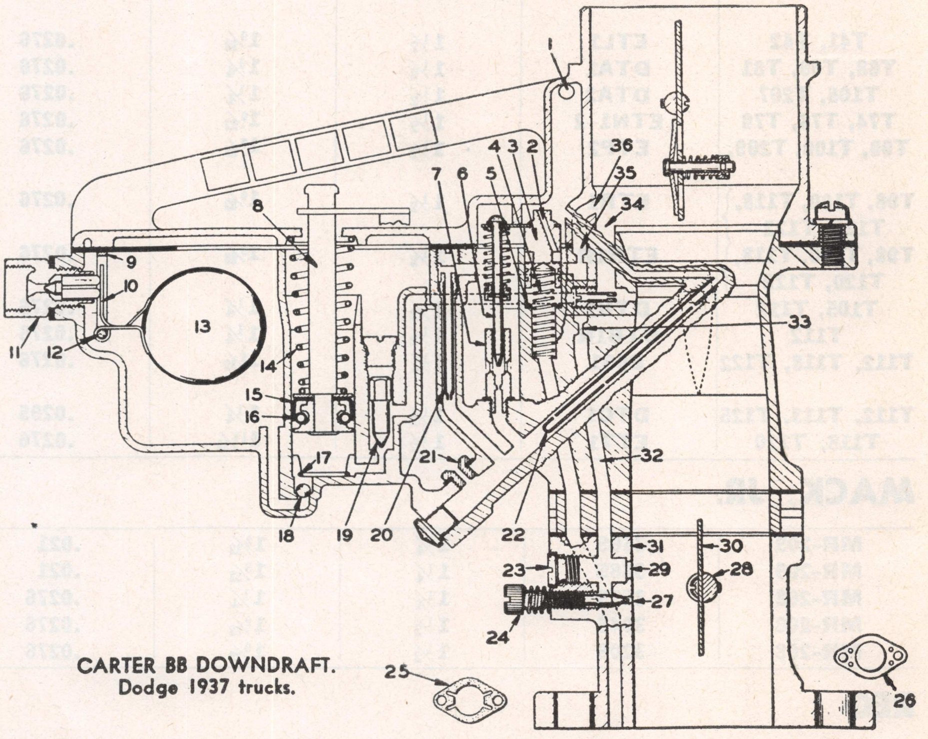
For extremely warm weather or for high altitudes above 3,000 feet, the pump link should be in the hole in the accelerating pump lever which is nearest to the throttle shaft. This position gives the shortest stroke of the pump.

For cold weather operation, the pump link should be in the pump lever hole which is farthest from the throttle shaft. For normal operation the pump link should be in the center hole.

For high altitudes, leaner main jets are available, which can be installed by removing the air horn and float. Then, with a special socket wrench which is made for the purpose, unscrew and remove the jet. If leaner main jets are used in lower altitudes, the maximum speed and power developed by the engine will be materially reduced, but slightly greater fuel economy may be obtained. However, it is recommended that the standard jet as furnished with the carburetor, be used for best results.



CARTER BB DOWNDRAFT.
Float level setting.



CARTER BB DOWNDRAFT.
Dodge 1937 trucks.

1—Vent hole. 2—Vent hole in piston. 3—Step-up piston. 4—Step-up piston spring. 5—Step-up piston gasket. 6—Step-up piston rod. 7—Step-up piston jet. 8—Pump plunger. 9—Float pin retainer. 10—Float lip. 11—Float needle & seat. 12—Float pin. 13—Float. 14—Pump spring. 15—Pump plunger leather. 16—Spring under pump leather. 17—Pump intake ball check ring. 18—Pump intake ball check. 19—Economizer by-pass valve. 20—Idle orifice tube. 21—Main metering screw. 22—Main vent tube. 23—Idle discharge plug. 24—Idle adjusting screw. 25—Carburetor gasket, slotted—used without governor. 26—Carburetor gasket—used with governor. 27—Idle discharge port. 28—Throttle shaft. 29—Idle discharge port. 30—Throttle valve. 31—Carburetor bore. 32—Low speed passage. 33—Economizer. 34—Air bleed. 35—Air bleed hole.

Float System: The float system controls the height of the gasoline level in the bowl and also in the nozzle. A gasoline level too high or too low will cause trouble in other systems and will make complaints hard to trace.

The float system consists of the needle valve and seat, float and float bowl, float bowl cover, float lever, pin retainer, float pin, and the vent hole. The float bowl acts as a reservoir to hold a supply of gasoline throughout the entire range of performance of the engine. The level of the gasoline is controlled by the combination of all the above-mentioned parts.

"Balanced" carburetors: On Reo models, a balance tube connects through suitable drilled passages to the float bowl. The balance tube is located in the air horn in such a manner that the tube is outside the choke valve when the valve is closed.

During the choking period, the balance tube acts as an outside vent to the float bowl, permitting a normal flow of fuel through the main nozzle. When the choke has been moved to the open position, the rush of air past the end of the balance tube tends to draw air from the float bowl, causing a slight vacuum, which retards the flow of fuel to the nozzle. The purpose of

CARTER BB DOWN

DODGE

Engine Model	Carburetor Number ①	Carburetor Size, Inch ②	Main Venturi Diameter, Inch	Idle Orifice Tube: Idle Jet, Inch	Idle Orifice Tube: Idle Passage Air Bleed, Inch	Idle Orifice Tube: Economizer or Idle Restriction, Inch
T23, T25, T26	CTF1	1¼	1¼	.0276	.063	.049
T27	ETG1	1½	1 9/32	.0276	.063	.049
T30, T38, T40	CTH1–2	1¼	1¼	.0276	.067	.049
T30, T38, T40	CTJ1	1¼	1¼	.0276	.067	.049
T41, T42	ETJ1–2	1½	1 9/32	.0276	.063	.049
T41, T42	ETL1	1½	1 9/32	.0276	.063	.049
T68, T69, T81	DTA1	1½	1¼	.0276	.067	.053–.054
T105, T207	DTA2	1½	1¼	.0276	.067	.053–.054
T74, T76, T78	ETN1–2	1½	1 9/32	.0276	.063	.049
T98, T100, T209,	ETP2	1½	1 9/32	.0276	.063	.049
T98, T100, T118, T120, T122	ETR1	1½	1 9/32	.0276	.063	.049
T98, T100, T118, T120, T122	ETR1R	1½	1 9/32	.0276	.063	.049
T105, T112	DTB1	1½	1¼	.0276	.067	.053–.054
T112	DTB1R	1½	1¼	.0276	.067	.053–.054
T112, T118, T122	B6S1	1¼	1 3/32	.0276	.053	.061
T112, T113, T125	DTC1	1½	1¼	.0295	.067	.054–.055
T118, T120	ETT1	1½	1 11/32	.0276	.063	.053

MACK, JR.

Engine Model	Carburetor Number ①	Carburetor Size, Inch ②	Main Venturi Diameter, Inch	Idle Orifice Tube: Idle Jet, Inch	Idle Orifice Tube: Idle Passage Air Bleed, Inch	Idle Orifice Tube: Economizer or Idle Restriction, Inch
MR-209	356S	1¼	1 3/32	.021	.063	.045
MR-209	368S	1¼	1 3/32	.021	.063	.045
MR-268	303S	1¼	1¼	.0276	.061–.063	.055–.057
MR-268	304S	1½	1 9/32	.0276	.049	.053–.055
MR-268	320S	1½	1 9/32	.0276	.051	.053–.055

REO

Engine Model	Carburetor Number ①	Carburetor Size, Inch ②	Main Venturi Diameter, Inch	Idle Orifice Tube: Idle Jet, Inch	Idle Orifice Tube: Idle Passage Air Bleed, Inch	Idle Orifice Tube: Economizer or Idle Restriction, Inch
S-209	356S	1¼	1 3/32	.021	.063	.045
S-209	368S	1¼	1 3/32	.021	.063	.045
S-268	303S	1¼	1¼	.0276	.061–.063	.055–.057
S-268	304S	1½	1 9/32	.0276	.049	.053–.055
S-268	320S	1½	1 9/32	.0276	.051	.053–.055

STUDEBAKER

Engine Model	Carburetor Number ①	Carburetor Size, Inch ②	Main Venturi Diameter, Inch	Idle Orifice Tube: Idle Jet, Inch	Idle Orifice Tube: Idle Passage Air Bleed, Inch	Idle Orifice Tube: Economizer or Idle Restriction, Inch
J30	362S	1½	1 9/32	.031	.063	.049
K10	427S	1¼	1¼	.0276	.067	.051–.052
K15	428S	1¼	1¼	.0276	.067	.051–.052
K20, K25	429S	1¼	1¼	.031	.067	.051–.052
M16	514S	1¼	1¼	.0276	.067	.051–.052

① Carburetor number usually stamped on tag attached to carburetor.

the "balanced" carburetor, is to provide a constant air-fuel ratio, regardless of type, size or condition of the air cleaner. Should the cleaner element become clogged, the capacity will be reduced, but the air-fuel ratio will not be changed.

Float System Service: Remove the bowl cover and see that the vent hole is open. The flow of gasoline from the bowl is dependent upon the difference in air pressure. The vent in the bowl is placed there to bring the normal air pressure to bear on the gasoline in the bowl, while the pressure in the bore of the carburetor is reduced by the operation of the engine. If the vent is clogged, the carburetor will run lean at high speed.

After the float bowl is removed, inspect the float lip to see if it is worn; if it is, smooth it with a piece of emery cloth—never use a file. Remove the float and

CARTER BB

DRAFT SPECIFICATIONS

Idle Ports								
Upper Length, Inch	Upper Width, Inch	Diameter Top of Hole, Inch	Lower Port Diameter (Idle Screw) Inch	Vacuum Spark Port, Width by Length, Inch	Vent Through Diffuser, Inch	Pump Discharge Jet, Inch	Step-up Jet, Inch or No.	Engine Model
								DODGE
.132	.030	.063	.053-.057	.069-.073⑧	.0315	.0315	65	T23, T25, T26
.128	.027	.063	.053-.057	None	.0315	.0354	63	T27
.160	.030	None	.053-.057	.069-.073	.0315	.0335	63	T30, T38, T40
.160	.030	None	.053-.057	.069-.073⑧	.0315	.0335	63	T30, T38, T40
.128	.027	.063	.053-.057	None	.0315	.030	63	T41, T42
.128	.027	.063	.053-.057	None	.0315	.030	63	T41, T42
.160	.030	.045	.053-.057	.040x.110	.0315	.0315	63	T68, T69, T81
.160	.030	.045	.053-.057	.040x.110	.0315	.0315	63	T105, T207
.128	.027	.063	.053-.057	None	.0315	.0374	63	T74, T76, T78
.128	.027	.063	.053-.057	.040x.110	.0315	.0374	63	T98, T100, T209
.128	.027	.063	.053-.057	.040x.110	.0315	.0374	63	T98, T100, T118, T120, T122
.128	.027	.063	.053-.057	.040x.110	.0315	.0374	63	T98, T100, T118, T120, T122
.160	.030	.045	.053-.057	.040x.110	.0315	.0315	63	T105, T112
.160	.030	.045	.053-.057	.040x.110	.0315	.0315	63	T112
.170	.030	None	.0669	.040x.110	.0315	.0236	.0236	T112, T118, T112
.160	.030	.045	.053-.057	.040x.110	.0315	.0276	63	T112, T113, T125
.128	.027	.063	.053-.057	.040x.110	.0315	.0374	.0413	T118, T120
								MACK, JR.
.138	.030	.063	.053-.057	.069-.073⑧	.0315	.0276	.0275	MR-209
.138	.030	.063	.053-.057	.069-.073⑧	.0315	.026	.024	MR-209
.200	.030	None	.053-.057	None	.0394	.0315	.0335	MR-268
.200	.030	None	.053-.057	None	.0315	.0354	.0354	MR-268
.200	.030	None	.053-.057	None	.0315	.0315	.0394	MR-268
								REO
.138	.030	.063	.053-.057	.069-.073⑧	.0315	.0276	.0275	S-209
.138	.030	.063	.053-.057	.069-.073⑧	.0315	.026	.024	S-209
.200	.030	None	.053-.057	None	.0394	.0315	.0335	S-268
.200	.030	None	.053-.057	None	.0315	.0354	.0354	S-268
.200	.030	None	.053-.057	None	.0315	.0315	.0394	S-268
								STUDEBAKER
.128	.027	.063	.053-.057	None	.0315	.0374	.0394	J30
.160	.030	.045	.053-.057	.040x.110	.0315	.0315	.0335	K10
.160	.030	.045	.053-.057	.040x.110	.0315	.0236	.0394	K15
.160	.030	.045	.053-.057	None	.0315	.0236	63	K29, K25
.160	.030	.045	.053-.057	.040x.110	.0315	.0236	.0394	M16

② See illustrations for other flange dimensions. **⑧ Round type—diameter shown.**

shake it to see that it does not contain any gasoline. Also inspect it to see that it is not cracked.

Inspect the float pin and be sure that it is not worn. Inspect the holes in the float lever to see that they are not worn-out-of-round. Make sure that the float pin retainer is not flattened out at the top as a small boss on the bowl cover is placed there to press on the top of the pin retainer to hold it in position. When installing the float pin retainer, always make sure that it is in the proper slot, and push clear to the bottom. Inspect the needle and seat for wear. Check for the proper float setting.

Float Level, Adjust: Measure the distance between the top of the float to the top of the float chamber. This measurement should be 5/64" and can be reset, if necessary, by bending the lip on the float lever

CARTER BB DOWN DRAFT SETTINGS

Engine Model	Carburetor Number	Float Setting, Inch ①	Accelerating Pump Setting ②	Vacuum Spark Port Location	Main Metering Jet Capacity ④	Idle Screw Setting, Turns Open ⑤	Idle Port Opening with Valve Closed ⑥
DODGE							
T23, T25, T26	CTF1	5/64 ± 1/64	⑧	.015③	262–266	1/8–3/4	.085–.089
T27	ETG1	5/64 ± 1/64	⑧	None	282–286	1/4–1	.081–.085
T30, T38, T40	CTH1–2	5/64 ± 1/64	None	.015③	244–248	1/4–1	.118–.122
T30, T38, T40	CTJ1	5/64 ± 1/64	None	.015③	244–248	1/4–1	.118–.122
T41, T42	ETJ1–2	5/64 ± 1/64	None	None	264–268	1/4–1	.081–.085
T41, T42	ETL1	5/64 ± 1/64	None	None	264–268	1/4–1	.081–.085
T68, T69, T81	DTA1	5/64 ± 1/64	3/8	.003–.009③	254–258	1/2–1 1/4	.118–.122
T105, T207	DTA2	5/64 ± 1/64	3/8	.003–.009③	254–258	1/2–1 1/4	.118–.122
T74, T76, T78	ETN1–2	5/64 ± 1/64	13/32	None	268–272	1/2–1 1/4	.088–.092
T98, T100, T209	ETP2	5/64 ± 1/64	13/32	.035–.041③	268–272	1/2–1 1/4	.088–.092
T98, T100, T118, T120, T122	ETR1	5/64 ± 1/64	13/32	.035–.041③	268–272	1/2–1 1/4	.088.–092
T98, T100, T118, T120, T122	ETR1R	5/64 ± 1/64	13/32	.035–.041③	268–272	1/2–1 1/4	.088–.092
T105, T112	DTB1	5/64 ± 1/64	3/8	.003–.009③	254–258	1/2–1 1/4	.118–.122
T112	DTB1R	5/64 ± 1/64	3/8	.003–.009③	254–258	1/2–1 1/4	.118–.122
T112, T118, T122	B6S1	5/64 ± 1/64	19/64	.035–.041③	168–172	1/2–1 1/2	.130–.134
T112, T113, T125	DTC1	5/64 ± 1/64	3/8	.003–.009③	254–258	1/2–1 1/2	.118–.122
T118, T120	ETT1	5/64 ± 1/64	13/32	.035–.041⑦	312–316	1/2–1 1/2	.088–.092
MACK, JR.							
MR-209	356S	5/64 ± 1/64	⑧	.022③	146–150	1/2–1 1/2	.093–.097
MR-209	368S	5/64 ± 1/64	⑧	.022③	156–160	1–2	.098–.102
MR-268	303S	5/64 ± 1/64	⑧	None	240–244	1/4–3/4	.008–.012
MR-268	304S	5/64 ± 1/64	⑧	None	268–272	1/4–3/4	.008–.012
MR-268	320S	5/64 ± 1/64	⑧	None	268–272	1/4–3/4	.008–.012
REO							
S-209	356S	5/64 ± 1/64	⑧	.022③	146–150	1/2–1 1/2	.093–.097
S-209	368S	5/64 ± 1/64	⑧	.022③	156–160	1–2	.098–.102
S-268	303S	5/64 ± 1/64	⑧	None	240–244	1/4–3/4	.008–.012
S-268	304S	5/64 ± 1/64	⑧	None	268–272	1/4–3/4	.008–.012
S-268	320S	5/64 ± 1/64	⑧	None	268–272	1/4–3/4	.008–.012
STUDEBAKER							
J30	362S	5/64 ± 1/64	⑧	None	264–268	1/2–1 1/4	.081–.085
K10	427S	5/64 ± 1/64	25/64	.035–.041⑦	248–252	1/4–3/4	.118–.122
K15	428S	5/64 ± 1/64	25/64	.035–.041⑦	248–252	1/2–1	.118–.122
K20, K25	429S	5/64 ± 1/64	25/64	None	248–252	1/4–3/4	.118–.122
M16	514S	5/64 ± 1/64	19/32	.035–.041⑦	248–252	1/2–1	.118 .122

① Measure from below the top surface of the carburetor body casting—without gasket.

② If the pump stroke is not as specified, remove the air horn, back out the throttle adjustment screw and place the pump operating link in the center hole of the throttle shaft arm. Use pump stroke gauge No. T109-117S and bend the horizontal portion of the pump connector link so that the top of the pump plunger shaft contacts the lip of the indicator on the gauge. Pump stroke is adjustable for seasonal requirements: short stroke for summer and long stroke for winter.

③ Bottom of spark port should be the dimension shown—above the throttle valve.

④ Calibrated to flow the number of cubic centimeters per minute as shown. Do not use drill gauges for checking size: if in doubt, install new part.

⑤ For richer mixture, turn screw OUT, and IN for leaner.

Notes continued on next page→

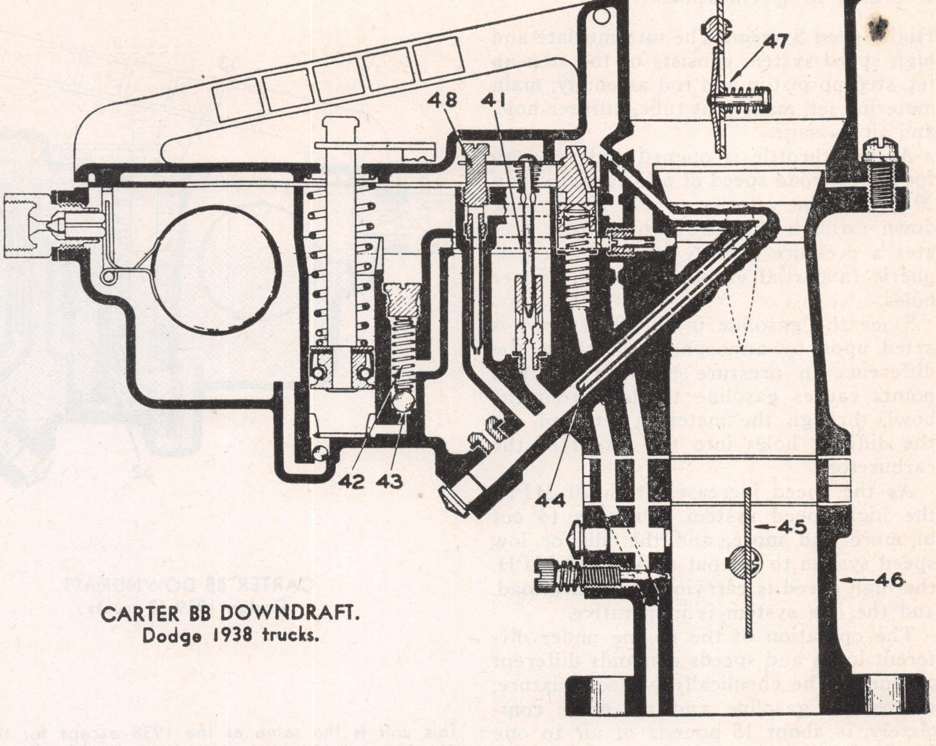
away from the needle to raise the float, and toward the needle to lower the float. Bend only the vertical lip of the float.

Low Speed System: The low or idle speed system completely controls the supply of gasoline to the engine during idle and no-load speeds up to 20 MPH, and it partially controls the supply for no-load speeds between 20 and 30 MPH.

The low speed system consists of the idle orifice tube and plug assembly, air bleed, idle port, idle mixture adjusting screw, throttle valve, carburetor bore, and economizer.

During idling and low speed operation of the engine, gasoline flows from the float bowl through the idle orifice tube to the point where it is combined with a stream of air coming in from the air horn through the air bleed. The combining of the stream of air with the stream of gasoline tends to atomize or break up the gasoline into a vapor.

This mixture of air and gasoline continues on through the passage until it begins to pass the economizer. This, again, tends to break the gasoline particles into a finer vapor. The gasoline and air mixture that flows downward in the passage from the economizer, is still richer than an idle mixture needs to be, but when it mixes with the air, which has come past the throttle valve, it forms a combustible mixture of the right proportions for idle speed.



CARTER BB DOWNDRAFT.
Dodge 1938 trucks.

This unit is the same as the 1937 except for the following changes: 41—Air bleed. 42—Pump discharge ball spring. 43—Pump discharge ball. 44—High speed vent tube. 45—Throttle valve. 46—Carburetor flange. 47—Choke air valve. 48—Idle orifice tube & plug.

The idle port is made in the form of a slot so that as the throttle valve is opened, it will not only allow more air to come in past it, but will also uncover more of the idle port, allowing a greater quantity of the gasoline and air mixture to enter the carburetor bore from the idle mixture passage.

The idle position of the throttle is such, that at an idle speed of 6 MPH, it leaves enough of the port as reserve to cover the range in speed between idle and the time when the high speed system begins to cut in.

The throttle lever adjusting screw varies the quantity of the idle mixture entering the carburetor throat, which mixes with air coming past the throttle valve. In this way, it varies the quality of the mixture finally entering the engine.

All the gasoline flowing from the float bowl during the idle period and at no-load speeds up to 20 MPH, flows through the small metering hole in the idle orifice tube. This hole is held to a manufacturing tolerance of .00025", and is a very important factor in controlling the gasoline entering into the engine during these speeds. It should never be cleaned out in any other way than by compressed air, as small wires or drills tend to increase the size of the hole, thereby changing the calibration of the carburetor. It can readily be seen that it would take a very small particle of dirt to restrict the passage of gasoline through this hole, and will totally destroy the idle of the engine.

Low Speed System Service: Remove the idle orifice tube and clean it with compressed air **only**—or replace the tube.

Leaky gaskets will admit more air than the calibration of the carburetor calls for, and if this condition is evident, a lean condition at idle will result. Leaky gaskets also affect the operation of the high speed step-up piston.

Make sure that all parts seat tightly. Scrape all the carbon from the bore of the carburetor. Even a thin coating of carbon will affect the seating of the throttle valve, and, when this happens, less of the idle port opening is left than is intended, and a poor idle will result. Make sure that there is no carbon around the seat of the throttle valve.

The air bleed hole, which is located in the low speed channel, must be fully open. If it is partly closed, it will affect the idle of the engine. The economizer and the low speed passage must be free from dirt and carbon.

Inspect the idle discharge ports and notice whether they are damaged or partly stopped up. If they are partly stopped up, clean thoroughly and blow out with compressed air. If the throttle shaft or throttle valve is worn, replace the worn parts.

Idle Adjustment: Inspect the idle adjustment screw and see that it has not been burred or roughened by being screwed in too far. If this is not smooth, it will be impossible to control the idle adjustment.

When adjusting the idle (always with engine hot), it should be set on the rich side of the highest vacuum. Attach a vacuum gauge to the manifold, screw the idle adjusting screw in or out, until the highest point of vacuum is reached, then continue backing out the screw until the vacuum starts to recede from the highest point. If it is necessary to change the setting of the throttle adjusting screw in order to reduce the engine speed to about 350 RPM, always recheck the idle adjustment to see that it is at the highest point of vacuum.

If the idle screw has to be turned in more than the specifications called for in order to have the engine idle properly on the carburetors for 1935, 1936 and 1937, it may be necessary to use a shim under the throttle valve. These shims are available

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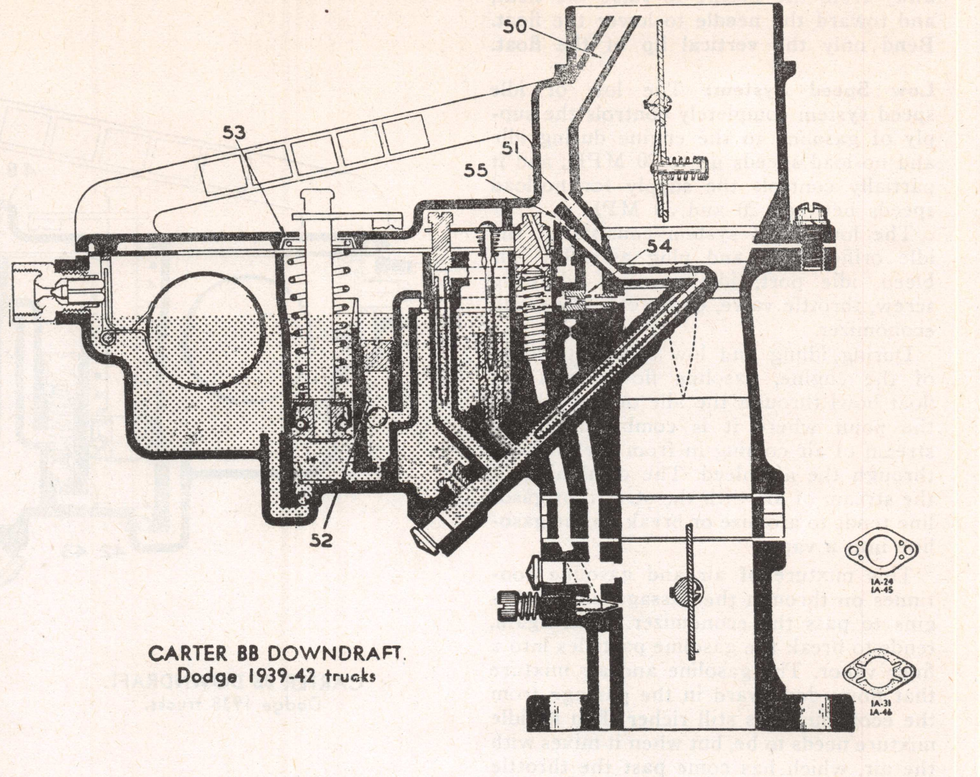
⑥ Top of idle port should set the dimension shown, measured in inches above the top edge of the throttle valve.

⑦ Top of spark port should be the dimension shown—above the top edge of throttle valve.

⑧ Short stroke for summer: long stroke for winter.



CARTER BB DOWNDRAFT.
Dodge 1939-42 trucks

This unit is the same as the 1938 except for the following: 50—Air vent. 51—Pump air bleed. 52—Pump discharge ball spring not used in this unit. 53—Pump plunger spring aligning washer. 54—Pump jet.

NOTE—The slotted gasket shown is used without governor whereas the gasket shown without slots is used with governor.

in two sizes. Do not use any greater thickness than is necessary to make the engine operate properly with the idle screw set according to specifications.

High Speed System: The intermediate and high speed system consists of the step-up jet, step-up piston and rod assembly, main metering jet, main vent tube, diffuser hole, and air passage.

As the throttle is opened wide enough for a level-road speed of a little more than 20 MPH, the velocity of the air flowing down through the carburetor throat creates a pressure slightly less than atmospheric (a partial vacuum) at the diffuser holes.

Since the gasoline in the float bowl is acted upon by atmospheric pressure, the difference in pressure between the two points causes gasoline to flow from the bowl, through the metering jet, and out the diffuser holes into the throat of the carburetor.

As the speed increases from 20 MPH, the high speed system continues to cut in more and more, and the idle or low speed system to cut out until, at 30 MPH, the high speed is carrying the entire load, and the idle system is inoperative.

The operation of the engine under different loads and speeds demands different mixtures. The chemically perfect mixture, where the gasoline and air unite completely, is about 15 pounds of air to one pound of gasoline. A vehicle will run on a leaner ratio than this, but the lean limit of firing will soon be reached. Mixtures which are leaner than 16 to 1, however, lose power so rapidly that gasoline consumption per mile is increased rather than decreased. The idling mixture has to be considerably richer than the ideal mixture already mentioned. The mixture for maximum power is also richer and is about 12½ to 1. The mixture for part-load conditions can be as low as 16 to 1.

For full-load operation, the mixture has to be made richer, and in the BB carburetor, this is accomplished by raising the step-up rod and allowing gasoline to flow through the step-up jet, in addition to that already flowing through the main metering jet. The following paragraph describes this operation.

When the manifold vacuum drops to about 5 inches due to increased throttle opening, the decrease in the vacuum pull on the step-up passage is such that the vacuum is not strong enough to hold the step-up piston down, and the spring under it raises the piston and the step-up rod which is attached to it, thus allowing additional gasoline to flow through the step-up jet, which enriches the mixture for maximum power.

At all times when the vacuum in the engine manifold is greater than about 5 inches of mercury, the pull on the step-up passage is great enough to hold the piston on its seat against the spring, and thereby hold the step-up rod in the jet, preventing the flow of gasoline in the jet.

Air coming through the vent is admitted through the air passage into the main vent tube. This air mixes with gasoline in the canal surrounding the tube, so that a mixture of gasoline and air is carried out of the diffuser hole at all times when the intermediate or high speed is in operation

High Speed System Service: The setting of the float level is very important. If the level is too high, gasoline will be brought over into the system too early, with the result that the mixture will be rich and the engine operation will be rough.

If the level is too low, there will be a lag between the low speed system and the time when the high speed system comes in, with the result that a flat spot will develop.

Make sure that the air bleed hole is open. If clogged, the operation will be too rich.

NOTE—In servicing 1937 carburetors, always replace the vent tube with the new tube having five holes. On the 1937 and 1938 carburetors, it is necessary to remove the plug and use Carter Tool No. T109-70 to remove the old tube. When replacing the new tube, insert it in the tool and force it into place in the casting. Always use a new plug.

Under the step-up piston, there should be a small gasket—and only one. In taking the carburetor apart, make sure that the old gasket is removed, as two gaskets will hold the pin off its seat and the result will be a rich condition. Make sure that the spring and piston are not worn or damaged. See that the vent hole in the piston is open. Inspect the step-up pin, which is part of this assembly, and see that it is not grooved, or that the seat in the jet is not damaged. If the step-up sticks, look for a bent jet or a bent step-up rod. If either is found to be bent, replace On complaints of poor acceleration, check the step-up jet as well as the pump.

Pump or Acceleration System: The pump system consists of the accelerating pump spring, pump plunger and rod assembly, pump leather, inlet valve, outlet valve, pump jet air bleed, and pump jet.

As the accelerator pedal is depressed, the pump piston and leather are forced downward by the pump spring. This forces the gasoline to leave the cylinder, closes the inlet valve, opens the outlet valve, and discharges gasoline into the throat of the carburetor.

The discharge is prolonged since the hole in the tip of the pump jet is small enough to restrict the flow of fuel so long as it is being forced out by the spring. The prolonging of the discharge gives the gasoline in the high speed system sufficient time to get flowing fast enough to satisfy the demands of the engine.

As the accelerator pedal is allowed to return to its original position, the accelerating pump plunger is pulled upward by the pump link. This creates a partial vacuum in the cylinder, which opens the inlet valve, closes the outlet valve, and draws in a charge of gasoline.

If it were not for the pump jet air bleed, gasoline would be drawn in through the throat of the carburetor through the pump jet during fixed throttle intermediate and high speeds. This air bleed breaks the vacuum of the pump circuit by bleeding in air from the air horn.

The pump spring controls the rate of pump discharge, and therefore, a spring that is weak or damaged should be replaced.

Pump System Service: Check pump discharge jet—early models used separate pump jet and pump jet screw plug; later models use rivet plug, driven in with a hammer. The plug is usually distorted upon removal, therefore, use a new plug and apply a thin coat of shellac on the surface that will press into the housing. Be sure the jet delivers a strong stream of fuel against the diffuser bar.

Intake and Discharge Pump Check Valves: At the bottom of the pump cylinder is the intake check ball, kept in place by a retainer spring. Be sure this ball shakes up and down freely, as gum and corrosion will cause this ball to stick, and depressing the pump plunger will not force the check to its seat, allowing fuel to return to the fuel bowl instead of out the pump discharge jet. On models using two steel balls as pump check valves, the one in the pump cylinder is the smaller of the two. The discharge check valves are different types. On early models, the check valve pin is octagonal along its entire length, while on later models, this was replaced with a pin machined about half its length. The later model used a steel ball and spring, and models from 1939 up use a steel ball only—no spring. The only usual service required here is cleaning.

The pump plunger leather should not be stiff or brittle, but soft and pliable. If it is distorted or curled at the end, fuel will leak by and a poor pump discharge will result. The pump spring is placed with the narrow end toward the pump leather, and wider end toward the top cover. This spring should be checked as they are often replaced the wrong way. Place pump link in center hole of throttle shaft arm for average performance. Check pump travel as per instructions given in BB Setting table.

Choke System: This system is used only in starting the engine: its purpose being to supply a rich mixture for starting. It consists of a choker valve and lever assembly, choker valve, choker breather valve and spring, and a means of controlling the position of the valve. It has a cam, called the throttle shaft dog, operating on the throttle shaft which is connected with the choker shaft by a rod, so that when the choke is closed, the throttle valve is forced open slightly by the cam to make starting easier and prevent stalling.

The choker breather valve allows sufficient air to enter so that the engine will start and not flood even when the choker valve is fully closed.

On the manually-operated choke, a wire from the dash is connected to the choker shaft lever by a clamp and screw.

CARTER BB UP-DRAFT SPECIFICATIONS

Engine Model	Carburetor Number ①	Carburetor Size, Inches ②	Main Venturi Diameter, Inches	Idle Jet, Inch	Idle Port Lower, Inch	Idle Port Upper (Idle Screw) Inch	Nozzle Discharge Jet, No.	Nozzle Air Bleed (Vent Tube) Inch	Accelerating Jet, Inch	Step-up Jet, Inch	Pump Intake Check Inch	Pump Discharge Jet, Inch	Vacuum Spark Port, Width by Length, Inch
CHEVROLET													
1939–40 (C.O.E.)	447S	1¼	1	.022	.062–.064	.053–.057	33	.0275–.0295	0394	.0275	⅛	.0925	.041x.125
1941–42 (C.O.E.)	489S	1¼	1	.0236	.062–.064	.053–.057	33	.0394	.0394	.038	⅛	.0635	.041x.125
1941–42 (C.O.E.)	517S	1¼	1	.0236	.062–.064	.053–.057	33	.0394	.0394	.038	⅛	.0635	.041x.125
DODGE													
1940–41 (C.O.E.)	6C1-2	1½	1¹⁄₁₆	.0236	.062–.064	.053–.057	33	.0394	.0394	.0472	⅛	.0925	.040x.110
1940–41 (C.O.E.)	6D1	1½	1¹⁄₁₆	.0236	.062–.064	.053–.057	33	.0394	.0394	.0472	⅛	.0925	.040x.110
1940 (C.O.E.)	6E1	1½	1¹⁄₁₆	.0236	.062–.064	.053–.057	33	.0394	.0394	.0472	⅛	.0925	.040x.110
1940–41 (C.O.E.)	6D1R	1½	1¹⁄₁₆	.0236	.062–.064	.053–.057	33	.0394	.0394	.0472	⅛	.0925	.040x.110
1941–42 (C.O.E.)	6F1	1½	1¹⁄₁₆	.0236	.062–.064	.053–.057	33	.0394	.0394	.0472	⅛	.0925	.040x.110

① Carburetor number usually stamped on tag attached to carburetor. ② See Illustrations for other flange sizes.

CARTER BB

UPDRAFT TYPE

This type carburetor consists of two iron castings, the lower body, or fuel bowl housing, and upper body or throttle housing. Into the lower body is assembled the float and fuel inlet needle and seat assembly, low speed jet, main metering jet and nozzle, step-up valve assembly, accelerating pump cylinder and choke plate. The upper body holds a passage tube for the idle system, idle adjusting screw, vacuum step-up piston assembly, throttle shaft and plate. The venturi tube is assembled between the two housings. Two external adjustments are provided, one to regulate the idling mixture, and the other, to control the volume of accelerating pump discharge. A connecting link between the choke and throttle holds the throttle plate partly open when choke plate is fully closed.

Float System: Fuel enters the bowl, at fuel pump pressure, passing by a triangular inlet needle that lies horizontally in the inlet

CARTER UP-DRAFT SETTINGS

Engine Model	Carburetor Number	Float Setting, Inch ①	Idle Port Opening, Inch ②	Idle Screw Setting, Turns Open ③	Main Metering Screw Capacity ④	Accelerating Pump Setting	Vacuum Spark Port Location, Inch ⑥
CHEVROLET							
1939-40 (C. O. E.)	**447S**	**1/32–1/16**	**.005–.009**	**½–1¼**	**236–240**	⑤	**.000–.004**
1941-42 (C. O. E.)	**489S**	**1/32–1/16**	**.005–.009**	**½–1½**	**268–272**	⑤	**.005–.009**
1941-42 (C. O. E.)	**517S**	**1/32–1/16**	**.005–.009**	**½–1½**	**268–272**	⑤	**.005–.009**
DODGE							
1940-41 (C. O. E.)	**6C1-2**	**1/32–1/16**	**.005–.009**	**½–1½**	**286–290**	⑤	**.003–.009**
1940-41 (C. O. E.)	**6D1**	**1/32–1/16**	**.005–.009**	**½–1½**	**286–290**	⑤	**.003–.009**
1940 (C. O. E.)	**6E1**	**1/32–1/16**	**.005–.009**	**¼–1¼**	**316–320**	⑤	**.003–.009**
1940-41 (C. O. E.)	**6D1R**	**1/32–1/16**	**.005–.009**	**½–1½**	**286–290**	⑤	**.003–.009**
1941-42 (C. O. E.)	**6F1**	**1/32–1/16**	**.005–.009**	**¼–1¼**	**286–290**	⑤	**.003–.009**

① Distance from top of float to top surface of lower body casting—without gasket.

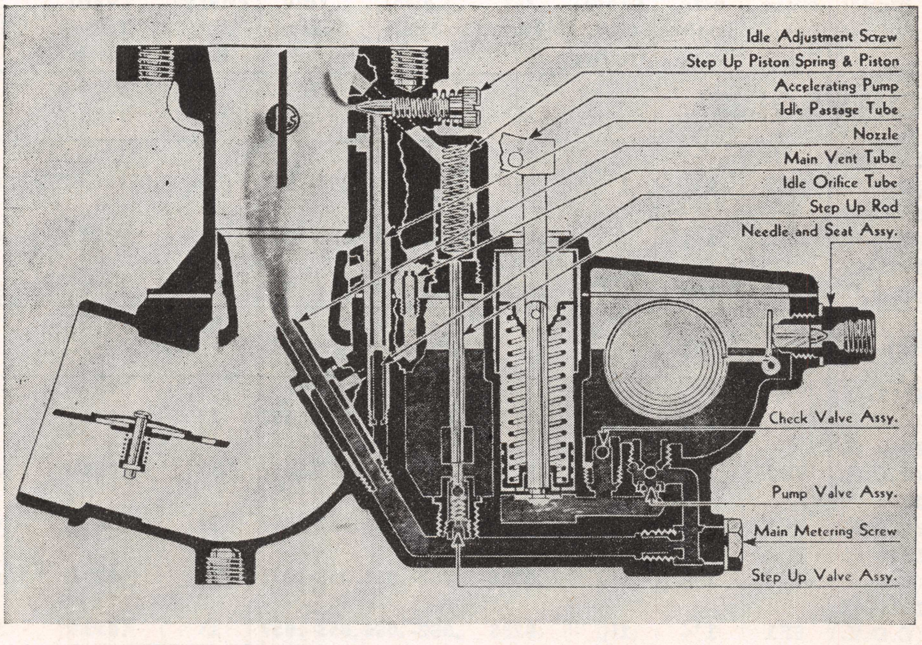
② Top of the lower port should be open below the lower edge of the throttle valve the dimension shown.

③ For richer mixture, turn screw OUT, and IN for leaner.

④ Calibrated to flow the number of cubic centimeters per minute as shown. Do not use drills to gauge size. If in doubt, install new part.

⑤ Summer setting, short stroke, 9/16″: winter setting, long stroke, 1″.

⑥ Top of spark port should be open below the throttle valve the dimension shown.



CARTER BB UPDRAFT. Used on Chevrolet and Dodge Cab-over-Engine trucks.

needle seat. As fuel rises in the bowl, the float moves up, allowing the fuel to come to a determined level, gradually pushing the inlet needle into the needle seat.

Float System Service: Examine inlet needle for wear at its point of contact with inlet needle seat. The amount of wear must not be a noticeable ridge or groove. Check float lever pin for out-of-round wear, as an uneven contact surface in the float bracket will allow the float to rock with side sway of fuel in the bowl, which would result in very uncertain performance going up a slight grade. Check the float by shaking it close to your ear; if any fuel has entered, or solder has broken away inside, you will hear it rattle. Do not try to repair a float, replace it with a new one. Also examine the float lip that contacts the needle valve. There should not be a noticeable hole at this point of contact, for after making a slight change in float setting, or installing a new float lever pin, the exact relation of this hole and inlet needle may be changed enough to allow the needle to cock, thereby improperly controlling the fuel inlet.

Float Height Setting: The fuel level can change from the factory setting by wear in the needle and seat and wear on the lip of the float lever, allowing a higher fuel level, causing the carburetor to load up. To check float setting, remove the gasket from the lower body and place a straight piece of stock across the machined edges of the float chamber. Hold the lip of float firmly against the seated inlet needle. Top of the float (not the soldered seam) should be 1/16 inch below the machined surface of the float chamber. To lower the float, bend the lip of the float lever toward needle. To raise the float, bend the lip away from the needle. Be sure to bend the **lip** of the float and **not** the bracket.

Low Speed System: Fuel for idle and low speed is measured by an idle jet tube, installed in a passage that feeds from the nozzle channel. This measured fuel is mixed with a measured amount of air and carried up an idle passage tube, to two discharge ports. The lower port is non-adjustable, and is below the throttle plate. The upper port is above the throttle plate and is controlled by a needle valve type idle adjusting screw which controls the fuel mixture. If a leaner mixture is desired, turn the screw in; for a richer mixture, turn the screw out.

Low Speed System Service: Remove and examine the two idle tubes. The long tube is in the upper body, and has a fairly large passage. The short tube is in the lower body and has a sized hole (about twenty-three thousandths, (see BB Updraft Specifications) and can be partially closed with dirt or lint. Clean all carbon formations at the idle discharge ports, as this carbon affects idle and cracked throttle performance.

Idle Adjustment: Have engine warmed up to normal running temperature, set idle mixture screw one turn open. Set throttle adjusting screw to idle engine 350 R.P.M. Turn idle mixture screw in ¼ turn, (to ¾ open) engine should run evenly, turn in another ¼ turn, (to ½ open) engine should start to stumble slightly, (too lean). Turn screw out to 1½ turns open, engine should start to roll, (too rich). This will show the idle system is functioning perfectly. A well tuned engine will idle best on ¾ turn of the idle mixture screw.

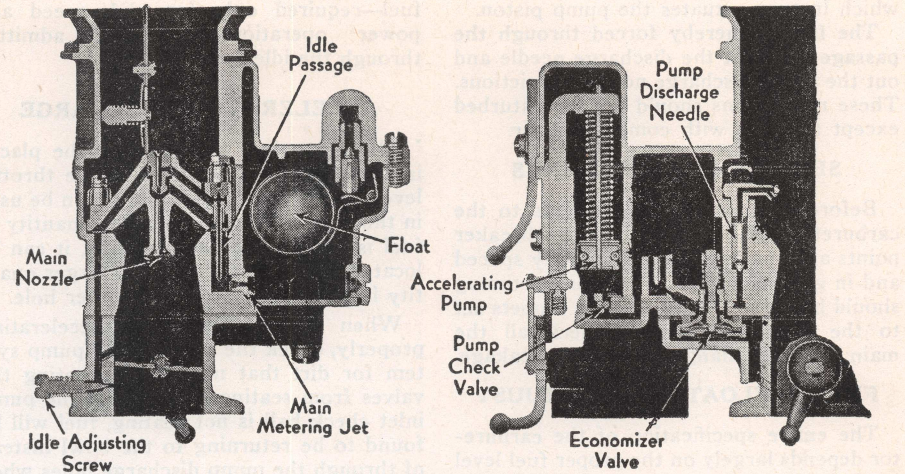
Intermediate and High Speed System: Fuel from the bowl passes through the main metering jet, through a passage to the discharge nozzle, the tip of which is out in the air stream, at the narrow section of the venturi tube, from where the air velocity picks up the fuel and carries it into the engine. The main jet is of the fixed type, being flow-tested at the factory and measured in cubic centimeters flow per minute. An added flow of fuel is provided for power and high speed operation, when a richer mixture is needed. This is accomplished with a vacuum-operated step-up piston and spring in the upper body, and a step-up valve and jet assembly, in the lower body.

As manifold vacuum drops (pulling up a hill with wide-open throttle) the step-up piston spring pushes the piston downward, the piston pushes the step-up push rod, which rests on a steel ball in the step-up valve assembly. The push rod moves the ball away from its seat (which is acting as a shut off valve) and allows fuel to flow by this valve, and through a step-up jet, (power orifice) into the discharge nozzle channel.

High Speed System Service: If engine lacks power, the main jet can be removed—with carburetor on the engine. Check sized hole for dirt, which retards the flow of fuel. This jet should not be measured with a drill, but on a flow meter. Leaner than standard jets are available for economy and special fuel. Check step-up piston for binding or sticking. If the piston sticks at the bottom, the engine will run too rich at intermediate speeds and if the piston sticks at the top, the mixture will be too lean for power and wide open throttle operation. The above also applies to a bent or sticking push rod.

Disassemble the step-up valve and jet assembly to see if the spring is broken or if the ball is sticking in the cage. To assemble, drop the steel ball in the cage, then insert the spring and screw the power jet in place. Check jet sizes in BB Updraft Specifications table.

Accelerating Pump System: This is a low pressure, delayed-action type pump, operating in a well in the lower body. The operation is mechanical, being actuated by a lever on the throttle shaft.



Holley used on Ford V8.

Accelerating Pump System Service: Remove and examine the pump ball checks, place to the lips and see if they seal when drawing in air. Check the brass pump sleeve, being sure it is replaced with the side holes down.

Pump Stroke Adjustment: The throttle lever has two holes for adjustment. The inner hole (closer to throttle shaft) is the hot weather, short stroke setting, also used at high altitudes, and with high test gasoline. This stroke should measure 9/16 inch. The outer hole gives a long stroke, for winter setting. This should travel one inch.

Choke System: Choke is operated by hand control. Choke plate has relief poppet valve, to prevent over-choking. Closing the choke actuates a connecting link which partly opens the throttle plate. This supplies a proper starting mixture. Be sure the choke plate closes all the way on all hard starting complaints, especially in the cold weather operation.

HOLLEY

AA-1 & AA-⅞

FORD V8

This carburetor is a double barrel downdraft unit incorporating a metering system where the fuel is drawn at idle, into the antechambers located above the main discharge nozzles. From these antechambers, fuel is drawn at idle to the discharge holes below the throttle, or, at higher speeds, will be discharged promptly out of the main discharge nozzles located in the throat of the venturi.

An economizer valve, which is a completely self-contained unit, is accurately tested and calibrated before it is assembled into the carburetor. This economizer valve is operated by manifold vacuum, and is fully automatic in operation and delivers the added supply of gasoline only when it is needed by the engine.

The accelerating pump is completely enclosed, eliminating the possibility of becoming inoperative due to dust and dirt. Varying length strokes for different seasons, and a snap lock pump link which makes it easy to change strokes without the necessity of removing screws, cotter pins, etc.

MAIN METERING SYSTEM

The fuel for idle and intermediate speeds flows from the fuel bowl through the main metering jet, into the idle tube, into the idle passage, through the antechamber, through passages, and discharges at the idle holes; the lower hole being controlled by the idle needle while the upper or intermediate holes being controlled by the throttle valve. The idle air bleed is drilled and calibrated at the factory and should not be disturbed except to clean.

At intermediate speed, the gas flows from the metering jet, to the passages and then discharges out of the main nozzle into the venturi.

When the vehicle has attained a predetermined speed, the economizer opens and admits an extra amount of fuel from the bowl into the economizer restrictions and then into the fuel passages.

The opening of the economizer is dependent on the vehicle speed and the manifold vacuum which acts on the economizer through the passage, which has its outlet below the throttle valves.

The economizer restrictions are drilled accurately at the factory and should not be disturbed except to clean with compressed air.

The hand throttle is held in place by a self-locking collar. To remove, push in against the spring and turn it to the left ¼ turn.

ACCELERATING PUMP

When the throttle is closed, the fuel is drawn into the pump chamber through the check valve. When the throttle is opened, the pump rod compresses the pump spring which in turn actuates the pump piston.

The fuel is thereby forced through the passage and past the discharge needle and out the pump discharge nozzle restrictions. These restrictions should not be disturbed except to clean with compressed air.

SERVICE & ADJUSTMENTS

Before making any adjustments to the carburetor, make sure that the breaker points and spark plugs are properly spaced and in good condition. The ignition timing should be correct and the valve tappets set to the proper clearance. Check all the main body and flange gaskets for leakage.

FUEL & FLOAT LEVEL, ADJUST

The entire specification of the carburetor depends largely on the proper fuel level in the bowl. This should be measured accurately, and the fuel pump pressure should be checked with a pressure gauge.

Under 3 pounds pressure, the fuel in the bowl should measure 11/16" below the top of the bowl surface. The level can be corrected by bending the float arms; be sure the float is level after bending the arms.

When using a glass tube as a level indicator, care must be exercised because the reading in the tube will be approximately 1/16" higher than in the carburetor bowl, due to capillary attraction. The float level can be set very close when the air horn is off, by measuring the distance between the bottom of the float (not the soldered seam) and the flange surface of the air horn. This distance should be between 1⅜" and 1 11/32". This measurement is taken with the air horn removed and held in an inverted position.

IDLE ADJUSTMENT

Set the idling speed with the throttle stop screw. The idle mixture is controlled by the idle adjusting needles. Turning the needles to the right, or in, makes the mixture leaner, and to the left, or out, makes the mixture richer. The needle should be set to about ⅞ of a turn.

When the engine is warmed up, turn one needle in until the engine slows down; then out until the engine slows down. A point halfway between these two will be very close to the correct idle mixture. Repeat with the other needle. After both needles are adjusted, it is well to cross-check by repeating this procedure.

After arriving at the correct mixture, it may be necessary to re-set the throttle stop screw to obtain the correct idle speed, which should be between 6 and 7 MPH.

If the engine fails to idle properly after making the adjustments already described, check for air leaks at the intake manifold; check the gaskets between the throttle valve body and the carburetor bowl. Remove the idle tube and, with compressed air, blow out the tube and the idle channels.

If a rich condition is noticeable at idle, check the vacuum economizer valve. If this valve is not seating properly or the diaphragm is leaking, the additional supply of fuel—required only for high speed and power operation—is being admitted through the idle system.

ACCELERATING DISCHARGE

The pump link assembly can be placed in three different positions in the throttle lever. Under most conditions it can be used in the middle hole. If a smaller quantity of fuel is required for acceleration, it can be located in the inner hole. If a larger quantity is required, place in the outer hole.

When the vehicle is not accelerating properly, check the accelerating pump system for dirt that may be preventing the valves from seating properly. If the pump inlet check ball is not seating, fuel will be found to be returning to the bowl instead of through the pump discharge holes when the throttle is worked.

If the pump outlet needle valve is not seating properly, fuel will be sucked back into the pump chamber. Check the leather piston in the pump chamber to see that it fits properly against the cylinder; if it does not, fuel will leak by the piston which will result in a weak discharge.

To clean the accelerating system, remove the piston assembly, check ball retaining spring and check ball. Remove the discharge nozzle and the discharge needle. Blow out all the channels with compressed air. The small restrictions should be checked carefully, and, when working properly, should deliver a fine, solid and round stream of gasoline. When the entire system is working properly, a quick, steady stream of gasoline will flow from the discharge hole, the instant the throttle is snapped open.

INTERMEDIATE SPEED TROUBLE

Check all the body and flange bolts to see that they are tight and also see that the gaskets do not leak. Remove the main metering jets and check the size according to specifications. Blow out the metering jet channel and the main discharge nozzle with compressed air. Check the fuel level.

HIGH SPEED TROUBLE

Check the vacuum economizer valve and the economizer restrictions. Blow out the channels with compressed air. Check the fuel pump pressure with a pressure gauge. Check the fuel level in the bowl and the travel of the float. Check spark plug gaps, breaker points and the compression of the engine.

HIGH ALTITUDE OPERATION

In cases where the vehicle is operated in high altitudes, it may be necessary to use leaner metering jets. Usually a 5% or 10% leaner jet will take care of any variation in altitude. The metering jets are marked in thousandths of an inch; the smaller the number, the smaller the hole. Do not change the size of economizer passages, or the pump discharge holes, as this will cause erratic performance.

ECONOMY COMPLAINTS

Changing jets rarely increases mileage more than slightly, and often ruins performance. Make a thorough check of the condition of the engine with a compression gauge and make sure the valves are in good condition.

Check the fuel level in the carburetor bowl; make sure the fuel pump pressure is not excessive. If these two items are alright, the various points as described in the foregoing paragraphs should be checked over.

AA-1 SPECIFICATIONS

VENTURI:—15/16". MAIN METERING JET:—.050". IDLE TUBE:—54 cc. FUEL LEVEL:—There should be 11/16" from the top of the bowl flange surface to the gas level. PUMP DISCHARGE HOLE:—No. 69 drill. PUMP CAPACITY: —From 9 to 13 cc for each ten strokes of the throttle with the pump link in the center hole. The idle stop screws must be backed out to allow throttle plate to close completely. VACUUM ECONOMIZER: This is set at the factory and should not be changed.

AA-⅞ SPECIFICATIONS

VENTURI:—⅞". MAIN METERING JET:—.043". IDLE AIR BLEED:—.070". FUEL LEVEL:—There should be 11/16" from the top of the bowl flange surface to the gas level. PUMP CAPACITY:—From 9 to 13 cc in ten strokes when throttle is completely closed and pump link in the middle position. VACUUM ECONOMIZER:—Set to open between 115 and 130 cubic feet of air flow. PUMP DISCHARGE HOLE:—No. 72 drill. IDLE SCREW SETTING:—¾ turn open.

FORD SIX

This carburetor is similar to the AA units used on the Ford V8 engines except that it is of the single-barreled type.

All the main channels are carried in a removable nozzle bar which carries the idle tube and aspirating nozzle. The central portion of the nozzle bar forms the discharge nozzle. The discharge nozzle is located in the smallest part of the venturi and its diameter is such that a high suction is created at the end of the nozzle. This suction, in addition to the atomizing holes in the nozzle, helps to vaporize the fuel completely.

See the illustrations showing the Idle System, Main Metering System, Power System and Acceleration System.

IDLE ADJUSTMENT

For best results, the idle adjustment should be set with a tachometer or for the highest and steadiest vacuum reading. Never turn the screw against its seat so hard that a groove is formed in the screw point. A grooved adjusting screw should be replaced in order to obtain a satisfactory idle adjustment.

For a richer mixture, turn the screw out, and for a leaner mixture, turn the screw in.

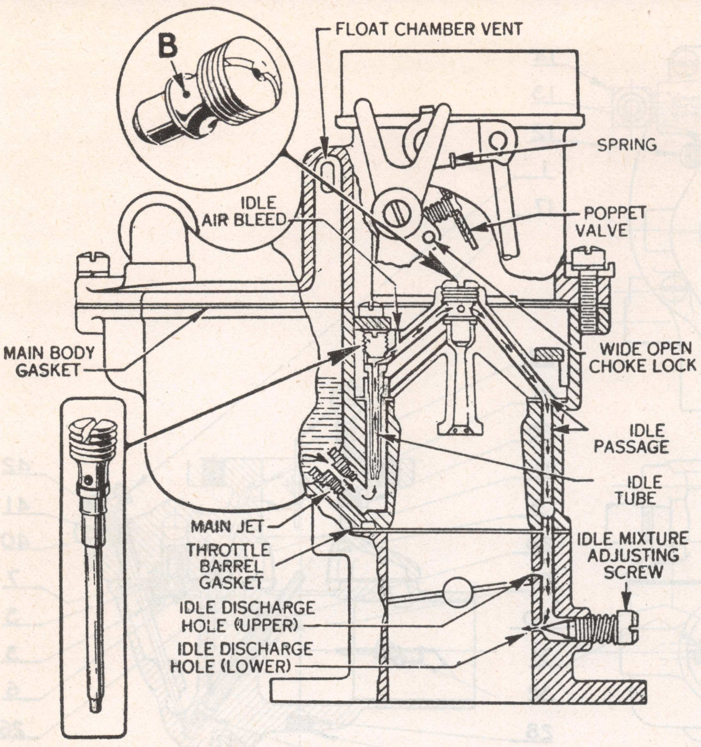

B
FLOAT CHAMBER VENT
SPRING
IDLE AIR BLEED
POPPET VALVE
MAIN BODY GASKET
WIDE OPEN CHOKE LOCK
IDLE PASSAGE
IDLE TUBE
MAIN JET
THROTTLE BARREL GASKET
IDLE MIXTURE ADJUSTING SCREW
IDLE DISCHARGE HOLE (UPPER)
IDLE DISCHARGE HOLE (LOWER)

Fig. 1. Idle system.

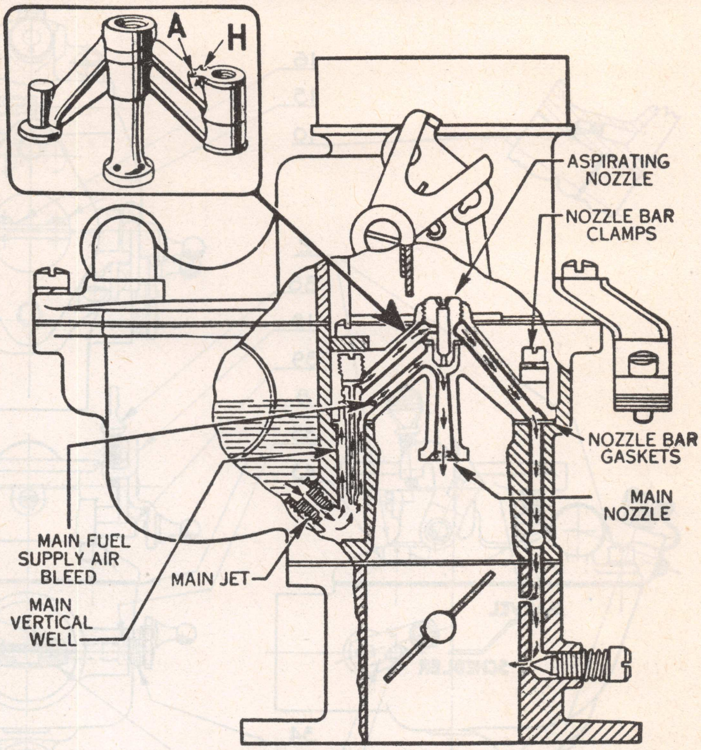

A
H
ASPIRATING NOZZLE
NOZZLE BAR CLAMPS
NOZZLE BAR GASKETS
MAIN NOZZLE
MAIN FUEL SUPPLY AIR BLEED
MAIN JET
MAIN VERTICAL WELL

Fig. 2. Main metering system.

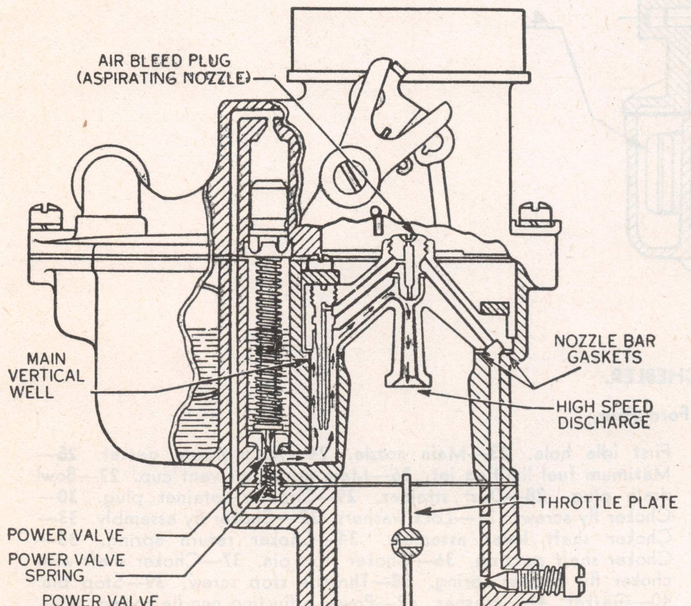

AIR BLEED PLUG (ASPIRATING NOZZLE)
NOZZLE BAR GASKETS
MAIN VERTICAL WELL
HIGH SPEED DISCHARGE
THROTTLE PLATE
POWER VALVE
POWER VALVE SPRING
POWER VALVE CONTROL PASSAGE

Fig. 3. Power system.

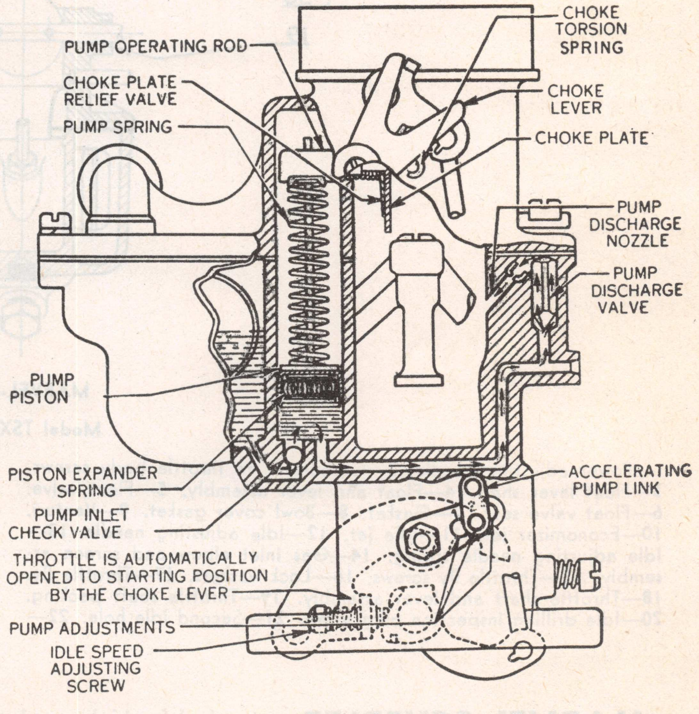

PUMP OPERATING ROD
CHOKE TORSION SPRING
CHOKE PLATE RELIEF VALVE
CHOKE LEVER
PUMP SPRING
CHOKE PLATE
PUMP DISCHARGE NOZZLE
PUMP DISCHARGE VALVE
PUMP PISTON
PISTON EXPANDER SPRING
ACCELERATING PUMP LINK
PUMP INLET CHECK VALVE
THROTTLE IS AUTOMATICALLY OPENED TO STARTING POSITION BY THE CHOKE LEVER
PUMP ADJUSTMENTS
IDLE SPEED ADJUSTING SCREW

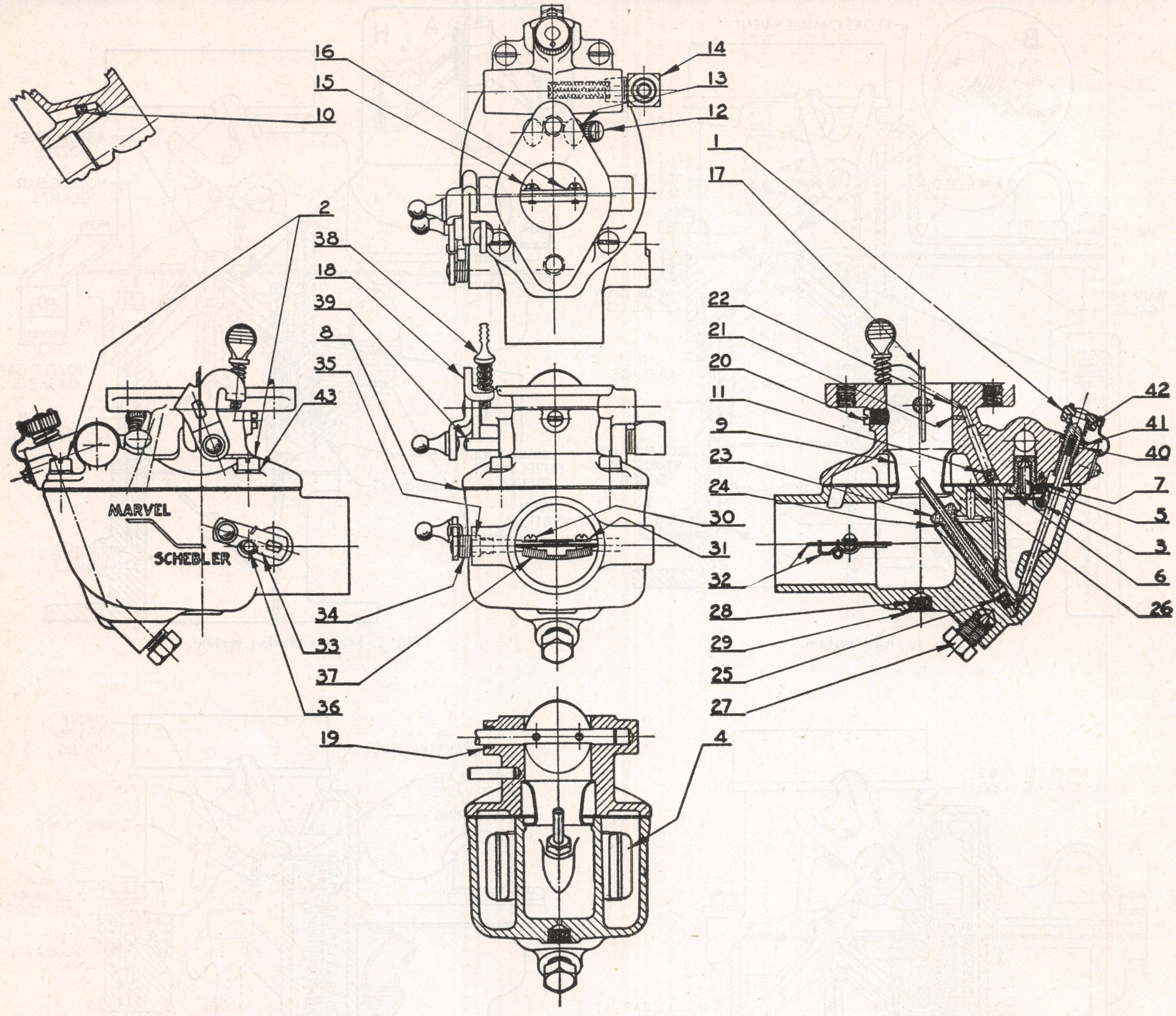
Fig. 4. Accelerating system.

Holley used on Ford Six.

ACCELERATING PUMP SETTING

The accelerating pump is provided with an adjustment for varying the quantity of the accelerating charge. A change can be made by changing the position of the pump link. The positions are marked 1, 2 and 3; number 2 being the average setting; number 1 the hot weather setting, and number 3, the extremely cold weather setting.

NOTE—Failure of the accelerating pump can usually be attributed to dirt in the pump inlet check ball seat. To make a check, remove the air horn and operate the pump with a small amount of fuel in the bowl. If the check is leaking, air or fuel will bubble back into the fuel bowl from the inlet hole. When cleaning this seat care should be used in re-installing the pump piston to be sure the leather is not damaged.



MARVEL-SCHEBLER.

Model TSX. Ford Four.

1—Power adjusting needle. 2—Carburetor to throttle body screws. 3—Float lever shaft. 4—Float and lever assembly. 5—Float valve. 6—Float valve seat. 7—Gasket. 8—Bowl cover gasket. 9—Venturi. 10—Economizer jet. 11—Idle jet. 12—Idle adjusting needle. 13—Idle adjusting needle spring. 14—Gas inlet elbow and screen assembly. 15—Throttle fly screws. 16—Lock washers. 17—Throttle fly. 18—Throttle shaft and lever assembly. 19—Throttle shaft packing. 20—Idle drilling inspection plug screw. 21—Second idle hole. 22—First idle hole. 23—Main nozzle. 24—Main nozzle gasket. 25—Maximum fuel limiting jet. 26—Main nozzle air vent cup. 27—Bowl drain plug. 28—Dust strainer. 29—Strainer retainer plug. 30—Choker fly screws. 31—Lock washers. 32—Choker fly assembly. 33—Choker shaft lever assembly. 34—Choker return spring. 35—Choker shaft packing. 36—Choker stop pin. 37—Choker shaft with choker fly flapper spring. 38—Throttle stop screw. 39—Stop pin. 40—Gasket. 41—Washer. 42—Power adjusting needle spring. 43—Lock washers.

MARVEL-SCHEBLER

MODEL TSX

Ford 1941-42 4-Cylinder

This carburetor is a single barrel, 7/8 inch flange size, updraft unit. There are three adjustments, the **throttle stop screw** for engine speed, the **idle adjusting needle,** to control the idle and low speed mixture, and the **power adjusting needle,** to admit sufficient fuel for high speed. A Venturi tube admits the proper amount of air for this engine, the size of which is 11/16 of an inch. The choke valve is manually operated. Located in the bottom of the casting is a dust strainer, held in place with a retainer plug. This is a fuel condensation drain and is provided to drain excess fuel from the carburetor mixing chamber when the engine is shut off, but it also prevents dust from entering carburetor when engine is in operation.

FLOAT SYSTEM

The fuel valve and seat assembly is attached to the upper body, and all fuel before passing by inlet needle valve must pass through a strainer, which is attached to the fuel inlet fitting. To check the float height setting, separate the two housings and hold upper housing with mounting flange down. With the gasket in place, the space between the gasket surface and the nearest edge of each float should be 9/32 of an inch. To correct this setting bend each side of float lever separately, at the narrow sections midway between fuel inlet valve and float.

LOW SPEED SYSTEM

Fuel for idle and low speed is picked up from the nozzle passage, after passing through maximum fuel limiting jet. The idle jet is screwed into the upper body, and cannot be measured for size, as all jets in this carburetor are calibrated on a factory flow meter.

There are two idle discharge ports that deliver the fuel for idle and low speed; be sure these are clear and free from carbon formation. A screw plug can be removed from the opposite side of the housing to blow air pressure directly into the ports.

A preliminary setting of the **idle adjusting needle** is two turns open, then warm up the engine, and turn idle adjusting needle in, or clockwise, until engine begins to falter or roll from richness, then turn the screw out, or counter-clockwise until the engine runs smoothly.

NOTE—It is better that this adjustment be slightly too rich than too lean.

INTERMEDIATE AND HIGH SPEED SYSTEM

Fuel for these speeds is calibrated by a maximum fuel limiting jet, and power adjusting needle. The limiting jet controls the flow of fuel when the adjusting needle is turned wide open, which is about 1¾ turns off its seat, the fuel then enters the discharge nozzle, the tip of which is located at the narrow diameter of the Venturi tube. Admitting air into the nozzle passage, is a main nozzle air vent cup, which is pressed into place, but can be pried out with a sharp tool if replacement is necessary. This is a calibrated orifice and must be reamed out to .035" when a new cup is installed.

POWER ADJUSTING NEEDLE SETTING

For a preliminary setting, to warm up the engine, turn power needle **one turn out** from its seat. With the engine running at governed speed under load, turn power adjusting needle in, or clockwise, a little at a time until the power drops appreciably. Then turn the needle out, or counter-clockwise, until the engine picks up power and runs smoothly. This will give an economical part throttle mixture, and, due to the enonomizer action, the proper power mixture for full throttle operation. If, in trying out the engine, it is inclined to backfire when the load is picked up, richen the mixture by backing out the power adjusting needle one notch at a time until good acceleration is obtained.

STROMBERG

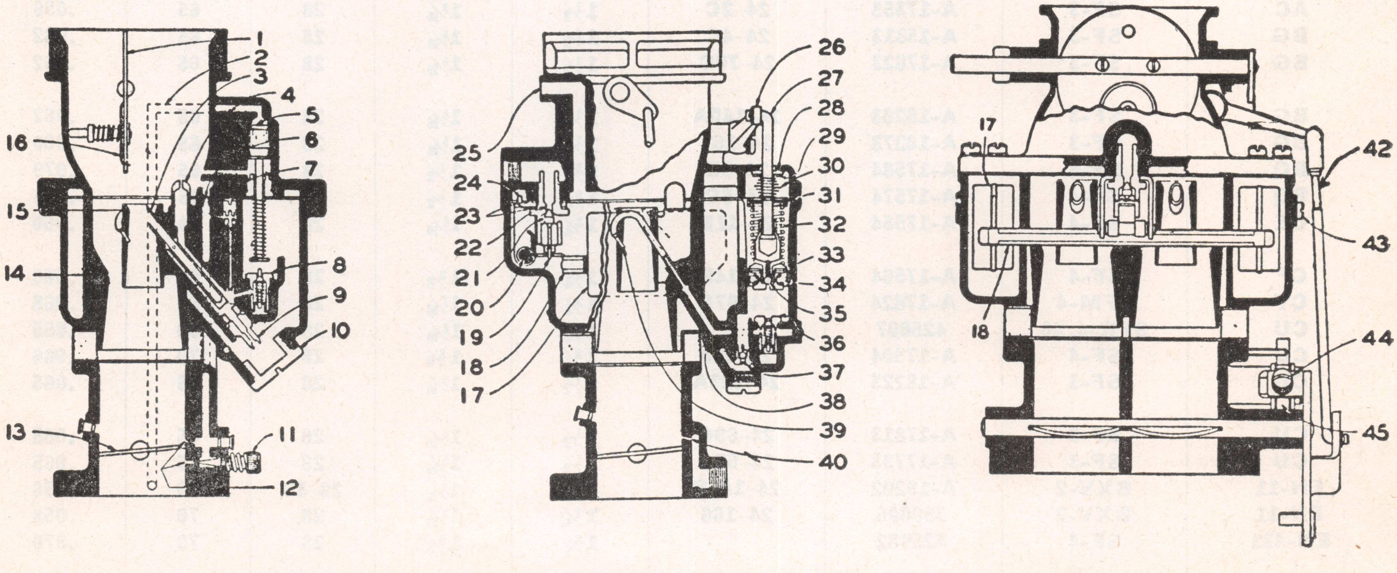
AAV-2

The "AA" series Stromberg carburetor is called the "Aero-Type" because it has been developed through experience with the aircraft type of carburetor. The objective in carburetor metering is to maintain the relation between the fuel level and the tip of the main discharge jet in various angles of operation. The fuel, in these units, is both ahead of and back of the main discharge jet, so that the vehicle can stand on an up or down grade without an overflow of fuel from the jets. This means the engine will not flood and stall when the vehicle is brought sharply to a stop.

These carburetors are the duplex downdraft type and are really two carburetors built into one. There is a set of venturi tubes, a main metering jet, an idle system with an adjustable needle, throttle valve and a pump discharge nozzle for each barrel. Both barrels are supplied with fuel by one float chamber, and there is only one air inlet.

The operating principle is the plain tube, using an air-bled jet to maintain the proper mixture throughout the entire range. The fuel chamber surrounds the carburetor body completely, which enables the fuel to be maintained at the proper level under various operating conditions. The baffles in the float chamber help to control the surge of the fuel on sharp, sudden turns. An accelerating pump is connected directly to the throttle: this, together with the economizer assures proper operation under all conditions. The float needle is connected to the float lever which makes its action positive at all times.

(Text continued on page 511)



Three views of Stromberg AAV-2 carburetor. Left: Main metering and vacuum-controlled power systems. Center: Acceleration system. Right: Fuel inlet and float system.

1—Choke valve. 2—Vacuum channel. 3—Main discharge jet. 4—High speed bleeder. 5—Power vacuum piston. 6—Idle air bleeder. 7—Idle tube. 8—Power by-pass jet. 9—Main metering jet. 10—Main discharge jet plug. 11—Idle needle valve. 12—Idle discharge holes. 13—Throttle valve. 14—Primary venturi. 15—Auxiliary venturi. 16—Choke relief valve. 17—Float. 18—Float lever. 19—Float needle valve clip. 20—Float fulcrum pin. 21—Float needle valve. 22—Float needle valve seat. 23—Float hanger gaskets. 24—Float hanger. 25—Float chamber vent. 26—Pump fulcrum arm. 27—Pump piston link. 28—Felt dust washer. 29—Retainer washer. 30—Dust washer spring. 31—Spring retainer washer. 32—Pump duration spring. 33—Pump piston. 34—Piston expansion spring. 35—Pump relief valve. 36—Pump by-pass jet. 37—Pump inlet check valve. 38—Pump discharge channel. 39—Pump discharge nozzle. 40—Spark control hole. 42—Pump rod. 43—Fuel level sight plug. 44—Throttle stop screw. 45—Fast idle cam.

STROMBERG

Engine Model	Carburetor Model	Equipment Number ①	Code Number	Carburetor Size, Inches ②	Main Venturi Diameter, Inches	Main Discharge Jet, No.	High Speed Bleeder, No.	Main Metering Jet, No. or Inch
CONTINENTAL								
M-6271	SF-2	A-18852	24-119C	1¼	1 3/16	32	70	.057
DODGE								
1936–38	BXOV-2	A-19042	3-46	1⅜	1 5/32	28-36	68	.060
T43, T44, T56, T80, T104, T124	SF-3	A-18183	3-48	1½	1 3/16	28	65	.058
		A-18233	3-56	1½	1¼	28	65	.058
T70, T72, T94, T96, T114, T116	BXV-3	A-18113	3-43A	1⅜	1 5/32	28-36	68	.058
		380009	3-58	1⅜	1 5/32	28-36	68	.058
GMC								
278	SFM-2	425074		1¼	1⅛	32	60	.054
308	SFM-2	425075		1¼	1⅛	32	60	.055
361	SFM-3	425054		1½	1 5/16	28	65	.059
426	SFM-3	425055		1½	1 5/16	28	65	.064
451	SFM-4	425052		1¾	1½	28	60	.072
477	SFM-4	425053		1¾	1½	28	58	.070
477	SFM-4	425061		1¾	1½	28	58	.070
HERCULES								
IXB	SF-1	A-18351	17-22	1	⅝	32	65	.034
MACK								
AB	SF-3	A-17333	24-1B	1½	1⅛	28	65	.049
AB	SF-3	A-17873	24-101B	1½	1⅛	28	65	.049
AC	SF-3	A-17353	24-2C	1½	1 3/16	28	65	.056
BG	SF-3	A-15313	24-4C	1½	1 5/16	28	65	.062
BG	SF-3	A-17823	24-70C	1½	1 5/16	28	65	.062
BG	SF-3	A-18203	24-140A	1½	1 5/16	28	65	.062
BG	SF-3	A-18273	24-161	1½	1 5/16	28	65	.060
BQ	SF-4	A-17584	24-9E	1¾	1½	28	65	.079
BQ	SF-4	A-17574	24-8C	1¾	1½	28	65	.075
CE	SF-4	A-17554	24-11E	1¾	1 5/16	28	70	.060
CF	SF-4	A-17564	24-14E	1¾	1⅜	28	60	.066
CT	SFM-4	A-17824	24-97C	1¾	1 7/16	28	60	.068
CU	SFR-4, 40	425007		1¾	1 5/16	28	60	.055
CU	SF-4	A-17904	24-160	1¾	1⅜	28	70	.066
CU	SF-3	A-18223	24-123A	1½	1 5/16	28	65	.065
CU	SF-3	A-17813	24-69C	1½	1 5/16	28	65	.065
CU	SF-3	A-17793	24-67C	1½	1 5/16	28	65	.065
EN-11	BXV-2	A-19202	24-145B	1¼	1 3/32	28-36	70	.056
EN-11	BXV-2	380006	24-166	1¼	1 3/32	28	70	.058
EN-431	SF-4	425082		1¾	1⅜	28	70	.070
EN-457	SFM-4	425013		1¾	1 5/16	28	70	.060
EN-457	SFR-4, 40	425091		1¾	1 5/16	28	60	.057
EN-471	SF-4	425083		1¾	1 7/16	28	60	.078
FK	SF-3	A-18053	24-125B	1½	1¼	28	65	.058
FK	SF-3	A-18253	24-151	1½	1¼	28	65	.058
FK	SFM-35	A-18213	24-142A	1½	1 3/16	28	65	.048
FM	SF-2	A-19252	24-153A	1¼	1 3/16	32	70	.057
FO	SF-2	A-18922	24-121C	1¼	1⅛	32	70	.054

STROMBERG CARBURETORS

SPECIFICATIONS

Combination Power and Pump By-pass Jet, No. or Inch	Power By-pass Jet, No. or Inch	Pump Discharge Nozzle, No.	Pump By-pass Jet, No.	Idle Discharge Holes, Nos.	Vacuum Spark Hole, No.	Idle Air Bleed No.	Idle Tube, No.	Engine Model
								CONTINENTAL
.036	None	None	None	58–66	None	None	72	M-6271
								DODGE
None	54	70	56	56–58	60	54	70	1936–38
.032	None	None	None	58–66	None	None	68	T43, T44, T56,
.034	None	None	None	58–66	None	None	68	T80, T104, T124
None	54	70	56	56–58	60	54	70	T70, T72, T94,
None	54	70	56	56–58	60	54	70	T96, T114, T116
								GMC
.032	None	None	None	54–60	None	None	68	278
.032	None	None	None	58–62	None	None	68	308
.044	None	None	None	58–62	None	None	68	361
.036	None	None	None	58–62	None	None	68	426
.056	None	None	None	54–60	None	None	66	451
.060	None	None	None	54–60	None	None	66	477
.060	None	None	None	54–60	None	None	66	477
								HERCULES
None	None	None	None	56–70	None	None	70	IXB
								MACK
.020	None	None	None	58–66	None	None	72	AB
.020	None	None	None	58–66	None	None	72	AB
.028	None	None	None	58–66	None	None	72	AC
.028	None	None	None	58–66	None	None	72	BG
.028	None	None	None	58–66	None	None	72	BG
.028	None	None	None	58–66	56	None	72	BG
.034	None	None	None	58–66	56	None	72	BG
.048	None	None	None	56–60	None	None	72	BQ
.048	None	None	None	54–60	None	None	72	BQ
034	None	None	None	56–60	None	None	72	CE
.044	None	None	None	56–60	None	None	72	CF
.048	None	None	None	56–60	None	None	72	CT
59	None	None	None	52–60	50	60	72	CU
.044	None	None	None	56–60	None	None	72	CU
.028	None	None	None	58–66	None	None	72	CU
.028	None	None	None	58–66	None	None	72	CU
.028	None	None	None	58–66	None	None	72	CU
None	55	70	56	56–58	None	56	70	EN-11
None	57	70	56	56–58	None	56	70	EN-11
.044	None	None	None	56–60	50	None	72	EN-431
.046	None	None	None	56–60	50	None	72	EN-457
60	None	None	None	52–60	50	60	72	EN-457
.040	None	None	None	56–60	50	None	72	EN-471
.040	None	None	None	58–66	60	None	72	FK
.040	None	None	None	58–66	60	None	72	FK
.028	None	None	None	58–66	60	None	72	FK
.036	None	None	None	58–66	60	None	72	FM
.034	None	None	None	58–66	None	None	72	FO

Continued on next page

STROMBERG

Engine Model	Carburetor Model	Equipment Number ①	Code Number	Carburetor Size, Inches ②	Main Venturi Diameter, Inches	Main Discharge Jet, No.	High Speed Bleeder, No.	Main Metering Jet, No. or Inch
WAUKESHA								
BK, BZ	BXUV-3	380577	③	1⅜	1 5/32	28–36	68	.062
BK, BZ	SF-3	380567	⑤	1½	1 3/16	28	65	.056
MKR, MZR	SF-3	F-6026	④	1½	1¼	28	65	Adjustable
WHITE								
20A	AAV-2	380012	29–50A	1¼	1⅛	36	65	.057
20A	AAV-2	A-18932	29–28A	1¼	1⅛	36	65	.057
20A	AAV-25	A-18812	29–24	1¼	1⅛	36	63	.057
20A, 30A	UUR-2	380010	29–51	1¼	1⅛	30	70	.044
20A, 30A	UUR-2	380017	29–56	1¼	1 1/32	30	70	.040
20A	SFG-4	A-17864	29–36	1¾	1 7/16	28	65	.066
30A	AAV-2	A-19152	29–34A	1¼	1 1/32	32	70	.047
30A	AAV-2	A-19052	29–32B	1¼	1⅛	32	70	.052
30A	SFG-4	380013	29–53A	1¾	1 5/16	25	70	.057
30A	SFG-4	A-17874	29–37A	1¾	1 5/16	25	70	.057
100A, 110A	UUR-2	380010	29–51	1¼	1⅛	30	70	.044
100A, 110A	UUR-2	380017	29–56	1¼	1 1/32	30	70	.040
100A, 110A	AAV-2	380018	29–55A	1¼	1 1/32	32	70	.045
120A, 140A	UUR-2	380010	29–51	1¼	1⅛	30	70	.044
120A, 140A	UUR-2	380017	29–56	1¼	1 1/32	30	70	.040
120A, 140A	AAV-2	380035	29–57A	1¼	1 1/32	32	70	.047
120A, 140A	AAV-2	A-19152	29–34A	1¼	1 1/32	32	70	.047

① Equipment number usually stamped on carburetor body or on tag attached to body.

② See drawings for other flange dimensions.

③ Except for the power by-pass jet, parts shown are made up from the standard unit.

④ Except for the venturi and by-pass jet, parts shown are made up from the standard unit.

STROMBERG SETTINGS

Engine Model	Carburetor Model	Equipment Number ①	Code Number	Fuel Level at Pounds Pressure ②	Float Setting, Inches	Power System Operates at Inches Vacuum	Pump Capacity and Link Setting ③	Pump Stroke Setting ④	Throttle Valve Location for Idle ⑤	Idle Screw Setting, Turns Open	Vacuum Spark Control ⑪
CONTINENTAL											
M-6271	SF-2	A-1885224-119C		9/16@2	1¾⑫	4 to 6	⑥	⅛	.023 ±.004	⑦	None
DODGE											
1936–38	BXOV-2	A-19042	3–46	⅝@3	T-24733⑧	4 to 6	11 to 14 Middle	⑨	Flush +.006—.000	⑩	Flush
T43, T44, T56, T80, T104, T124	SF-3	A-18183 A-18233	3–48 3–56	⅞@2	2¼⑫	4 to 6	⑥	⅛	Flush ±.004	⑦	None
T70, T72, T94, T96, T114, T116	BXV-3	A-18113 380009	3–43A 3–58	⅝@3	T-24733⑧	4 to 6	11 to 14 Middle	⑨	Flush +.006—.000	⑩	Flush

Continued on opposite page

SPECIFICATIONS

Combination Power and Pump By-pass Jet, No. or Inch	Power By-pass Jet, No. or Inch	Pump Discharge Nozzle, No.	Pump By-pass Jet, No.	Idle Discharge Holes, Nos.	Vacuum Spark Hole, No.	Idle Air Bleed No.	Idle Tube, No.	Engine Model
								WAUKESHA
None	54	70	56	56–58	60	54	70	BK, BZ
.030	None	None	None	58–66	None	None	68	BK, BZ
.032	None	None	None	58–66	None	None	68	MKR, MZR
								WHITE
None	52	70	63	54–58	56	36–60 ⑥	68	20A
None	52	70	63	54–58	56	36–60 ⑥	66	20A
None	52	70	63	54–58	56	36–60 ⑥	66	20A
None	.036	74	60 ⑦	54–58	60	48	68	20A, 30A
None	.032	74	62 ⑦	54–58	60	48	68	20A, 30A
.076	None	None	None	52–56	56	None	72	20A
None	62	65	63	54–58	56	36–70 ⑥	70	30A
None	54	65	63	54–58	56	36–70 ⑥	70	30A
.036	None	None	None	52–54	56	None	72	30A
.036	None	None	None	52–54	56	None	70	30A
None	.036	74	60 ⑦	54–58	60	48	68	100A, 110A
None	.032	74	62 ⑦	54–58	60	48	68	100A, 110A
None	62	65	63	54–58	56	36–70 ⑥	70	100A, 110A
None	.036	74	60 ⑦	54–58	60	48	68	120A, 140A
None	.032	74	62 ⑦	54–58	60	48	68	120A, 140A
None	62	65	63	54–58	56	36–70 ⑥	70	120A, 140A
None	62	65	63	54–58	56	36–70 ⑥	70	120A, 140A

⑤ Except for the by-pass and metering jets, parts shown are made up from the standard unit.

⑥ Smaller number in throttle body: larger number in main body.

⑦ Pump reducer.

Continued from previous page

STROMBERG SETTINGS

Engine Model	Carburetor Model	Equipment Number ①	Code Number	Fuel Level at Pounds Pressure ②	Float Setting, Inches	Power System Operates at Inches Vacuum	Pump Capacity and Link Setting ③	Pump Stroke Setting ④	Throttle Valve Location for Idle ⑤	Idle Screw Setting Turns Open	Vacuum Spark Control ⑪
GMC											
278	SFM-2	425074		9/16@2	1 3/4 ⑫	4 to 6	⑥	1/8	Flush ±.004	⑦	None
308	SFM-2	425075		9/16@2	1 3/4 ⑫	4 to 6	⑥	1/8	Flush ±.004	⑦	None
361	SFM-3	425054		7/8@2	2 3/32 ⑫	4 to 6	⑥	1/8	Flush ±.004	⑦	None
426	SFM-3	425055		7/8@2	2 3/32 ⑫	4 to 6	⑥	1/8	Flush ±.004	⑦	None
451	SFM-4	425052		7/8@2	2 3/32 ⑫	4 to 6	⑥	1/8	⑬	⑦	None
477	SFM-4	425053		7/8@2	2 3/32 ⑫	4 to 6	⑥	1/8	⑬	⑦	None
477	SFM-4	425061		7/8@2	2 3/32 ⑫	4 to 6	⑥	1/8	⑬	⑦	None
HERCULES											
IXB	SF-1	A-18351	17–22	9/16@2	1 3/4 ⑫	None	None	None	Flush ±.004	⑦	None

STROMBERG SETTINGS

Engine Model	Carburetor Model	Equipment Number ①	Code Number	Fuel Level at Pounds Pressure ②	Float Setting, Inches	Power System Operates at Inches Vacuum	Pump Capacity and Link Setting ③	Pump Stroke Setting ④	Throttle Valve Location for Idle ⑤	Idle Screw Setting, Turns Open	Vacuum Spark Control ⑪
MACK											
AB	SF-3	A-17333	24-1B	31/32@2	2 7/32⑫	4 to 6	⑥	1/8	Flush +.004—.000	⑦	None
AB	SF-3	A-17873	24-101B	31/32@2	2 7/32⑫	4 to 6	⑥	1/8	Flush +.004—.000	⑦	None
AC	SF-3	A-17353	24-2C	31/32@2	2 7/32⑫	4 to 6	⑥	1/8	Flush +.004—.000	⑦	None
BG	SF-3	A-15313	24-4C	31/32@2	2 7/32⑫	4 to 6	⑥	1/8	Flush +.004—.000	⑦	None
BG	SF-3	A-17823	24-70C	31/32@2	2 7/32⑫	4 to 6	⑥	1/8	Flush +.004—.000	⑦	None
BG	SF-3	A-18203	24-140A	31/32@2	2 7/32⑫	4 to 6	⑥	1/8	.006-.014	⑦	.036-.044
BG	SF-3	A-18273	24-161	31/32@2	2 7/32⑫	4 to 6	⑥	1/8	Flush ±.004	⑦	.036-.044
BQ	SF-4	A-17584	24-9E	31/32@2	2 1/4⑫	4 to 6	⑥	1/8	Flush ±.004	⑦	None
BQ	SF-4	A-17574	24-8C	31/32@2	2 1/4⑫	4 to 6	⑥	1/8	⑬	⑦	None
CE	SF-4	A-17554	24-11E	31/32@2	2 1/4⑫	4 to 6	⑥	1/8	Flush ±.004	⑦	None
CF	SF-4	A-17564	24-14E	31/32@2	2 1/4⑫	4 to 6	⑥	1/8	Flush ±.004	⑦	None
CT	SFM-4	A-17824	24-97C	31/32@2	2 9/32⑫	4 to 6	⑥	1/8	Flush	⑦	None
CU	SFR-4,40	425007		31/32@2	2 1/4⑫	4 to 6	⑥	1/8	Flush ±.004	⑦	.040
CU	SF-4	A-17904	24-160	31/32@2	2 1/4⑫	4 to 6	⑥	1/8	Flush ±.004	⑦	None
CU	SF-4	A-18223	24-143A	31/32@2	2 1/4⑫	4 to 6	⑥	1/8		⑦	None
CU	SF-3	A-17813	24-69C	31/32@2	2 7/32⑫	4 to 6	⑥	1/8	Flush +.004—.000	⑦	None
CU	SF-3	A-17793	24-67C	31/32@2	2 7/32⑫	4 to 6	⑥	1/8	Flush +.004—.000	⑦	None
EN-11	BXV-2	A-19202	24-145B	5/8@3	T-24733⑧	4 to 6	11 to 14 Middle	⑨	Flush +.006—.000	⑩	None
EN-11	BXV-2	380006	24-166	5/8@3	T-24733⑧	4 to 6					
EN-431	SF-4	425082		31/32@2	2 1/4⑫	4 to 6	⑥	1/8	Flush ±.004	⑦	.040
EN-457	SFM-4	425013		31/32@2	2 9/32⑫	4 to 6	⑥	1/8	+.010—.004	⑦	.040
EN-457	SFR-4,40	425091		31/32@2	2 1/4⑫	4 to 6	⑥	1/8	Flush ±.004	⑦	.040
EN-471	SF-4	425083		31/32@2	2 1/4⑫	4 to 6	⑥	1/8	Flush ±.004	⑦	.040
FK	SF-3	A-18053	24-125B	7/8@2	2 7/32⑫	4 to 6	⑥	1/8	.019-.027	⑦	Flush
FK	SF-3	A-18253	24-151	7/8@2	2 7/32⑫	4 to 6	⑥	1/8	.019-.027	⑦	Flush
FK	SFM-35	A-18213	24-142A	7/8@2	2 17/64⑫	4 to 6	⑥	1/8	⑬	⑦	Flush
FM	SF-2	A-19252	24-153A	9/16@2	1 31/32⑫	4 to 6	⑥	1/8	.023 ±.004	⑦	Flush
FO	SF-2	A-18922	24-121C	9/16@2	1 31/32⑫	4 to 6	⑥	1/8	.023 ±.004	⑦	None
WAUKESHA											
BK, BZ	BXUV-3	380577	⑯	5/8@3	T-24733⑧	4 to 6	11 to 14 Middle	⑨	Flush +.006—.000	⑩	Flush
BK, BZ	SF-3	380567	⑯	7/8@2	2 17/64⑫	4 to 6	⑥	1/8	Flush ±.004	⑦	None
MKR, MZR	SF-3	F-6026	⑯	7/8@2	2 17/64⑫	4 to 6	⑥	1/8	Flush ±.004	⑦	None
WHITE											
20A	AAV-2	380012	29-50A	5/8@4	⑲	4 to 6	18 to 22 Minimum	⑨	.030 ±.004	⑩	.015 ±.004
20A	AAV-2	A-18932	29-28A	5/8@4	⑲						
20A	AAV-25	A-18812	29-24	5/8@4	⑲						
20A, 30A	UUR-2	380010	29-51	3/4@4	⑱	6	13 to 17	⑨	Flush ±.004	⑩	Flush
20A, 30A	UUR-2	380017	29-56	3/4@4	⑱	6	13 to 17	⑨	Flush ±.004	⑩	Flush
20A	SFG-4	A-17864	29-36	7/8@2	2 9/32⑫	4 to 6	⑥	1/8	Flush ±.004	⑦	Flush

Continued on next page

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STROMBERG SETTINGS

Engine Model	Carburetor Model	Equipment Number ①	Code Number	Fuel Level at Pounds Pressure ②	Float Setting, Inches	Power System Operates at Inches Vacuum	Pump Capacity and Link Setting ③	Pump Stroke Setting ④	Throttle Valve Location for Idle ⑤	Idle Screw Setting, Turns Open	Vacuum Spark Control ⑪
30A	AAV-2	A-19152	29-34A	⅝@4	⑰	4 to 6	18 to 22 Minimum	⑨	.030±.004	⑯	.016±.004
30A	AAV-2	A-19052	29-32B	⅝@4	⑲						Flush
30A	SFG-4	380013	29-53A	⅞@2	2 9/32⑫	4 to 6	⑥	⅛	Flush ±.004	⑦	Flush
30A	SFG-4	A-17874	29-37A	⅞@2	2 9/32⑫	4 to 6	⑥	⅛	Flush ±.004	⑦	Flush
100A, 110A, 120A, 140A	UUR-2	380010	29-51	¾@4	⑱	6	13 to 17	⑨	Flush ±.004	⑩	Flush
100A, 110A, 120A, 140A	UUR-2	380017	29-56	¾@4	⑱	6	13 to 17	⑨	Flush ±.004	⑩	Flush
100A, 110A	AAV-2	380018	29-55A	⅝@4	⑰	4 to 6	18 to 22 Minimum	⑨	.030±.004	⑩	.016±.004
120A, 140A	AAV-2	380035	29-57A	⅝@4	⑰						
120A, 140A	AAV-2	A-19152	29-34A	⅝@4	⑰						

① Equipment number usually stamped on carburetor or on tag attached to body.

② Using a suitable depth gauge, the fuel level should be the dimension shown as measured from below the top surface of the bowl—without gasket.

③ Figures shown are the number of cubic centimeters per 10 slow strokes with the pump link rod set in the hole indicated.

④ Adjusted by means of a screw above vacuum piston. Turn screw IN to shorten stroke, and OUT to lengthen. Screw should be set to dimension shown, measured below the top surface of the throttle body flange.

⑤ With throttle valve fully closed, insert the size drill which just fits into the idle discharge hole and locate the throttle by placing feelers of the thickness shown in the table, between the edge of the throttle valve and the drill.

⑥ See "Pump Stroke Setting" column.

⑦ Adjust to smooth idle, IN for a richer mixture and OUT for leaner.

⑧ Tool number to use for changing position of float.

⑨ See "Pump Capacity and Link Setting" column.

⑩ Adjust to smooth idle, OUT for a richer mixture and IN for leaner.

⑪ With throttle valve fully closed and the proper size drill inserted in the spark hole above the valve, edge of valve is located the dimension shown—from the drill.

⑫ Fuel level can be corrected by holding the throttle body in an inverted position and set the float the dimension shown, measuring from the top of the float to the gasket surface.

⑬ With throttle valve fully closed, the lower idle hole to open from a No. 57 to a No. 64 drill.

⑮ With throttle valve fully closed, the lower idle hole should be open from a No. 70 to a No. 77 drill.

⑯ See footnotes regarding these units in specification table.

⑰ Fuel level may be corrected by holding the air horn in an inverted position and placing Tool No. T-24971 ON the gasket. Tops of floats should be 3/64″ above the tops of vertical guides (brass floats) and 1/64″ for tin-plated floats. Sides of floats should be parallel to guides of tool without drag.

⑱ Fuel level can be corrected by holding the throttle body in an inverted position and set the float so that a 15/64″ drill rod will just pass between the center of the float and the gasket surface of the throttle body.

⑲ Proceed as described in footnote 17 except that with brass floats, the tops of floats should be flush with tops of vertical guides, and 1/32″ below the guides for tin-plated floats.

(*Text continued from page* 505)

Main Metering System: Fuel enters the carburetor at the gasoline inlet through the float needle valve and into the float bowl where it is maintained at constant level by the floats.

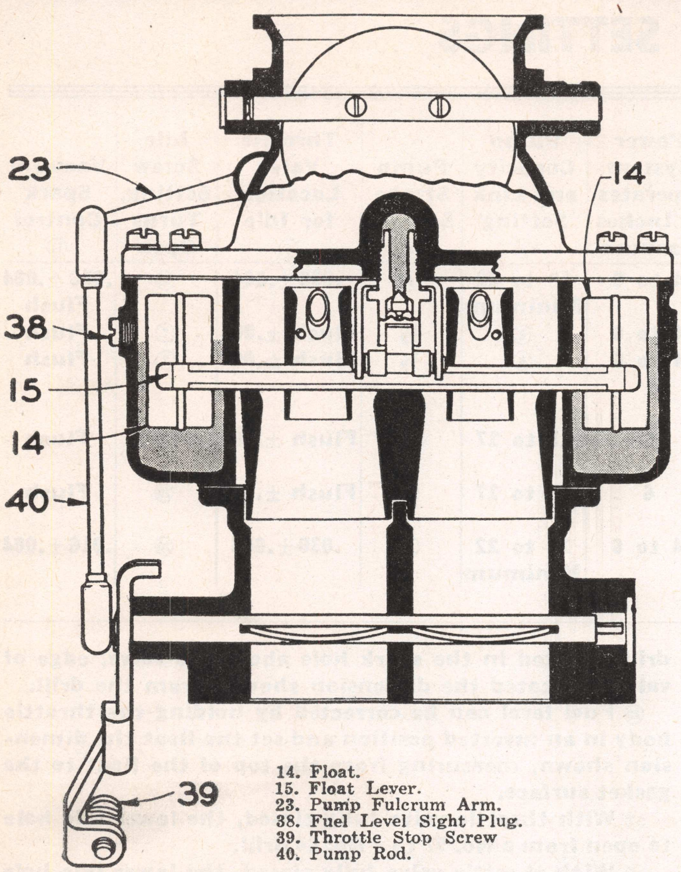
Air enters the carburetor through the air inlet and places suction on the main discharge jet or idle discharge holes, depending upon the amount of throttle opening.

The main metering jets are of the fixed type and control the flow of gas during intermediate or part throttle operation. From the metering jet, the fuel passes into the main discharge jet where it is mixed with air from the high speed bleeder, and flows into the carburetor barrel down to the intake manifold.

All jets of the fixed type are so calibrated to supply the correct mixture for normal operating conditions and should not be changed. When servicing the carburetor, and the main discharge jets are removed, the lead gasket must be replaced with a new one, to assure a good seal when the jet is reassembled.

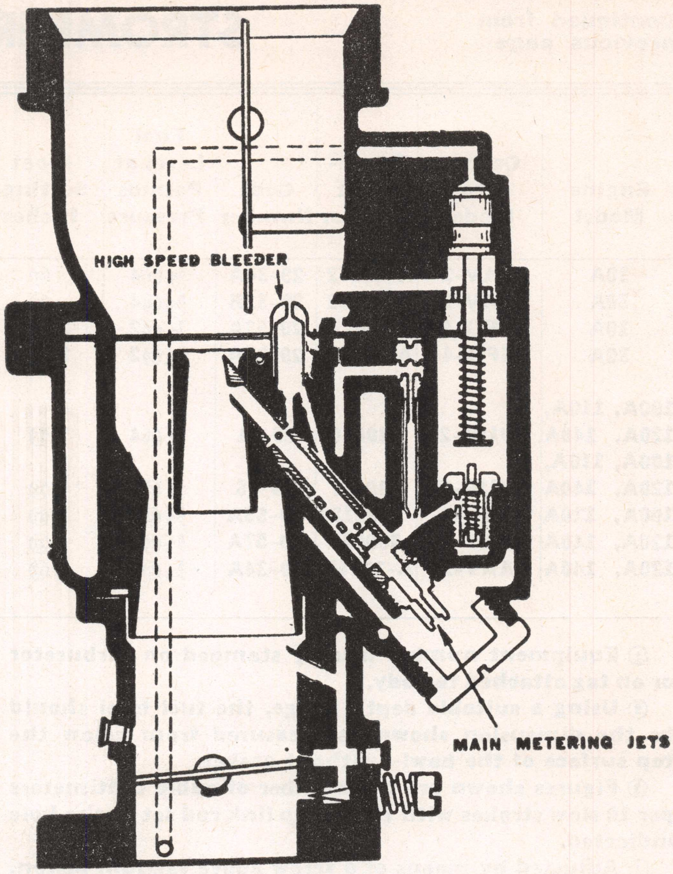
Maximum Power Operation: For wide open throttle operation on these carburetors, manifold vacuum controls the action of the economizer valve. In the part throttle range, the manifold vacuum has sufficient suction to hold the economizer piston to its "UP" position. When the throttle is wide open, the manifold vacuum decreases so that the vacuum piston spring has a greater force and moves the piston downward to open the economizer jet and consequently feeds the additional fuel required into the main discharge jet.

Acceleration: On the up stroke of the piston, fuel is drawn into the piston chamber through the inlet check valve. On the down stroke, the compression closes the

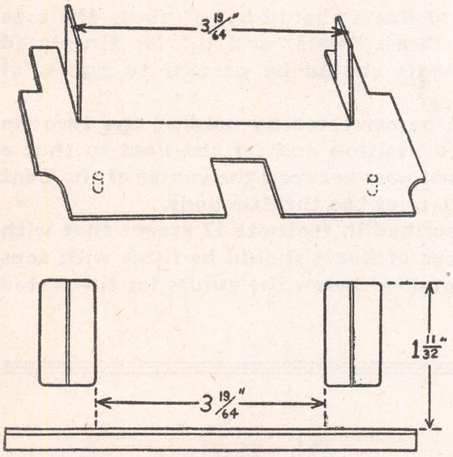


14. Float.
15. Float Lever.
23. Pump Fulcrum Arm.
38. Fuel Level Sight Plug.
39. Throttle Stop Screw
40. Pump Rod.

Stromberg AAV carburetors. Correct fuel level is indicated by the gray tint at the lower part of the sight plug (38).



Stromberg AAV. When servicing these units, be sure that the tip of the discharge jet is not distorted and that the high speed bleeder is not restricted.



Stromberg AAV carburetors. Showing application of float setting tool.

check valve and forces open the pump bypass valve. The fuel is then discharged through the pump discharge nozzles into each of the carburetor barrels.

Three holes are provided in the throttle lever for the accelerator pump rod. Place the rod in the middle hole for normal operating conditions. If less pump discharge is required, the rod should be placed in the hole which gives the shortest stroke. The rod should be placed in the hole which gives the longest stroke if more pump discharge is required.

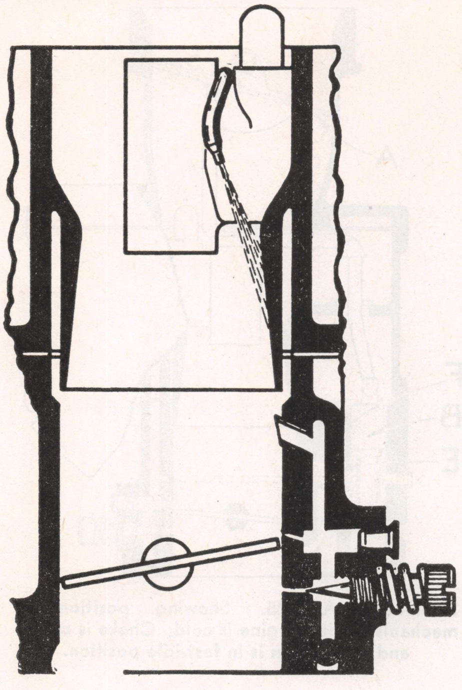
Idle System and Adjustment: Fuel for idle speeds is taken through the idle tube where it is mixed with air from the air bleeder. The mixture passes to the idle channel where it is mixed with additional air through the secondary air bleeder. It is then discharged through the idle holes.

On closed throttle, fuel is drawn only from the lower idle discharge hole due to the high suction at this point. As the throttle is opened, suction is also placed on the upper idle discharge hole to feed additional fuel until the throttle is opened to a position where the main discharge jet comes into operation.

When making the adjustment on the idle needle valves, the engine should be well warmed up, so that the intake manifold is warm to the hand. The idle speed of the engine should be set to a road speed equivalent to 7 to 8 MPH. Turning the needle OUT or counterclockwise, gives a richer mixture, and IN or clockwise gives a leaner mixture. Adjust one barrel at a time. Turn the idle adjustment IN slowly until the engine begins to run irregular, then slowly turn the adjustment OUT until the engine begins to "Roll". Then, very slowly, turn in the adjustment again, just enough to obtain a smooth idle for this throttle opening. This adjusts the mixture for one half of the cylinders. Repeat this procedure for the other half with the other needle.

It may be necessary, after completing the adjustments, to cut down the engine idle slightly. If a smooth idle cannot be obtained, remove the idle needles and check to make sure that no dirt has accumulated around the seats.

Fuel Level: The Fuel Level is set at ⅝" below the top surface of the float chamber which corresponds to the bottom of level sight plug, with the engine idling. The plug should be removed to observe the position of the level before the carburetor is disassembled to reset the float. When resetting the floats it is necessary to remove the air horn assembly. Holding the air horn in an inverted position, Service Tool T-24971 should be placed on the cover gasket. The top of the vertical guides of the tool should be flush with the tops of the floats when floats are properly set. The guides also serve to check the clearance between the floats. The floats should be set so that they are tangent to the guides without drag. This will allow sufficient clearance with the main body and not interfere with free movement. If the float tool is not available the distance between the top of the float and the gasket should be 1-11/32".



Stromberg AAV-2. Acceleration discharge should strike below the throat of the large venturi.

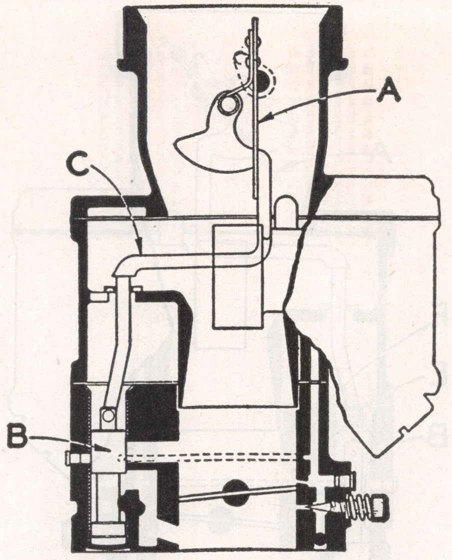
IMPORTANT—Fuel level can be checked only when engine is running. **Do not start engine while air horn is removed because a backfire through the manifold may cause a serious fire.**

Service: Main discharge jet, or nozzle, should be removed with a jet puller, if it does not fall out after main metering jet is removed. It is sometimes wedged in place by the lead gasket which is placed at the upper seat. Do not strike the tip of this jet to push it out, as it may distort the take-off action of the fuel at this point.

If a rich condition exists, with the proper size main metering jet, examine the high speed bleeder dome. After the upper housing is removed, and the fuel bowl housing is placed upside down on the work bench, small particles of dirt can be forced into the high speed bleeder orifice, as the housing is moved around to remove or replace main metering jet or jet plug. Remove the dome by twisting with a pair of pliers, and tap back into place, after cleaning, with a hollow tool, being careful not to close the sized orifice at the tip of the dome.

On some of the early production AAV-2 carburetors, there was a slight flat spot on acceleration. This was found to be due to the discharge of the pump tubes hitting on top of the large venturi.

To eliminate the condition, it is necessary to re-position the pump discharge tubes so that the discharge strikes below the throat of the large venturi as shown in the accompanying illustration. It is desirable to have the discharge hit the venturi wall between the throat and the lower edge. To do this it is necessary to remove the air cleaner and the air horn and bend the tubes so that they lie against the small venturi



Stromberg AAV-25. Showing position of mechanism when engine is hot. Choke is wide open and mechanism is in slow-idle position.

support. After re-positioning the tubes, work the pump piston a few times to make certain that the discharge strikes in the desired section.

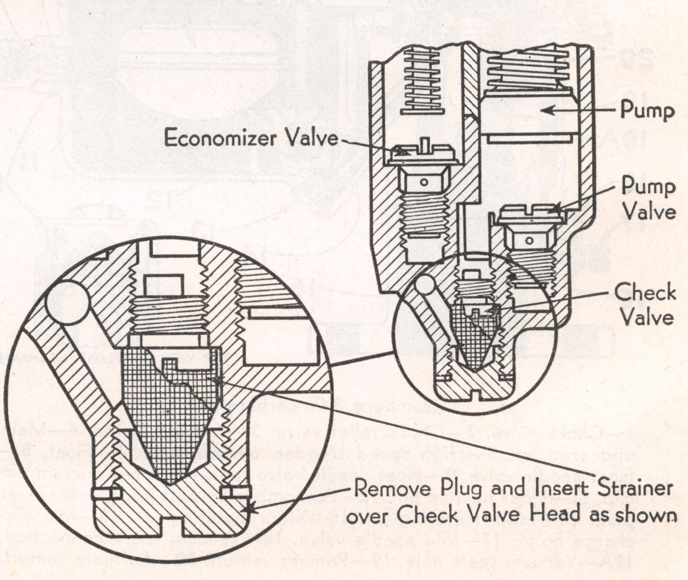
Another important point to check in an acceleration complaint, is the check valve strainer. If this strainer is left out, or mutilated, dirt will lodge in the valve and hold it open. This, of course, allows the accelerating charge to go back into the float chamber instead of out the pump tubes, and results in a flat spot or miss on acceleration. The dirt will be washed out of the check valve after the pump is operated several times and the valve will again seat, resulting in perfect performance again until more dirt lodges in the check valve. A special tool is supplied to insert this strainer.

AAV-25

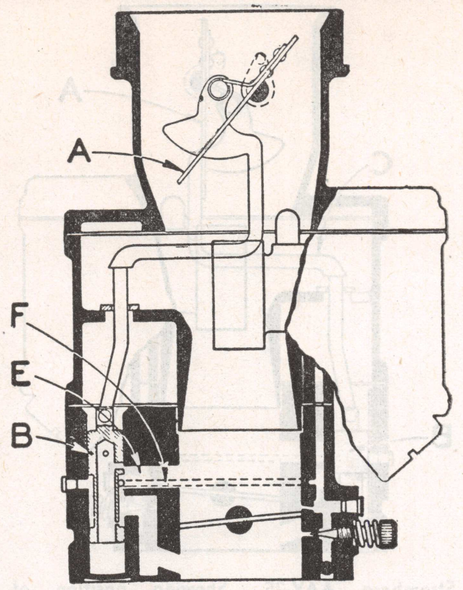
Same as the AAV-2 with the addition of a built-in automatic choke and a special fast idle feature. The principles are namely manifold vacuum, heat on a thermostat spring, and offset choke valve in the carburetor. The vacuum piston which is used to open the choke valve when the engine begins to fire is connected to the choke valve, while the thermostat spring is connected to the choke stem. The fast idle feature is accomplished by internal channels supplying additional fuel below the throttle valve during the cranking and fast-idle periods.

On a cold engine, the thermostat spring applies a tension on the choke shaft, keeping the choke plate in a closed position, and through proper linkage, the vacuum piston is held in the raised position. This position allows the piston to leave a passage open to admit a fuel mixture for fast idle. During the cranking of the engine the choke plate remains in the closed position. As the engine begins to fire, and a manifold vacuum is created, the vacuum piston is pulled downward, still allowing additional fuel for the fast idle mixture. With this action the choke plate opens slightly to admit sufficient air for running. The choke plate in the carburetor being off center continues to open by the force of the in-rushing air, which works against the tension of the thermostat, until, with the warming up of the engine, the thermostat absorbs sufficient heat so that it will not offer any resistance. As the choke plate opens, it allows the vacuum piston to lower, until the piston closes the passage, cutting off the additional supply of fuel for fast idle. Fuel is then only taken through the regular idle discharge holes.

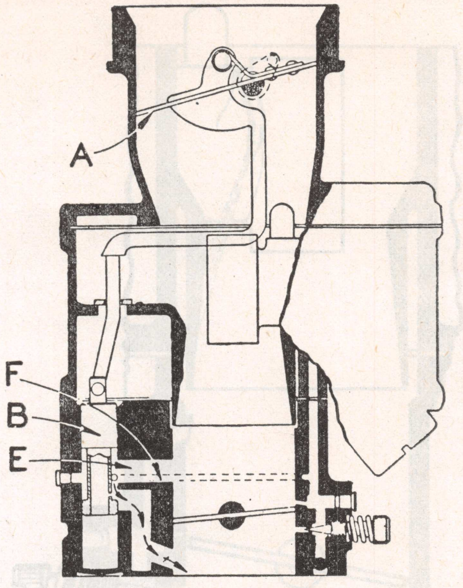
Vacuum Piston Setting: The pull of the vacuum piston should be set in accordance with the choke valve opening. Remove the plug from channel and insert shank end of a new No. 34 drill. The choke valve should be opened until the piston comes to rest on the No. 34 drill. In this position the choke valve should be opened so that a 11/32" drill can be placed between the valve and the air horn. Change the opening by bending the lever between the choke valve and the piston link.


Pump
Economizer Valve
Pump Valve
Check Valve
Remove Plug and Insert Strainer over Check Valve Head as shown

Stromberg AAV Pump check valve strainer.



Stromberg AAV-25. Showing position of mechanism during warming up period. Choke is partially open and mechanism is in fast-idle position.



Stromberg AAV-25. Showing position of mechanism when engine is cold. Choke is closed and mechanism is in fast-idle position.

Adjusting Thermostat: Remove thermostat case, allowing thermostat to cool or warm until it has reached the temperature of 70 degrees. This is important.

When the thermostat reaches 70 degrees, the inside hook of the thermostat should coincide with the "zero" marking on the thermostat case, which is the original setting. When installing a new thermostat or other new parts, check the zero location very carefully at 70 degrees temperature and change the location if necessary. If it is impossible for the thermostat to reach 70 degrees, you can provide for the difference by allowing one graduation on thermostat case for every 5-degree variation in temperature of the thermostat.

To adjust thermostat, reassemble case onto the air horn so that hook comes into contact with pin on the lever without any tension and with choke valve in wide-open position. The zero marking on the case will then coincide with the notch on the air horn.

Revolve thermostat case ten notches rich as indicated by the arrow and fasten screws securely.

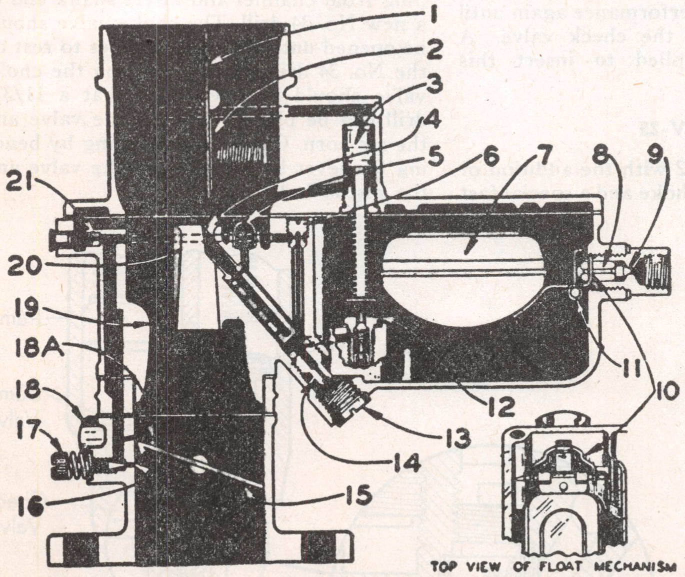
Service: Carburetor settings and adjustments for AAV-25 are the same as AAV-2. The vacuum piston used for the fast idle feature will need cleaning when mileage drops suddenly. Due to occasional backfiring, carbon will collect on the piston, and it will stick, keeping the choke plate from opening as rapidly as it should, and allowing the additional fast idle fuel mixture to enter the engine for too long a period.

STROMBERG BXV SERIES

BXV2, BXV-3, BXOV-2, BXUV-3: The BXV type is a downdraft, single-barrel carburetor, with a mechanically-operated accelerating pump, and a manifold vacuum-operated economizer and power system.

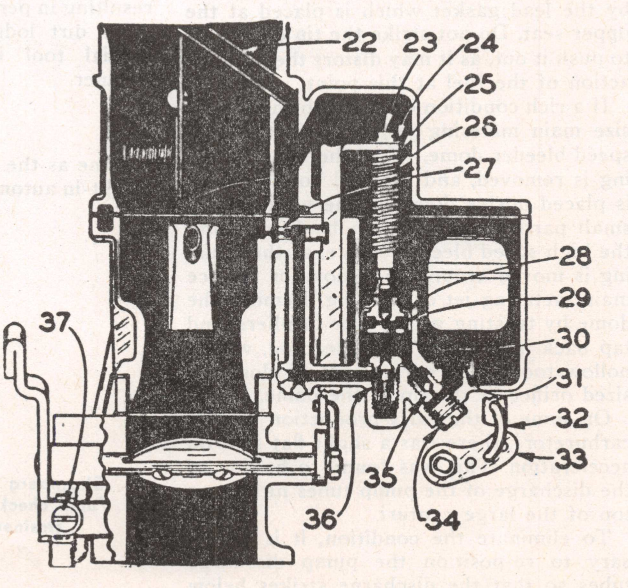
Low Speed System: Fuel for idle speeds is drawn through an idle tube, into a passage where it is mixed with air from the idle air bleeder. The mixture passes through the idle channel and is then discharged through the idle discharge ports. On closed throttle, fuel is drawn only from the lower idle discharge hole, due to the high suction at this point. As the throttle is opened, suction is also placed on the upper idle discharge hole to feed additional fuel until the throttle is opened to the position where the main discharge jet comes into operation.

Main Metering System: Fuel in the bowl is maintained at a constant level by a float. Air, which enters the carburetor through the air entrance at the top, is measured by a sized Venturi tube, which is cast into the housing. The air places suction on the main



Stromberg BXV carburetors.

1—Choke valve. 2—Choke relief valve. 3—Vacuum piston. 4—Main discharge jet. 5—High speed bleeder. 6—Idle tube. 7—Float. 8—Float needle valve. 9—Float needle valve seat. 10—Float fulcrum pin clip. 11—Float fulcrum pin. 12—Economizer by-pass jet. 13—Main jet plug. 14—Main metering jet. 15—Main metering jet. 16—Idle discharge holes. 17—Idle needle valve. 18—Vacuum spark connection. 18A—Vacuum spark hole. 19—Primary venturi. 20—Auxiliary venturi.



Stromberg BXV carburetors.

21—Idle air bleeder. 22—Float chamber vent. 23—Piston connecting rod. 24—Cotter pin. 25—Pump piston rod. 26—Pump duration spring. 27—Pump discharge nozzle. 28—Pump piston. 29—Pump piston expansion spring. 30—Pump relief valve. 31—Pump inlet strainer. 32—Pump link. 33—Pump lever. 34—Pump inlet plug. 35—Pump inlet check valve. 36—Pump by-pass jet. 37—Throttle stop screw.

discharge jet. Fuel passes from the bowl, through a main metering jet of the fixed type (See Stromberg Specification Charts) into the main discharge jet (also sized), near the upper end of which is installed a high speed air bleeder.

Power System: For maximum power or high speed running, a richer mixture is required. On a hard pull, with a load, the vacuum economizer comes into operation. As manifold vacuum decreases to below six inches, the vacuum piston spring tension is the dominant force, and moves the piston assembly downward to open the by-pass jet and allow additional fuel to flow into the main discharge jet.

Acceleration System: The pump piston being connected to the throttle moves in conjunction with it. On the up stroke of the pump piston, fuel is drawn through the inlet check valve and into the piston chamber. On the down stroke, the compression of the fuel closes the check valve and forces open the by-pass valve. The fuel is then discharged through the pump discharge nozzle. When the throttle is opened part way only, a small amount of fuel is discharged and the spring in the by-pass valve returns the valve to its seat.

SERVICE AND ADJUSTMENTS

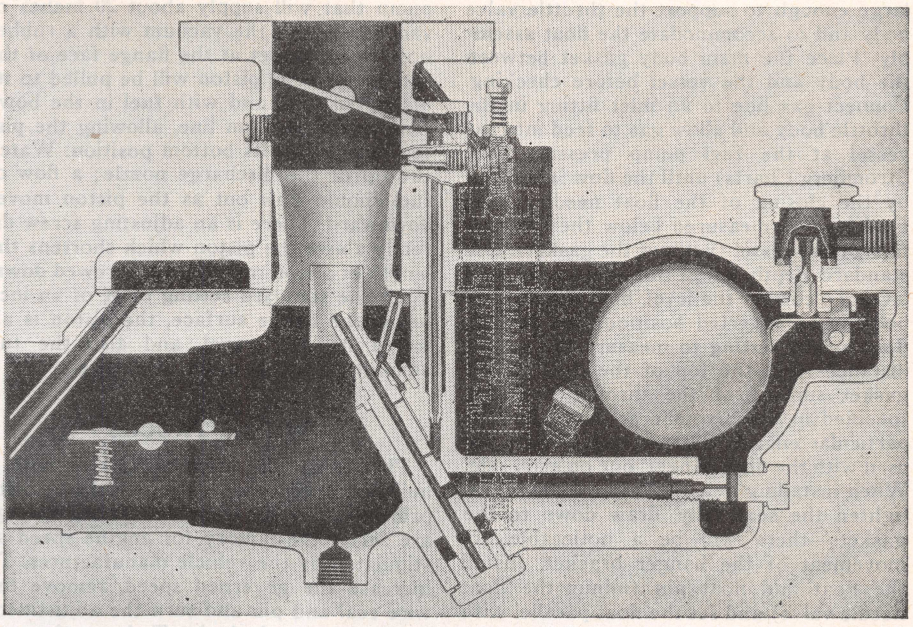
Fuel level should be ⅝ of an inch below the top surface of the float chamber with the gasket removed and with the engine idling. It can be corrected by bending the float lever arm, where it meets the float, up or down to give the desired position. A Stromberg tool No. T-24733 is available for this purpose. The float fulcrum pin is held in position by a clip. When reassembling the float parts, make certain the clip is properly positioned in the notches provided for it.

Pump Adjustment: There are three adjustments for the pump, namely, summer, normal and winter. The summer setting is the hole nearest the throttle shaft—short stroke. The winter setting is the hole furthest from the throttle shaft—long stroke. The center hole is for average operating conditions, and in this hole, pump capacity should be 11 to 14 C. C. per 10 slow strokes.

Idle Adjustments: When adjusting the idle needle valve, have the engine well warmed up to operating temperature, and the throttle stop screw is on slow idle. The idle speed of the engine should be set at a speed equivalent to 7 to 8 miles per hour. Turning the needle **out** gives a richer mixture, and **in**, a leaner mixture. Turn the idle adjustment in slowly until the engine begins to "lag" or run irregularly, then slowly turn it out until the engine begins to "roll". Finally, very slowly, turn in the adjustment again just enough so that the engine runs smoothly for this throttle opening. It may be necessary after completing this adjustment to cut down the engine speed slightly.

STROMBERG SF SERIES

This is an updraft, single-barrel carburetor, with a vacuum-operated accelerating pump and vacuum-controlled power system. It has the double Venturi tube feature. The large one measures the amount of air required for the engine, is marked for size and is held in place by the assembly of the upper and lower body. The secondary, or small Venturi tube is made up as one piece with the main discharge jet, and promotes fuel atomization due to high air velocity at the tip of the jet. The fuel bowl must be sealed to atmospheric pressure surrounding the carburetor, but is open to the air existing in the air cleaner by means of a vent tube. This allows the same pressure to be applied to the fuel in the bowl as is applied to jets in the air stream.



Stromberg SF carburetor. Schematic view.

Low Speed System: When the throttle valve is closed, gasoline is delivered to the engine by means of the idle system of the carburetor. Gasoline is taken up through the idle tube, which measures the quantity of fuel for the idle system. It is mixed with air, the amount of which is governed by the idle needle valve, and reaches the engine by means of the idle discharge holes, and up through the barrel of the carburetor. On closed throttle, fuel is drawn only from the upper idle discharge hole, due to the high suction at this point. As the throttle is opened, suction is also placed on the lower idle discharge hole to feed additional fuel until the throttle is opened to the position where the main discharge jet comes into operation.

Main Metering System: The main metering system controls the flow of the fuel during the intermediate speed of the engine. Fuel is kept at a constant level in the bowl by the float mechanism. From the bowl the fuel passes through the main metering jet, which is marked for size in decimal parts of an inch. (See Stromberg Specification Charts). The fuel then passes into the main discharge jet, which delivers the fuel to the small Venturi tube, where it is mixed with air and flows into the carburetor barrel. The amount of air used in the mixture is controlled by the large Venturi tube.

Power System: Up to ¾ open throttle, the fixed main metering jet supplies sufficient fuel, but for maximum power or higher speeds, at the full open throttle position, a richer mixture is supplied by means of a power by-pass jet. At moderate engine speeds a high vacuum is created in the intake manifold. This vacuum holds a piston in an up position against the tension of the vacuum piston spring, but when the throttle is opened beyond the ¾ position, to compensate for the extra power that may be needed from the engine, the manifold vacuum falls off accordingly, and the pressure of the vacuum piston spring moves the piston assembly downward, till it comes in contact with and opens the valve in the by-pass jet. The opening of this valve allows an additional flow of fuel to pass through the power jet and enter the main discharge jet.

Accelerating System: The pump piston is directly connected to the vacuum piston, and on sudden opening of the throttle the vacuum drops off very rapidly and the piston spring forces the pump piston down, which in turn forces a discharge of fuel to be driven through the by-pass jet, and out of the main discharge jet. This sudden surplus of fuel enrichens the mixture for the moment and furnishes the engine the extra power needed for fast acceleration. Fuel enters the pump cylinder on the up stroke of the pump piston through the check valve and strainer in the fuel bowl. On the downward movement of the piston, the pressure of the fuel closes the check valve and prevents the return of fuel to the bowl.

SERVICE AND ADJUSTMENTS

Fuel level can be accurately checked with the use of an open vessel with a leveled top, large enough to support the throttle valve body and to accommodate the float assembly. Place the main body gasket between the body and the vessel before checking. Connect gas line to an inlet fitting in the throttle body and allow gas to feed into the vessel at the fuel pump pressure (see Stromberg Charts) until the flow is stopped by the closing of the float needle valve. Fuel level is measured below the top surface of the vessel (without the gasket) Use standard depth gauge for measuring fuel level. To correct the level, hold the throttle body in an inverted position, and set the **float height setting** to measure the proper distance from the top of the float to the gasket surface of the throttle body, as specified in the Stromberg Charts for the particular engine. Be sure two gaskets are used with the float hanger, one on each side. When installing new fuel valve seat, do not **tighten the seat fully, draw down to the** gaskets—there will be a noticeable arc movement of the hanger bracket. Install the float and float pin (minus the float needle valve) and set the float parallel with the carburetor housing, then tighten the fuel valve seat.

Idle Adjustment: The idle needle valve controls the admission of more or less air to the idle system, therefore, turning the adjustment **out** gives a leaner mixture and turning the adjustment **in**, gives a **richer** mixture. For a preliminary setting, turn the adjustment in until it seats, then turn it out one full turn and allow engine to warm up to operating temperature. A smooth idle should occur between ½ to 1½ turns open. If less than ½ turn is required, the idle tube is probably dirty and restricted. If more than 1½ turns is required, the air passage to the carburetor barrel is probably carbonized and restricted, or the idle jet size is too large. Another cause of poor idle and low-speed operation is the formation of carbon in the carburetor barrel at the idle discharge ports. When replacing the idle tubes, use the type that meters the fuel at its upper tip. On Mack trucks use the following, on SF2 use P23722, on SF3 use P22711, on SF4 and 5 use P22702.

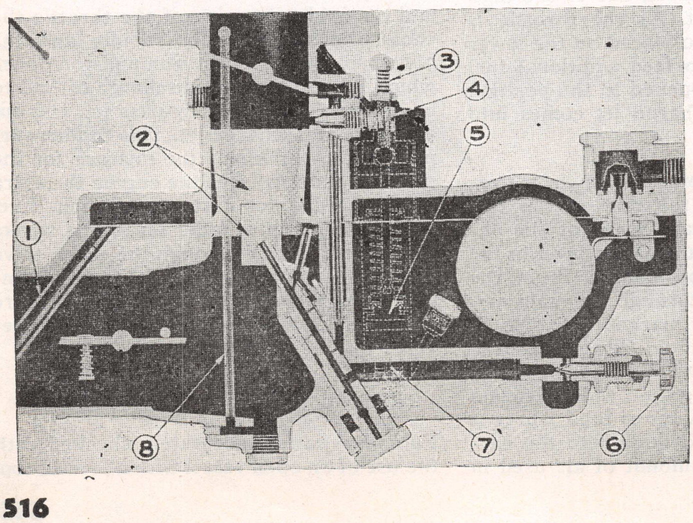
Vacuum piston can be tested with a vacuum pump that will supply about 20 inches of vacuum. Apply the vacuum with a rubber hose to the outlet at the flange face of the carburetor. The piston will be pulled to its upper position, and with fuel in the bowl, remove the vacuum line, allowing the piston to move to its bottom position. Watch the tip of the discharge nozzle; a flow of fuel should flow out as the piston moves downward. There is an adjusting screw directly above the piston which shortens the length of piston travel if it is screwed down. With the standard setting of ⅛ of an inch below the flange surface, the piston is allowed its full travel, and also the full amount of acceleration discharge.

SFG-4
WHITE TRUCKS

This is an SF series carburetor with a built-in governor, operating on the velocity principle. The governor calibrating springs are set at the factory for engine speed as stipulated by the vehicle manufacturer. To increase the governed speed, remove the wire seal and pin and turn the adjustment to the right, or clockwise. To lower the governed speed turn the adjustment to the left, or anti-clockwise. Should a surge become apparent at the new speed setting, remove the screw plug below the speed adjusting screw, and turn the compensating adjustment screw to the left, or anti-clockwise. If the governing action is too flat, turn the adjustment to the right, or clockwise. Recheck the governed speed. The throttle shaft is hardened and operates on steel ball bearings. As these balls are not in a cage, they will fall out of place if the ball outer race is removed on the governor housing side. The governor fly wheel is pressed on the throttle shaft at a specified angle, which does not permit the full opening of the throttle plate, and for this reason the throttle plate cannot be removed from the carburetor until the fly wheel is removed from the shaft. A special puller is required to remove the fly wheel and special measuring blocks are needed to replace the fly wheel in its proper position.

SFM CARBURETORS

This unit is also the same as the "SF" series with the addition of a pick up tube, or **Automatic Drain System.** Gasoline which accumulates in the bottom of the carburetor during starting and while the engine is cold, is carried away by suction and discharged above the throttle through a separate jet. In addition to disposing of the condensed fuel, which is the primary object, this arrangement also provides a slightly rich mixture for starting and during the warming up period. This requires no service, except to check the channel for cleanliness.



Stromberg SFM carburetor. Schematic view.

1—Float chamber vent. 2—Double venturi. 3—Accelerating pump adjustment. 4—Low speed and idle adjustment. 5—Accelerating pump. 6—Main metering jet. 7—Economizer. 8—Automatic drain system.

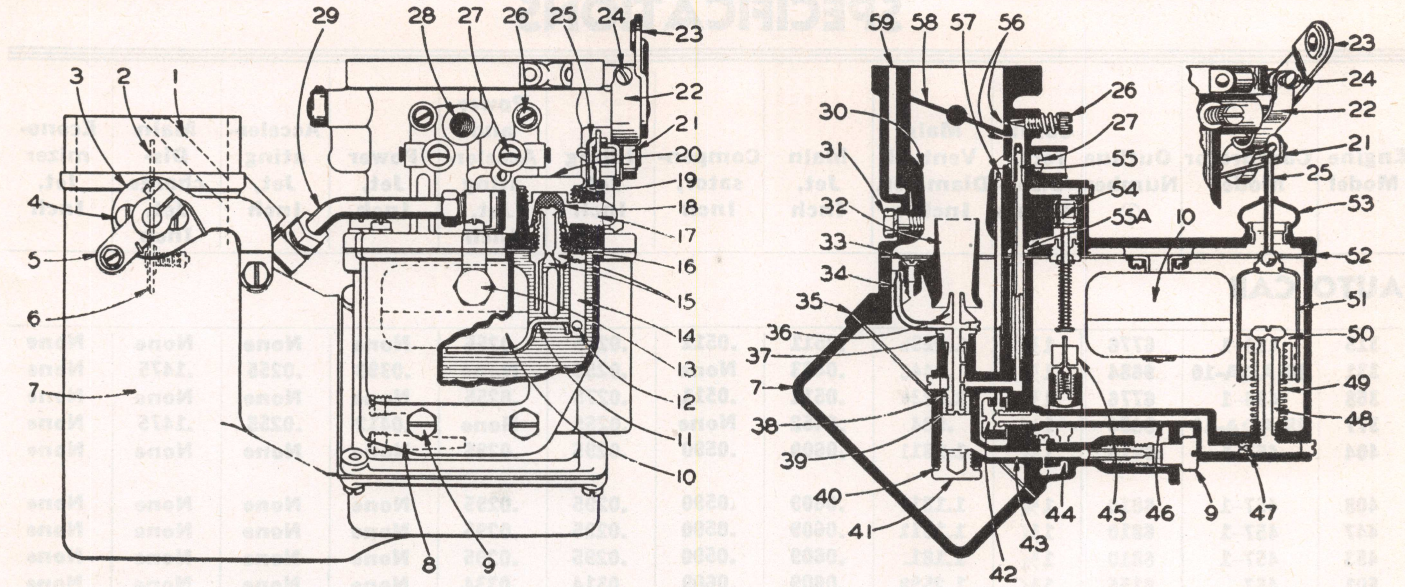
UUR-2

This is a double barrel, updraft type, with a mechanical or throttle-operated accelerating pump and a vacuum-operated power piston. Fuel enters the gasoline inlet, flows past a strainer and fuel needle valve seat into the float chamber, or fuel bowl. A float mechanism automatically maintains a constant fuel level. There is only one float and one fuel bowl. From the fuel bowl, the fuel flows through two main metering orifices to two main discharge jets and to two idle tubes. Depending on how far the throttle valves are open, the fuel will flow either out of the main discharge jets, or through the idle tubes and out of the idle discharge holes.

The upper idle discharge holes deliver fuel for speeds between 5 and 10 miles per hour. For speeds between 10 and 20 miles per hour, fuel is delivered through both the upper and lower discharge holes. At speeds above 20 miles per hour, both idle holes and main discharge jets deliver fuel. As the speed increases, a point is reached where all the fuel is delivered through the main discharge jets. The idle air bleed acts in the smooth transfer of the fuel discharge from the idle range to the intermediate range. Correct mixture is maintained at all speeds and loads by the high speed air bleeders. Air is drawn into the center passage of the main discharge jet, through a series of small holes, located below the fuel level, which are fed by the air bleeders.

Power System: At intermediate speeds the manifold vacuum is high and holds the vacuum piston up, keeping the valve in the power by-pass jet closed. At high speeds, or under load, when maximum engine power is required, manifold vacuum will drop. This allows the vacuum piston spring to push down the piston rod, to contact the valve of the power jet and hold it open. Additional fuel then flows through the power by-pass jet and into the main discharge jets. Power jet should come into operation at 6 inches of manifold vacuum.

Accelerating System: When the accelerator is depressed and released, fuel is drawn into the accelerating pump chamber, through the clearance between the pump sleeve and the pump piston. When accelerating, the cam attached to the throttle shaft pushes down the pump arm. This forces down the pump sleeve. The fuel in the pump chamber pushes down the pump piston, uncovering holes in the pump syringe valve. The fuel is forced through the valve and through a pump discharge



Stromberg UUR-2 carburetor.

1—Float chamber vent tube. 2—Choke valve. 3—Choke tube holder. 4—Choke tube holder attach. screw. 5—Choke lever. 6—Choke poppet valve. 7—Air horn. 8—Pump channel plug. 9—Metering jets. 10—Float. 11—Float lever. 12—Float fulcrum pin. 13—Fuel level sight plug. 14—Float hanger. 15—Float needle valve and seat. 16—Float needle valve and seat gasket. 17—Gas inlet. 18—Gas strainer. 19—Gas strainer plug gasket. 20—Gas strainer plug. 21—Pump lever and roller. 22—Pump lever cam. 23—Throttle lever. 24—Throttle stop screw. 25—Pump link. 26—Idle needle valve. 27—Idle air bleeder. 28—Vacuum spark connection. 29—Balance tube. 30—Primary venturi. 31—Venturi set screw. 32—Auxiliary venturi. 33—Auxiliary venturi attach. screw. 34—High speed bleeder. 35—Air horn gasket. 36—Main disch. jet. 37—Main disch. jet gasket. 38—Main disch. jet nut gasket. 39—Main disch. jet nut. 40—Main disch. jet plug gasket. 41—Main disch. jet plug. 42—Pump disch. nozzle attach. screw. 43—Main metering channel. 44—Power by-pass jet channel. 45—Power by-pass jet. 46—Pump disch. channel. 47—Pump disch. reducer. 48—Pump syringe valve. 49—Pump spring. 50—Pump piston. 51—Pump piston sleeve. 52—Main body gasket. 53—Pump link seal. 54—Vacuum power piston. 55—Idle tube. 55A—Idle tube cork gasket. 56—Idle disch. holes. 57—Pump disch. tube. 58—Throttle valve. 59—Vacuum power channel.

reducer jet, and then carried to the pump discharge tubes and out into the manifold.

SERVICE AND ADJUSTMENTS

Fuel level should be ¾ of an inch below the top surface of the float chamber with the gasket removed. Readjustments may be made by bending the float lever arm in the corner where it touches the float needle and where it meets the float body. To set the float, hold the throttle body in an inverted position. Set so that a 15/64" rod can be just passed between the center of the float and the gasket surface of the throttle body.

Pump Adjustment: There is no seasonal adjustment. Pump travel should be 21/32 of an inch. The pump capacity is 13 to 17 C.C. per 10 strokes, fast or slow. Check the pump reducer jet for dirt upon failure of pump operation.

Idle Adjustment: The idle needle valves, or idle adjusting screws, are fuel adjustments. Turning the needle **in**, admits less fuel, therefore a leaner mixture. Turning the needle **out**, admits more fuel, therefore a richer mixture. A satisfactory idle setting should be acquired with each needle valve one to one and a quarter turns off its seat. Set to idle 7 to 8 miles per hour.

SPECIFICATIONS

Engine Model	Carburetor Model	Outline Number ①	Carburetor Size, Inches ②	Main Venturi Diameter, Inches	Main Jet, Inch	Compensator, Inch	Idling Jet, Inch	Power and Accelerating Jet, Inch	Power Jet, Inch	Accelerating Jet, Inch	Main Discharge Jet, Inch	Economizer Jet, Inch
AUTO CAR												
315	456-1	6776	1½	1.0236	.0511	.0511	.0275	.0255	None	None	None	None
331	28-ADA-10	9684	1¼	.9448	.0433	None	.0255	None	.0393	.0255	.1475	None
358	456-1	6776	1½	1.0236	.0511	.0511	.0275	.0255	None	None	None	None
377	28-ADA-10	9654	1¼	.9842	.0452	None	.0255	None	.0412	.0255	.1475	None
404	457-1	6810	1¾	1.1811	.0609	.0590	.0295	.0295	None	None	None	None
408	457-1	6810	1¾	1.1811	.0609	.0590	.0295	.0295	None	None	None	None
447	457-1	6810	1¾	1.1811	.0609	.0590	.0295	.0295	None	None	None	None
453	457-1	6810	1¾	1.1811	.0609	.0590	.0295	.0295	None	None	None	None
501	457	8155	1¾	1.2598	.0609	.0609	.0314	.0334	None	None	None	None
BUDA												
BTU	96-AG	5607	1½	1.0236	.0511	.0472	.0236	None	None	None	None	None
BTU	156	5720	1½	1.0629	.0511	.0511	.0275	.0275	None	None	None	None
BTU	156	5720	1½	1.0236	.0511	.0491	.0255	.0255	None	None	None	None
BTU	156	6357	1½	1.0236	.0551	.0491	.0255	.0275	None	None	None	None
BTU	456-2	7862	1½	1.0629	.0511	.0511	.0275	.0275	None	None	None	None
ET-350	155	5699	1¼	.9055	.0433	.0412	.0255	.0255	None	None	None	None
ET-350	156	5720	1½	1.0236	.0491	.0452	.0255	.0275	None	None	None	None
FR	156	6419	1½	1.0236	.0511	.0472	.0255	.0314	None	None	None	None
FR	96-AG	6760	1½	1.0236	.0491	.0511	.0236	None	None	None	None	None
FR	456-2	7860	1½	1.0236	.0511	.0472	.0255	.0314	None	None	None	None
GF-6	96½-XG	5915	1¾	1.2598	.0669	.0570	.0275	None	None	None	None	None
GF-6	157	5983	1¾	1.2598	.0648	.0609	.0295	.0275	None	None	None	None
GF-6	157	6165	1¾	1.2598	.0629	.0570	.0295	.0314	None	None	None	None
GF-6	457-2	6841	1¾	1.2598	.0648	.0609	.0295	.0275	None	None	None	None
GF-6	157-1	6852	1¾	1.2598	.0648	.0609	.0295	.0275	None	None	None	None
GF-6	457-1	7789	1¾	1.2598	.0648	.0609	.0295	.0275	None	None	None	None
GF-6	458	7883	2	1.4566	.0748	.0727	.0314	.0354	None	None	None	None
GF-6	457-1	8357	1¾	1.2598	.0648	.0609	.0295	.0275	None	None	None	None
GF-638	458	6521-A	2	1.3779	.0727	.0688	.0314	.0354	None	None	None	None
GL-6	157	5914	1¾	1.2598	.0648	.0609	.0295	.0275	None	None	None	None
GL-6	457-1	8290	1¾	1.2598	.0648	.0609	.0295	.0275	None	None	None	None
H-205	94-OG	5495	1	.8464	.0412	.0412	.0196	None	None	None	None	None
H-205	154	7280	1	.8661	.0393	.0412	.0236	.0236	None	None	None	None
H-205	454	7989	1	.8661	.0393	.0412	.0236	.0236	None	None	None	None
H-205	455-2	8231	1¼	.8661	.0393	.0433	.0275	.0215	None	None	None	None
H-217	94-OG	5495	1	.8464	.0433	.0412	.0196	None	None	None	None	None
H-217	155	5699	1¼	1.0236	.0491	.0472	.0236	.0255	None	None	None	None
H-217	154	5762	1	.9842	.0472	.0452	.0236	.0236	None	None	None	None
H-217	455-2	7779	1¼	1.0236	.0491	.0472	.0236	.0255	None	None	None	None
H-217	455-2	7780	1¼	1.0236	.0491	.0472	.0236	.0255	None	None	None	None
H-217	124½-TOX	8135	1¼	.8661	.0412	.0433	.0236	None	None	None	None	None
H-217	455-2	8762	1¼	1.0236	.0491	.0472	.0236	.0255	None	None	None	None

① Outline number stamped on small metal disc, usually on the fuel bowl cover. ② See drawings for other flange dimensions.

Continued on next page

SPECIFICATIONS

Engine Model	Carburetor Model	Outline Number ①	Carburetor Size, Inches ②	Main Venturi Diameter, Inches	Main Jet, Inch	Compensator, Inch	Idling Jet, Inch	Power and Accelerating Jet, Inch	Power Jet, Inch	Accelerating Jet, Inch	Main Discharge Jet, Inch	Economizer Jet, Inch
BUDA *(Continued)*												
H-217	455-2RL	8901	1¼	1.0236	.0491	.0472	.0236	.0255	None	None	None	None
H-260	156	5935X1	1½	1.0236	.0511	.0530	.0255	.0314	None	None	None	None
H-260	156	5953	1½	1.0236	.0511	.0530	.0255	.0314	None	None	None	None
H-260	155	7277	1¼	1.0236	.0511	.0530	.0255	.0314	None	None	None	None
H-260	456-2	7921	1½	1.0236	.0511	.0530	.0255	.0314	None	None	None	None
H-260	456-2	8004	1½	1.0236	.0511	.0530	.0255	.0314	None	None	None	None
H-298	96-AG	5607	1½	.9842	.0511	.0472	.0255	None	None	None	None	None
H-298	155	5699	1¼	1.0236	.0530	.0472	.0275	.0255	None	None	None	None
H-298	156	5950	1½	1.1023	.0570	.0491	.0275	.0275	None	None	None	None
H-298	156	5951	1½	1.1023	.0570	.0491	.0275	.0275	None	None	None	None
H-298	156	6452	1½	1.1023	.0570	.0491	.0275	.0275	None	None	None	None
H-298	155	6844	1¼	.8661	.0412	.0491	.0275	.0215	None	None	None	None
H-298	IN-186Ex1	6889	1¾	1.1811	.0551	.0412	.0295	None	.0295	.0196	None	None
H-298	156-2	6962	1½	1.1023	.0530	.0530	.0275	.0275	None	None	None	None
H-298	456-2	7701	1½	1.1023	.0570	.0472	.0275	.0275	None	None	None	None
H-298	455-2	7990	1¼	.8661	.0412	.0491	.0275	.0215	None	None	None	None
H-298	456-2	8015	1½	1.1023	.0570	.0491	.0275	.0275	None	None	None	None
H-298	456-2	8055	1½	1.1023	.0530	.0472	.0255	.0334	None	None	None	None
H-298	23-AV-12	8337	1½	1.0629	.0393	.0393	.0275	None	.0275	.0255	None	None
H-326	156	7625	1½	1.0236	.0551	.0491	.0255	.0275	None	None	None	None
H-326	456-2	7884	1½	.9448	.0452	.0452	.0255	.0275	None	None	None	None
H-326	456-2	7922	1½	1.0236	.0551	.0491	.0255	.0275	None	None	None	None
H-326	456-2	7988	1½	1.0236	.0551	.0491	.0255	.0275	None	None	None	None
HP-217	124½-TOP	9409	1	.7480	.0334	.0354	.0236	None	None	None	None	None
HP-260	454	9415	1	.8661	.0373	.0373	.0236	.0196	None	None	None	None
HP-298	23-AV-12	8337	1½	1.0629	.0393	.0393	.0275	None	.0275	.0255	None	None
HP-298	454	9417	1	.8661	.0491	.0491	.0236	.0236	None	None	None	None
HP-298	454	9418	1	.8661	.0491	.0491	.0236	.0236	None	None	None	None
HP-326	454	9416	1	.9055	.0393	.0393	.0236	.0196	None	None	None	None
J-214	155	5737	1¼	.9448	.0452	.0452	.0275	.0255	None	None	None	None
J-214	155	6450	1¼	.9448	.0452	.0452	.0275	.0255	None	None	None	None
J-214	155	6843	1¼	.9448	.0452	.0452	.0275	.0255	None	None	None	None
J-214	155-1	7004	1¼	.9448	.0433	.0452	.0275	.0255	None	None	None	None
J-214	455-2	7991	1¼	.9448	.0452	.0452	.0275	.0255	None	None	None	None
J-214	455-1	8023	1¼	.9448	.0433	.0452	.0275	.0255	None	None	None	None
K-325	155	5699	1¼	1.0236	.0530	.0472	.0255	.0275	None	None	None	None
K-325	156	5720	1½	1.2598	.0648	.0511	.0295	.0314	None	None	None	None
K-325	157	5764	1¾	1.2992	.0688	.0511	.0295	.0295	None	None	None	None
K-325	455-2	7751	1¼	1.0236	.0530	.0472	.0255	.0275	None	None	None	None
K-325	IN-167	8378	1¾	1.4173	.0530	.0551	.0255	.0393	None	None	None	None
K-369	157	5764	1¾	1.2204	.0629	.0590	.0295	.0275	None	None	None	None
K-369	157	6605	1¾	1.2204	.0629	.0590	.0295	.0275	None	None	None	None
K-369	155	6706	1¼	1.1023	.0570	.0511	.0255	.0275	None	None	None	None

① Outline number stamped on small metal disc, usually on the fuel bowl cover. ② See drawings for other flange dimensions.

Continued on next page

SPECIFICATIONS

Engine Model	Carburetor Model	Outline Number ①	Carburetor Size, Inches ②	Main Venturi Diameter, Inches	Main Jet, Inch	Compensator, Inch	Idling Jet, Inch	Power and Accelerating Jet, Inch	Power Jet, Inch	Accelerating Jet, Inch	Main Discharge Jet, Inch	Economizer Jet, Inch
BUDA *(Continued)*												
K-369	155	6707	1¼	1.1023	.0570	.0511	.0255	.0275	None	None	None	None
K-369	IN-186EXx2	6882	1¾	1.1811	.0551	.0412	.0295	None	.0295	.0196	None	None
K-369	157	7370	1¾	1.2204	.0629	.0590	.0295	.0275	None	None	None	None
K-369	457-2	7887	1¾	1.2204	.0629	.0590	.0295	.0275	None	None	None	None
K-369	457-2	8022	1¾	1.2204	.0629	.0590	.0295	.0275	None	None	None	None
K-369	455-2	8330	1¼	1.1023	.0570	.0511	.0255	.0275	None	None	None	None
K-369	23-AVX-12	8460	1¾	1.1811	.0393	.0472	.0275	None	.0314	.0255	None	None
K-393	157	6448	1¾	1.3385	.0688	.0590	.0295	.0314	None	None	None	None
K-393	157	6449	1¾	1.3385	.0688	.0590	.0295	.0314	None	None	None	None
K-393	156-1	6850	1½	1.2204	.0629	.0570	.0275	.0275	None	None	None	None
K-393	IN-167	7351	1¾	1.4173	.0590	.0590	.0255	.0334	None	None	None	None
K-393	457-2	7929	1¾	1.3385	.0688	.0590	.0295	.0314	None	None	None	None
K-393	457-2	7930	1¾	1.3385	.0688	.0590	.0295	.0314	None	None	None	None
K-428	156	5720	1½	1.1023	.0570	.0511	.0275	.0275	None	None	None	None
K-428	157	5764	1¾	1.2992	.0669	.0629	.0295	.0275	None	None	None	None
K-428	157	5764	1¾	1.2992	.0688	.0629	.0314	.0314	None	None	None	None
K-428	96½-XG	5992	1¾	1.2204	.0669	.0570	.0314	None	None	None	None	None
K-428	157	6627	1¾	1.1023	.0551	.0629	.0314	.0314	None	None	None	None
K-428	IN-186EXx2	6883	1¾	1.2992	.0609	.0491	.0314	None	.0314	.0236	None	None
K-428	IN-167	7351	1¾	1.3779	.0590	.0511	.0255	.0334	None	None	None	None
K-428	457-2	7833	1¾	1.2992	.0688	.0511	.0314	.0314	None	None	None	None
K-428	457-2	8085	1¾	1.2992	.0688	.0511	0314	.0314	None	None	None	None
K-428	23-AVX-12	8460	1¾	1.1811	.0393	.0472	.0275	None	.0314	.0255	None	None
K-428	456-2	8815	1½	1.0236	.0472	.0491	.0255	.0236	None	None	None	None
KTU	155	5699	1¼	.9055	.0452	.0452	.0275	.0255	None	None	None	None
L-468	157	5764	1¾	1.3385	.0688	.0590	.0295	.0314	None	None	None	None
L-468	457-2	7886	1¾	1.3385	.0688	.0590	.0295	.0314	None	None	None	None
L-525	157	5764	1¾	1.4173	.0826	.0669	.0314	.0334	None	None	None	None
L-525	156	5950	1½	1.1023	.0570	.0491	.0275	.0275	None	None	None	None
L-525	157	6555	1¾	1.4173	.0826	.0669	.0314	.0334	None	None	None	None
L-525	IN-186EXx2	6883	1¾	1.2992	.0609	.0491	.0314	None	.0314	.0236	None	None
L-525	IN-186EXx2	6883A	1¾	1.2992	.0609	.0491	.0314	None	.0314	.0236	None	None
L-525	457-2	7743	1¾	1.4173	.0826	.0669	.0314	.0334	None	None	None	None
L-525	457-2	7861	1¾	1.4173	.0826	.0669	.0314	.0334	None	None	None	None
L-525	457-2	7875	1¾	1.4173	.0826	.0669	.0314	.0334	None	None	None	None
L-525	157	7907	1¾	1.1811	.0609	.0590	.0314	.0295	None	None	None	None
L-525	457-2	8066	1¾	1.1811	.0609	.0590	.0314	.0295	None	None	None	None
LO-525	IN-167	7351	1¾	1.4173	.0629	.0530	.0295	.0433	None	None	None	None
LO-525	IN-167	7933	1¾	1.4960	.0629	.0530	.0255	.0433	None	None	None	None
M-766	457-2	8233	1¾	1.2598	.0648	.0629	.0295	.0314	None	None	None	None
YR-425	156	6631	1½	1.0629	.0570	.0511	.0275	.0275	None	None	None	None
YR-425	156	6631X1	1½	1.0629	.0570	.0511	.0275	.0275	None	None	None	None
YR-425	96-AG	6760	1½	1.0236	.0511	.0472	.0236	None	None	None	None	None
YT-381	155	6386	1¼	.8661	.0452	.0452	.0275	.0236	None	None	None	None
YT-381	455-2	7882	1¼	.8661	.0452	.0452	.0275	.0236	None	None	None	None

SPECIFICATIONS

CONTINENTAL

NOTE: Engine numbers followed by "B" are special Brockway models.

Engine Model	Carburetor Model	Outline Number ①	Carburetor Size, Inches ②	Main Venturi Diameter, Inches	Main Jet, Inch	Compensator, Inch	Idling Jet, Inch	Power and Accelerating Jet, Inch	Power Jet, Inch	Accelerating Jet, Inch	Main Discharge Jet, Inch	Economizer Jet, Inch
15-H	157	6270	1¾	1.2204	.0648	.0629	.0275	.0275	None	None	None	None
15-H	157	6671	1¾	1.2204	.0648	.0629	.0275	.0275	None	None	None	None
16-C	155	6243	1¼	.9055	.0452	.0491	.0295	.0255	None	None	None	None
16-C	155-B	6367	1¼	.9055	.0452	.0452	.0255	.0255	None	None	None	None
16-C	455-2	6836	1¼	.9448	.0472	.0433	.0255	.0236	None	None	None	None
16-C	455-2	7680	1¼	.9055	.0452	.0452	.0295	.0255	None	None	None	None
16-H	158	5896	2	1.4173	.0748	.0688	.0354	.0314	None	None	None	None
16-H	158	6248	2	1.4173	.0748	.0688	.0354	.0314	None	None	None	None
20-C	155	5883	1¼	.9055	.0491	.0452	.0295	.0255	None	None	None	None
20-C	324½-X	7111	1¼	.8661	.0412	.0393	.0236	.0314	None	None	None	None
20-R	157	5764	1¾	1.1023	.0590	.0530	.0275	.0255	None	None	None	None
20-R	156	5866	1½	1.1417	.0590	.0530	.0275	.0255	None	None	None	None
20-R	457-S	6816	1¾	1.1811	.0491	.0609	.0314	.0452	None	None	None	None
20-R	52-A-14	7534	1¾	1.1417	.0590	.0570	.0314	.0275	None	None	None	None
21-R	156	5720	1½	1.1417	.0590	.0570	.0275	.0255	None	None	None	None
21-R	156	5861	1½	1.1417	.0590	.0570	.0275	.0255	None	None	None	None
21-R	457-S	6816	1¾	1.2598	.0511	.0609	.0314	.0452	None	None	None	None
21-R	457-2	6841	1¾	1.1811	.0530	.0590	.0314	.0354	None	None	None	None
21-R	457-S	6914	1¾	1.2598	.0511	.0609	.0314	.0452	None	None	None	None
21-R	52-A-14	7524	1¾	1.1811	.0590	.0551	.0314	.0275	None	None	None	None
22-R	158	5896	2	1.2992	.0648	.0648	.0314	.0314	None	None	None	None
22-R	158	6310	2	1.2992	.0669	.0688	.0314	.0314	None	None	None	None
22-R	458	6521	2	1.2992	.0669	.0669	.0314	.0354	None	None	None	None
22-R	158	6688	2	1.2992	.0669	.0669	.0314	.0314	None	None	None	None
22-R	457-S	6816	1¾	1.3779	.0609	.0648	.0314	.0412	None	None	None	None
22-R	52-A-14	7514	1¾	1.2204	.0590	.0590	.0314	.0275	None	None	None	None
22-R	458	8137	2	1.2992	.0669	.0669	.0314	.0314	None	None	None	None
22-R	457-S	8822	1¾	1.2992	.0609	.0629	.0314	.0491	None	None	None	None
24-B	755½	7251	1¼	1.0236	.0433	.0472	.0295	.0354	None	None	None	None
25-A	155	5838	1¼	.9842	.0472	.0433	.0255	.0255	None	None	None	None
25-A	155	6143	1¼	.9842	.0491	.0452	.0255	.0255	None	None	None	None
25-A	324½-X	7110	1¼	.8661	.0412	.0412	.0236	.0314	None	None	None	None
25-A	455-2	7829	1¼	.9842	.0491	.0452	.0255	.0255	None	None	None	None
25-B	456-2	7470	1½	1.0236	.0491	.0491	.0255	.0255	None	None	None	None
25-B	456-2	9570	1½	1.0236	.0393	.0452	.0255	.0393	None	None	None	None
28-B	456-2	6931	1½	.9842	.0491	.0491	.0255	.0255	None	None	None	None
29-B	456-2	7283	1½	1.0236	.0491	.0491	.0255	.0255	None	None	None	None
31-B	456-2	8468	1½	1.0629	.0491	.0472	.0255	.0275	None	None	None	None
32-B	456-2	7285	1½	1.1417	.0491	.0551	.0255	.0412	None	None	None	None
32-B	456-2	7337	1½	1.1417	.0491	.0551	.0255	.0412	None	None	None	None
33-B	457-S	6855	1¾	1.1811	.0491	.0609	.0314	.0452	None	None	None	None
34-B	457-S	6856	1¾	1.2598	.0511	.0609	.0314	.0452	None	None	None	None
35-B	457-S	7214	1¾	1.3779	.0629	.0648	.0295	.0412	None	None	None	None
38-B	456-2	8618	1½	1.1023	.0433	.0511	.0236	.0393	None	None	None	None

① Outline number stamped on small metal disc, usually on the fuel bowl cover. ② See drawings for other flange dimensions.

Continued on next page

SPECIFICATIONS

CONTINENTAL *(Continued)*

Engine Model	Carburetor Model	Outline Number ①	Carburetor Size, Inches ②	Main Venturi Diameter, Inches	Main Jet, Inch	Compensator, Inch	Idling Jet, Inch	Power and Accelerating Jet, Inch	Power Jet, Inch	Accelerating Jet, Inch	Main Discharge Jet, Inch	Economizer Jet, Inch
39-B	456-2	8831	1½	1.0236	.0393	.0491	.0236	.0373	None	None	None	None
40-B	456-2	9160	1½	1.1811	.0472	.0551	.0275	.0433	None	None	None	None
41-B	457	9675	1¾	1.1811	.0491	.0551	.0295	.0373	None	None	None	None
41-B	457	9686	1¾	1.1811	.0491	.0551	.0295	.0373	None	None	None	None
42-B	457-S	9606	1¾	1.2992	.0491	.0551	.0295	.0472	None	None	None	None
42-B	457-S	9687	1¾	1.2992	.0511	.0609	.0295	.0275	None	None	None	None
A-6244	456-2	8413	1½	1.0236	.0491	.0491	.0255	.0255	None	None	None	None
C-400	193½-P	6910	⅞	.7086	.0314	.0354	.0314	None	None	None	None	None
C-400	193½-P	7863	⅞	.7086	.0314	.0354	.0314	None	None	None	None	None
C-400	193½-P	8113	⅞	.7086	.0314	.0354	.0236	None	None	None	None	None
DS-6202	124½-EX	7607	1¼	.8267	.0412	.0433	.0236	.0354	None	None	None	None
E-600	156	6201	1½	1.0236	.0530	.0491	.0255	.0255	None	None	None	None
E-602	156	6203	1½	1.1417	.0590	.0511	.0255	.0255	None	None	None	None
E-602	456-2	7682	1½	1.1417	.0590	.0511	.0255	.0255	None	None	None	None
E-602	23-BV-12	8279	1½	1.2598	.0433	.0491	.0275	None	.0334	.0255	None	None
E-602	23-AV-12	8768	1½	1.2598	.0373	.0452	.0275	None	.0334	.0255	None	None
E-603	156	6358	1½	1.1023	.0551	.0530	.0295	.0255	None	None	None	None
E-603	457-1	6519	1¾	1.1417	.0491	.0472	.0295	.0393	None	None	None	None
E-603	IN-186EXx2	6925	1¾	1.4173	.0708	.0551	.0295	None	.0551	.0334	None	None
E-603	457	7683	1¾	1.2598	.0629	.0708	.0295	.0295	None	None	None	None
E-603	23-AV-12	8768	1½	1.2598	.0373	.0452	.0275	None	.0334	.0255	None	None
F-4140	20-AX-9	8346	1¼	.9448	.0334	.0393	.0236	None	None	③	None	None
F-4140	124½-TXOP	8525	1¼	.7480	.0334	.0354	.0236	None	None	None	None	None
F-4140	124½-TOX	8529	1¼	.7480	.0334	.0354	.0236	None	None	None	None	None
F-4140	124½-TXOP	8616	1¼	.7480	.0334	.0354	.0236	None	None	None	None	None
F-4140	28-BVX-9	8774	1¼	.9055	.0412	None	.0255	None	.0236	③	.1081	None
F-4140	28-BVX-9	9007	1¼	.9055	.0412	None	.0255	None	.0236	③	.1081	None
F-4140	161-XX7	9676	1	.7086	.0412	None	.0215	None	None	None	.0984	None
F-4162	124½-TOX	8265	1¼	.7874	.0373	.0373	.0255	None	None	None	None	None
F-4162	124½-TXOP	8546	1¼	.7874	.0373	.0373	.0255	None	None	None	None	None
F-4162	28-AX-9	8615	1¼	.9448	.0433	None	.0236	None	.0236	③	.1278	None
F-4162	28-AX-9	9001	1¼	.9448	.0433	None	.0236	None	.0236	③	.1278	None
F-4162	161-XX7	9628	1	.7480	.0433	None	.0236	None	None	None	.1081	None
F-6170	23-AVX-9	7669	1¼	.9448	.0275	.0373	.0236	None	.0295	.0255	None	None
F-6209	IN-185EFx1	7269	1¼	1.1023	.0511	.0412	.0295	None	.0275	.0196	None	None
F-6209	324½-XO	8304	1¼	.8267	.0354	.0334	.0255	.0275	None	None	None	None
F-6209	20-BV-10	8508	1¼	1.0629	.0354	.0472	.0255	None	.0491	.0255	None	None
F-6209	28-BVX-9RL	9282	1¼	.9448	.0452	None	.0255	None	.0215	None	.1181	None
F-6209	28-BVX-9R	9441	1¼	.9448	.0393	None	.0295	None	.0255	None	.0984	None
F-6218	20-BV-11	8105	1¼	1.0236	.0354	.0393	.0255	None	.0452	.0275	None	None
F-6218	20-BV-11	8106	1¼	1.0236	.0334	.0373	.0255	None	.0452	.0275	None	None
F-6218	23-AV-10	8554	1¼	1.0629	.0334	.0452	.0255	None	.0275	.0275	None	None
M-6253	456-2	6838	1½	1.0236	.0393	.0491	.0236	.0373	None	None	None	None
M-6290	456-2	8413	1½	1.1023	.0433	.0511	.0236	.0393	None	None	None	None
M-6330	456-2	8413	1½	1.1417	.0511	.0590	.0236	.0354	None	None	None	None

③ Jet is installed but may be either plugged or not drilled.

SPECIFICATIONS

Engine Model	Carburetor Model	Outline Number ①	Carburetor Size, Inches ②	Main Venturi Diameter, Inches	Main Jet, Inch	Compensator, Inch	Idling Jet, Inch	Power and Accelerating Jet, Inch	Power Jet, Inch	Accelerating Jet, Inch	Main Discharge Jet, Inch	Economizer Jet, Inch
DODGE												
T-43	456-1	8182	1½	1.1417	.0530	.0530	.0255	.0275	None	None	None	None
T-80	456-1	8182	1½	1.1417	.0530	.0530	.0255	.0275	None	None	None	None
T-104	456-1	8182	1½	1.1417	.0530	.0530	.0255	.0275	None	None	None	None
Z	156-BX	6096	1¾	1.1417	.0511	.0530	.0255	.0275	None	None	None	None
GMC												
213	20-BV-11	7492	1¼	.9448	.0314	.0373	.0236	None	.0314	.0255	None	None
213	20-BV-11	7612	1¼	.9448	.0314	.0373	.0236	None	.0314	.0255	None	None
223	20-BV-10	8451	1¼	1.1417	.0393	.0412	.0236	None	.0373	.0215	None	None
223	28-BV-10	8518	1¼	1.1023	.0472	None	.0255	None	.0314	.0255	.1278	None
223	28-BV-10	9018	1¼	1.1023	.0511	None	.0255	None	.0314	.0255	.1278	None
228	80-BV-10	8658	1¼	1.0629	.0393	.0433	.0275	None	.0551	.0255	None	None
228	755½	8825	1¼	.9842	.0373	.0452	.0236	.0354	None	None	None	None
228	755½	8940	1¼	.9842	.0373	.0452	.0236	.0354	None	None	None	None
228	28-AV-11	9043	1¼	1.0629	.0472	None	.0236	None	.0295	.0236	.1377	None
228	28-AV-11RL	9074	1¼	1.0625	.0472	None	.0255	None	.0295	.0236	.1377	None
228	28-AV-11DL	9428	1¼	1.1417	.0551	None	.0255	None	.0314	.0236	.1377	None
228	755½	9490	1¼	.9842	.0373	.0452	.0236	.0354	None	None	None	None
228	28-AVX-9	9565	1¼	.9842	.0433	None	.0236	None	.0236	.0236	.1181	None
228	63-AW-10	9682	1¼	.9448	.0354	None	.0275	None	.0255	.0314	.1278	None
228	63-AW-11	9696	1¼	1.0629	.0433	None	.0295	None	.0236	.0412	.1377	None
228	63-AW-11R	9857	1¼	1.0629	.0433	None	.0295	None	.0275	.0412	.1377	None
230	20-BV-11	7492	1¼	.9448	.0314	.0373	.0236	None	.0314	.0255	None	None
230	20-BV-11	7612	1¼	.9448	.0314	.0373	.0236	None	.0314	.0255	None	None
230	80-BV-10	8108	1¼	1.0629	.0393	.0433	.0275	None	.0551	.0255	None	None
230	80-BV-10	8179	1¼	1.0629	.0393	.0433	.0275	None	.0551	.0255	None	None
230	20-BV-11	8191	1¼	1.1023	.0393	.0433	.0236	None	.0433	.0255	None	None
230	20-BV-10	8451	1¼	1.1417	.0393	.0412	.0236	None	.0373	.0215	None	None
230	80-BV-10	8496	1¼	1.0629	.0393	.0433	.0275	None	.0551	.0255	None	None
230	28-BV-10	8519	1¼	.9448	.0393	None	.0236	None	.0255	.0236	.1181	None
230	28-BV-10	8539	1¼	.9448	.0393	None	.0236	None	.0255	.0236	.1181	None
230	80-BV-10	8658	1¼	1.0629	.0393	.0433	.0275	None	.0551	.0255	None	None
230	20-BV-11	8704	1¼	1.1023	.0393	.0433	.0236	None	.0433	.0255	None	None
230	28-BV-10	9018	1¼	1.1023	.0511	None	.0255	None	.0314	.0255	.1278	None
230	28-BV-10	9019	1¼	.9448	.0412	None	.0236	None	.0255	.0236	.1181	None
230	28-BV-10	9020	1¼	.9448	.0412	None	.0236	None	.0255	.0236	.1181	None
236	28-AV-11	9829	1¼	1.1023	.0530	None	.0275	None	.0236	.0334	None	None
239	20-AV-11	7494	1¼	1.0629	.0354	.0472	.0275	None	.0491	.0255	None	None
239	28-AV-11	8534	1¼	1.0629	.0511	None	.0275	None	.0215	.0255	.1377	None
239	20-AV-11	8594	1¼	1.0629	.0354	.0433	.0275	None	.0472	.0255	None	None
239	28-AV-11	9031	1¼	1.0629	.0511	None	.0275	None	.0215	.0255	.1377	None
248	755½	8826	1¼	1.0629	.0412	.0511	.0236	.0354	None	None	None	None
248	755½	8941	1¼	1.0629	.0412	.0511	.0236	.0354	None	None	None	None
248	28-AV-11	9044	1¼	1.1417	.0570	None	.0255	None	.0314	.0236	.1377	None
248	28-AV-11	9048	1¼	1.1417	.0570	None	.0255	None	.0314	.0236	.1377	None

① Outline number stamped on small metal disc, usually on the fuel bowl cover. ② See drawings for other flange dimensions.

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SPECIFICATIONS

Engine Model	Carburetor Model	Outline Number ①	Carburetor Size, Inches ②	Main Venturi Diameter, Inches	Main Jet, Inch	Compensator, Inch	Idling Jet, Inch	Power and Accelerating Jet, Inch	Power Jet, Inch	Accelerating Jet, Inch	Main Discharge Jet, Inch	Economizer Jet, Inch
GMC *(Continued)*												
248	28-AV-11RL	9149	1¼	1.1417	.0570	None	.0255	None	.0314	.0236	.1377	None
248	28-AV-11DL	9428	1¼	1.1417	.0551	None	.0255	None	.0314	.0236	.1377	None
248	28-AV-11DL	9429	1¼	1.1417	.0530	None	.0255	None	.0255	.0255	.1475	None
248	28-AV-11	9445	1¼	1.0236	.0590	None	.0295	None	.0393	.0236	.1377	None
248	63-AW-11	9689	1¼	1.1023	.0511	None	.0295	None	.0215	.0452	.1377	None
248	63-AW-11	9794	1¼	1.1023	.0511	None	.0295	None	.0215	.0452	.1377	None
256	28-AV-11	9689	1¼	1.1023	.0511	None	.0295	None	.0215	.0452	.1377	None
256	63-AW-11	9794	1¼	1.1023	.0511	None	.0295	None	.0215	.0452	.1377	None
257	20-AV-11	7486	1¼	1.1023	.0393	.0433	.0275	None	.0452	.0255	None	None
257	28-AV-11	8533	1¼	1.1023	.0530	None	.0275	None	.0275	.0255	.1377	None
257	28-AV-11	9030	1¼	1.1023	.0530	None	.0275	None	.0275	.0255	.1377	None
270	28-AV-11	9778	1¼	1.1417	.0551	None	.0275	None	.0314	.0236	.1377	None
270	63-AW-11	9794	1¼	1.1023	.0511	None	.0295	None	.0215	.0452	.1377	None
278	28-AV-11	9040	1¼	1.1417	.0530	None	.0275	None	.0255	.0255	.1475	None
278	28-AV-11	9050	1¼	1.1417	.0530	None	.0275	None	.0255	.0255	.1475	None
278	28-AV-11DL	9429	1¼	1.1417	.0530	None	.0255	None	.0255	.0255	.1475	None
286	20-AV-11	7491	1¼	1.1023	.0393	.0433	.0275	None	.0452	.0255	None	None
286	28-AV-11	8535	1¼	1.1023	.0530	None	.0275	None	.0295	.0255	.1377	None
286	28-AV-11	9032	1¼	1.1023	.0530	None	.0275	None	.0295	.0255	.1377	None
308	28-AV-11	9041	1¼	1.1811	.0570	None	.0275	None	.0314	.0255	.1475	None
308	28-AV-11	9051	1¼	1.1811	.0570	None	.0275	None	.0314	.0255	.1475	None
331	IN-186Ex1	7031	1¾	1.2992	.0648	.0334	.0295	None	.0314	.0255	None	None
361	28-AV-12	9045	1½	1.2204	.0590	None	.0275	None	.0314	.0255	.1475	None
400	IN-186Ex1	7030	1¾	1.3779	.0688	.0334	.0334	None	.0412	.0255	None	None
426	28-AV-12	9046	1½	1.2598	.0609	None	.0275	None	.0354	.0255	.1475	None
450	IN-167P	8314	1¾	1.4960	.0590	.0530	.0255	.0433	None	None	None	None
451	IN-167SJ	8905	1¾	1.4960	.0727	None	.0295	None	.0295	.0491	.0984	None
477	IN-167SJ	8905	1¾	1.4960	.0727	None	.0295	None	.0295	.0491	.0984	None
HALL-SCOTT												
135	457-2	6841	1¾	1.3385	.0648	.0648	.0314	.0334	None	None	None	None
160-1	457-1	6519	1¾	1.2598	.0648	.0629	.0236	.0373	None	None	None	None
160-1	IN-167	7351	1¾	1.5354	.0609	.0590	.0255	.0412	None	None	None	None
160	457-1	7686	1¾	1.2598	.0648	.0629	.0236	.0373	None	None	None	None
175	458-1	7858	2	1.5748	.0866	.0826	.0354	.0354	None	None	None	None
176	157-MV	8466	1¾	.6299	.0452	.0511	.0295	.0236	None	None	None	None
180	458	6521	2	1.6535	.0885	.0767	.0354	.0412	None	None	None	None
HERCULES												
GXB	IN-167	7844	1¾	1.4173	.0590	.0590	.0295	.0354	None	None	None	None
HXB	158	5697	2	1.4173	.0727	.0708	.0314	.0314	None	None	None	None
HXB	158-MV	6294	2	.7874	.0570	.0609	.0295	.0215	None	None	None	None
HXB	IN-158	6323	2	1.4173	.0727	.0708	.0295	.0314	None	None	None	None
HXB	IN-158	6560	2	1.4173	.0727	.0708	.0295	.0314	None	None	None	None

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SPECIFICATIONS

Engine Model	Carburetor Model	Outline Number ①	Carburetor Size, Inches ②	Main Venturi Diameter, Inches	Main Jet, Inch	Compensator, Inch	Idling Jet, Inch	Power and Accelerating Jet, Inch	Power Jet, Inch	Accelerating Jet, Inch	Main Discharge Jet, Inch	Economizer Jet, Inch
HERCULES *(Continued)*												
HXB	IN-167	7351	1¾	1.4173	.0590	.0590	.0255	.0452	None	None	None	None
HXB	458	7409	2	1.4173	.0727	.0708	.0314	.0314	None	None	None	None
HXB	457	7746	1¾	1.3779	.0708	.0688	.0314	.0275	None	None	None	None
HXB	457	7790	1¾	1.3779	.0708	.0688	.0314	.0275	None	None	None	None
HXB	IN-167	7873	1¾	1.5748	.0590	.0590	.0255	.0452	None	None	None	None
HXC	158	6116	2	1.2204	.0688	.0648	.0314	.0314	None	None	None	None
HXC	IN-158	6325	2	1.4960	.0748	.0727	.0295	.0314	None	None	None	None
HXC	IN-158	6325	2	1.4960	.0787	.0767	.0295	.0314	None	None	None	None
HXC	IN-166D	6768	1½	1.1811	.0393	.0551	.0275	.0354	None	None	None	None
HXC	IN-167	7844	1¾	1.4173	.0590	.0590	.0295	.0354	None	None	None	None
HXC	IN-167	8005	1¾	1.6141	.0609	.0590	.0255	.0452	None	None	None	None
HXC	458	8870	2	1.2204	.0609	.0648	.0314	None	None	None	None	None
HXC	458	8906	2	1.2204	.0609	.0648	.0314	None	None	None	None	None
HXC	IN-167SJ	9735	1¾	1.4960	.0727	None	.0295	None	.0255	.0491	.0984	None
HXD	157	5904	1¾	1.3779	.0708	.0688	.0314	.0275	None	None	None	None
HXD	IN-158	6323	2	1.4566	.0727	.0708	.0275	.0295	None	None	None	None
HXD	458	6521	2	1.4960	.0787	.0748	.0314	.0314	None	None	None	None
HXD	IN-158	9788	2	1.5784	.0826	.0708	.0314	.0334	None	None	None	None
HXE	158	5697	2	1.4566	.0688	.0708	.0314	.0433	None	None	None	None
HXE	158	5697	2	1.4566	.0767	.0748	.0314	.0314	None	None	None	None
HXE	157	5890	1¾	1.1811	.0570	.0590	.0314	.0314	None	None	None	None
HXE	157	6069	1¾	1.4566	.0688	.0648	.0314	.0236	None	None	None	None
HXE	158	6116	2	1.4566	.0767	.0748	.0314	.0314	None	None	None	None
HXE	IN-158	6323	2	1.5748	.0767	.0748	.0295	.0334	None	None	None	None
HXE	458	6521	2	1.4566	.0767	.0748	.0314	.0314	None	None	None	None
HXE	458	7849	2	1.4566	.0767	.0748	.0314	.0314	None	None	None	None
HXE	457	7967	1¾	1.3385	.0648	.0629	.0314	.0236	None	None	None	None
HXE	458	8008	2	1.2204	.0688	.0648	.0314	.0314	None	None	None	None
HXE	458	8103	2	1.4566	.0767	.0748	.0314	.0314	None	None	None	None
HXE	158-MV	8782	2	.8661	.0629	.0748	.0295	.0275	None	None	None	None
HXE	458	8797	2	1.4566	.0767	.0748	.0314	.0314	None	None	None	None
HXE	458	8904	2	1.2992	.0669	.0669	.0314	None	None	None	None	None
HXE	20-AV-16	9420	2	1.4960	.0551	.0590	.0295	None	.0787	.0275	None	None
IX	193½	5664	⅞	.7086	.0354	.0393	.0354	None	None	None	None	None
IX	193½	6438	⅞	.5511	.0295	.0314	.0196	None	None	None	None	None
IX	193½-X	6911	1	.5118	.0255	.0255	.0196	None	None	None	None	None
IX	193½	6959	⅞	.5511	.0275	.0295	.0196	None	None	None	None	None
IX	193½	6968	⅞	.5118	.0255	.0255	.0196	None	None	None	None	None
IX	193½	7135	⅞	.5511	.0255	.0354	.0255	None	None	None	None	None
IX	R-20	7426	⅝	.5118	.0275	.0275	.0236	None	None	None	None	None
IX	TU-3½-XI	7706	⅞	.7480	.0354	.0236	.0236	None	None	None	None	None
IX	93½-OXG	8010	1	.5511	.0255	.0354	.0255	None	None	None	None	None
IX	193½	8552	⅞	.5905	.0334	.0314	.0255	None	None	None	None	None
IXA	155	5699	1¼	.7086	.0354	.0334	.0255	.0255	None	None	None	None
IXA	154	6421	1	.6692	.0295	.0334	.0255	.0196	None	None	None	None

① Outline number stamped on small metal disc, usually on the fuel bowl cover. ② See drawings for other flange dimensions.

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SPECIFICATIONS

HERCULES *(Continued)*

Engine Model	Carburetor Model	Outline Number ①	Carburetor Size, Inches ②	Main Venturi Diameter, Inches	Main Jet, Inch	Compensator, Inch	Idling Jet, Inch	Power and Accelerating Jet, Inch	Carburetor Power Jet, Inch	Accelerating Jet, Inch	Main Discharge Jet, Inch	Economizer Jet, Inch
IXA	154	6559	1	.6692	.0295	.0334	.0255	.0196	None	None	None	None
IXA	93½-OG	6727	⅞	.7086	.0354	.0393	.0196	None	None	None	None	None
IXA	193½	6969	⅞	.5118	.0275	.0275	.0196	None	None	None	None	None
IXA	193½-PX	7072	1	.6299	.0314	.0354	.0255	None	None	None	None	None
IXA	193½	7135	⅞	.5511	.0295	.0334	.0196	None	None	None	None	None
IXA	193½	7416	⅞	.5905	.0275	.0354	.0255	None	None	None	None	None
IXA	193½-X	8001	1	.5905	.0275	.0354	.0255	None	None	None	None	None
IXA	454	8521	1	.6692	.0295	.0334	.0255	.0196	None	None	None	None
IXA	TU-3½-XV	8673	⅛	.7086	.0373	.0295	.0314	None	None	None	None	None
IXA	TU-3½-XV	8684	⅞	.7086	.0373	.0295	.0314	None	None	None	None	None
IXA	193½	9248	⅛	.5905	.0295	.0295	.0255	None	None	None	None	None
IXA	454	9253	1	.7086	.0354	.0373	.0255	.0255	None	None	None	None
IXA	193½-PX	9419	1	.5905	.0295	.0295	.0215	None	None	None	None	None
IXA	193½	9479	⅛	.5905	.0295	.0295	.0255	None	None	None	None	None
IXB	154	6420	1	.7086	.0354	.0373	.0255	.0255	None	None	None	None
IXB	154	6422	1	.9448	.0452	.0452	.0255	.0255	None	None	None	None
IXB	154	6549	1	.7086	.0354	.0373	.0255	.0255	None	None	None	None
IXB	155	6557	1¼	.9448	.0472	.0433	.0295	.0215	None	None	None	None
IXB	154	6578	1	.7086	.0354	.0373	.0255	.0255	None	None	None	None
IXB	93½-OG	6727	⅛	.7480	.0354	.0393	.0196	None	None	None	None	None
IXB	193½	7135	⅛	.6299	.0314	.0334	.0255	None	None	None	None	None
IXB	193½	7135	⅛	.5905	.0295	.0314	.0255	None	None	None	None	None
IXB	193½	7135	⅛	.5511	.0275	.0295	.0196	None	None	None	None	None
IXB	193½	7135	⅛	.6692	.0354	.0334	.0255	None	None	None	None	None
IXB	193½	7135	⅞	.5905	.0334	.0314	.0255	None	None	None	None	None
IXB	193½-X	7153	1	.5905	.0295	.0314	.0255	None	None	None	None	None
IXB	193½-X	7153	1	.6692	.0354	.0393	.0255	None	None	None	None	None
IXB	193½	7443	⅞	.6299	.0354	.0334	.0255	None	None	None	None	None
IXB	TU-3½-XI	7574	⅞	.7874	.0373	.0295	.0314	None	None	None	None	None
IXB	193½-X	7753	1	.5905	.0295	.0314	.0255	None	None	None	None	None
IXB	TU-3½-XI	7885	⅞	.7086	.0373	.0295	.0314	None	None	None	None	None
IXB	TU-4-V	7983	1	.9055	.0452	.0236	.0236	None	None	None	None	None
IXB	93½-OXG	8009	1	.7480	.0354	.0393	.0196	None	None	None	None	None
IXB	TU-3½-XI	8270	⅞	.7086	.0373	.0295	.0314	None	None	None	None	None
IXB	193½	8309	⅞	.5905	.0295	.0314	.0255	None	None	None	None	None
IXB	193½-PX	8338	1	.5905	.0295	.0314	.0255	None	None	None	None	None
IXB	TU-4-V	8383	1	.9055	.0452	.0236	.0236	None	None	None	None	None
IXB	455	8558	1¼	.9448	.0472	.0433	.0295	.0215	None	None	None	None
IXB	61-A7	8629	⅞	.5511	.0393	None	.0215	None	None	None	.0984	None
IXB	193½	8787	⅞	.5905	.0275	.0354	.0255	None	None	None	None	None
IXB	TU-4-V	8855	1	.9055	.0530	.0236	.0236	None	None	None	None	None
IXB	61-AJ-7	9246	⅞	.7480	.0472	None	.0236	None	None	None	.1181	None
IXB	TU-3½-XI	9301	⅛	.7086	.0334	.0295	.0314	None	None	None	None	None
IXB	61-A7	9322	⅛	.5511	.0354	None	.0236	None	None	None	.1081	None
IXB	193½	9474	⅛	.5905	.0295	.0314	.0255	None	None	None	None	None

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SPECIFICATIONS

HERCULES *(Continued)*

Engine Model	Carburetor Model	Outline Number ①	Carburetor Size, Inches ②	Main Venturi Diameter, Inches	Main Jet, Inch	Compensator, Inch	Idling Jet, Inch	Power and Accelerating Jet, Inch	Power Jet, Inch	Accelerating Jet, Inch	Main Discharge Jet, Inch	Economizer Jet, Inch
IXB	193½-PX	9528	1	.6299	.0314	.0334	.0255	None	None	None	None	None
IXF	193½	9412	⅞	.5118	.0295	.0295	.0196	None	None	None	None	None
JXA	155	5699	1¼	.7874	.0354	.0393	.0255	.0255	None	None	None	None
JXA	155	5699	1¼	.8661	.0412	.0452	.0255	.0255	None	None	None	None
JXA	155	6288	1¼	.7480	.0334	.0373	.0255	.0177	None	None	None	None
JXA	155	6598	1¼	.8661	.0412	.0452	.0255	.0255	None	None	None	None
JXA	155	6648	1¼	.7874	.0354	.0393	.0255	.0255	None	None	None	None
JXA	IN-185EFx1	7145	1¼	1.1417	.0530	.0393	.0275	None	.0275	.0236	None	None
JXA	124½-TXOP	7172	1¼	.7086	.0334	.0373	.0236	None	None	None	None	None
JXA	20-BV-11	7708	1¼	1.0236	.0314	.0433	.0255	None	.0491	.0255	None	None
JXA	20-B-10	7745	1¼	1.0629	.0334	.0452	.0255	None	.0354	.0255	None	None
JXA	455	7747	1¼	.8661	.0412	.0452	.0255	.0255	None	None	None	None
JXA	23-AV-10	7842	1¼	1.0236	.0334	.0452	.0236	None	.0236	.0255	None	None
JXA	455-1	7880	1¼	.9448	.0452	.0412	.0236	.0255	None	None	None	None
JXA	20-BV-10	8127	1¼	1.0629	.0354	.0452	.0236	None	.0491	.0236	None	None
JXA	455	8134	1¼	.7874	.0373	.0373	.0255	.0177	None	None	None	None
JXA	20-BV-10	8409	1¼	1.0629	.0354	.0452	.0236	None	.0491	.0236	None	None
JXA	28-BV-10	8773	1¼	1.0629	.0491	None	.0255	None	.0334	.0236	.1278	None
JXA	28-BV-10RL	8775	1¼	1.0629	.0491	None	.0255	None	.0334	.0236	.1278	None
JXA	455	8785	1¼	.7874	.0412	.0373	.0255	.0177	None	None	None	None
JXA	28-BV-10	9023	1¼	1.0629	.0491	None	.0255	None	.0334	.0236	.1278	None
JXA	28-BV-10RL	9026	1¼	1.0629	.0472	None	.0255	None	.0295	.0236	.1278	None
JXA	455	9290	1¼	.7874	.0412	.0373	.0255	.0177	None	None	None	None
JXA	455-C	9316	1¼	.9448	.0452	.0412	.0236	.0255	None	None	None	None
JXA	455-1R	9448	1¼	.9448	.0452	.0412	.0236	.0255	None	None	None	None
JXA	28-BV-10R	9450	1¼	1.0629	.0472	None	.0255	None	.0295	.0236	.1278	None
JXA	455-C	9710	1¼	.8661	.0373	.0412	.0196	.0275	None	None	None	None
JXB	155	6251	1¼	.9448	.0452	.0472	.0255	.0255	None	None	None	None
JXB	155	6660	1¼	.9448	.0452	.0433	.0295	.0255	None	None	None	None
JXB	155	6895	1¼	.9448	.0452	.0472	.0255	.0255	None	None	None	None
JXB	IN-185EFx1	7146	1¼	1.1417	.0530	.0412	.0275	None	.0295	.0215	None	None
JXB	IN-185x1	7218	1¼	1.1417	.0511	.0412	.0275	None	.0295	.0215	None	None
JXB	IN-185Ex1	7291	1¼	1.1417	.0511	.0412	.0275	None	.0295	.0215	None	None
JXB	455	7408	1¼	.9448	.0452	.0472	.0255	.0255	None	None	None	None
JXB	455	7578	1¼	.9448	.0452	.0472	.0255	.0255	None	None	None	None
JXB	20-BV-11	7708	1¼	1.0236	.0314	.0433	.0255	None	.0491	.0255	None	None
JXB	124½-TXOP	7739	1¼	.9055	.0433	.0433	.0236	None	None	None	None	None
JXB	20-B-10	7745	1¼	1.0629	.0334	.0452	.0255	None	.0354	.0255	None	None
JXB	455	7778	1¼	.9448	.0452	.0472	.0255	.0255	None	None	None	None
JXB	455-1	7880	1¼	.9448	.0452	.0412	.0236	.0255	None	None	None	None
JXB	20-AV-10	8076	1¼	1.0629	.0354	.0472	.0255	None	.0491	.0275	None	None
JXB	23-AV-11	8078	1¼	1.1417	.0354	.0452	.0236	None	.0334	.0275	None	None
JXB	20-BV-10	8127	1¼	1.0629	.0354	.0452	.0236	None	.0491	.0236	None	None
JXB	455-2	8219	1¼	1.0236	.0472	.0511	.0255	.0255	None	None	None	None
JXB	124½-TOXP	8247	1¼	.8661	.0433	.0452	.0236	None	None	None	None	None

① Outline number stamped on small metal disc, usually on the fuel bowl cover. ② See drawings for other flange dimensions.

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SPECIFICATIONS

HERCULES *(Continued)*

Engine Model	Carburetor Model	Outline Number ①	Carburetor Size, Inches ②	Main Venturi Diameter, Inches	Main Jet, Inch	Compensator, Inch	Idling Jet, Inch	Power and Accelerating Jet, Inch	Power Jet, Inch	Accelerating Jet, Inch	Main Discharge Jet, Inch	Economizer Jet, Inch
JXB	23-AV-11	8303	1¼	1.1811	.0373	.0472	.0255	None	.0314	.0275	None	None
JXB	455	8307	1¼	.9448	.0452	.0472	.0255	.0255	None	None	None	None
JXB	20-BV-10	8409	1¼	1.0629	.0354	.0452	.0236	None	.0491	.0236	None	None
JXB	23-AV-11	8588	1¼	1.1417	.0354	.0452	.0236	None	.0334	.0275	None	None
JXB	28-AV-10	8712	1¼	1.0629	.0511	None	.0255	None	.0295	.0236	.1278	None
JXB	28-BV-10	8773	1¼	1.0629	.0491	None	.0255	None	.0334	.0236	.1278	None
JXB	28-BV-10RL	8775	1¼	1.0629	.0491	None	.0255	None	.0334	.0236	.1278	None
JXB	455	8792	1¼	1.0236	.0511	.0412	.0255	.0255	None	None	None	None
JXB	28-AV-10	9016	1¼	1.0629	.0511	None	.0255	None	.0295	.0236	.1278	None
JXB	28-BV-10	9023	1¼	1.0629	.0491	None	.0255	None	.0334	.0236	.1278	None
JXB	28-BV1-0RL	9026	1¼	1.0629	.0472	None	.0255	None	.0295	.0236	.1278	None
JXB	28-BV-10	9049	1¼	1.0629	.0511	None	.0295	None	.0295	.0236	.1278	None
JXB	28-BV-10	9056	1¼	1.0629	.0511	None	.0295	None	.0295	.0236	.1278	None
JXB	28-AV-11	9287	1¼	1.1417	.0530	None	.0295	None	.0295	.0236	.1475	None
JXB	455	9444	1¼	.9842	.0354	.0472	.0236	.0373	None	None	None	None
JXB	455-1R	9448	1¼	.9448	.0452	.0412	.0236	.0255	None	None	None	None
JXB	28-BV-10R	9450	1¼	1.0629	.0472	None	.0255	None	.0295	.0236	.1278	None
JXB	28-AV-12	9496	1½	1.1417	.0530	None	.0255	None	.0314	.0236	.1377	None
JXC	IN-156B	5670	1½	1.1811	.0472	.0530	.0314	.0295	None	None	None	None
JXC	155	5699	1¼	.9448	.0472	.0472	.0275	.0215	None	None	None	None
JXC	155	5699	1¼	.9055	.0452	.0452	.0275	.0215	None	None	None	None
JXC	155	5699	1¼	.9448	.0452	.0452	.0255	.0275	None	None	None	None
JXC	156	5720	1½	1.1811	.0590	.0472	.0275	.0236	None	None	None	None
JXC	155	6263	1¼	1.0236	.0472	.0472	.0275	.0215	None	None	None	None
JXC	155	6289	1¼	1.0236	.0472	.0472	.0275	.0215	None	None	None	None
JXC	124½-P	7069	1	.7086	.0334	.0373	.0236	None	None	None	None	None
JXC	124½-P	7076	1	.7086	.0334	.0373	.0215	None	None	None	None	None
JXC	IN-185EFx1	7130	1¼	1.1417	.0530	.0433	.0275	None	None	.0196	None	None
JXC	IN-185EFx1	7147	1¼	1.1417	.0530	.0433	.0275	None	.0295	.0215	None	None
JXC	IN-186Ex1	7407	1¾	1.1811	.0551	.0433	.0275	None	.0412	.0215	None	None
JXC	455	7586	1¼	.9488	.0452	.0452	.0255	.0275	None	None	None	None
JXC	20-AV-12	7594	1½	1.0629	.0295	.0412	.0236	None	.0452	.0236	None	None
JXC	455	7684	1¼	.9448	.0452	.0452	.0255	.0275	None	None	None	None
JXC	20-BV-11	7708	1¼	1.0236	.0314	.0433	.0255	None	.0491	.0255	None	None
JXC	20-B-10	7745	1¼	1.0629	.0334	.0452	.0255	None	.0453	.0255	None	None
JXC	455	7876	1¼	1.0236	.0472	.0472	.0275	.0215	None	None	None	None
JXC	455-1	7880	1¼	.9448	.0452	.0412	.0236	.0255	None	None	None	None
JXC	455	7927	1¼	.0955	.0491	.0452	.0275	.0215	None	None	None	None
JXC	455	7997	1¼	.9448	.0472	.0472	.0275	.0215	None	None	None	None
JXC	20-AV-10	8075	1¼	1.1417	.0412	.0452	.0255	None	.0393	.0255	None	None
JXC	23-AV-11	8077	1¼	1.1417	.0354	.0452	.0236	None	.0334	.0275	None	None
JXC	20-AV-12	8140	1½	1.2598	.0472	.0530	.0275	None	.0551	.0275	None	None
JXC	20-BV-10	8177	1¼	1.1023	.0373	.0452	.0236	None	.0491	.0255	None	None
JXC	455-2	8219	1¼	1.0236	.0472	.0511	.0255	.0255	None	None	None	None
JXC	23-AV-11	8303	1¼	1.1811	.0373	.0472	.0255	None	.0314	.0275	None	None

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SPECIFICATIONS

Engine Model	Carburetor Model	Outline Number ①	Carburetor Size, Inches ②	Main Venturi Diameter, Inches	Main Jet, Inch	Compensator, Inch	Idling Jet, Inch	Power and Accelerating Jet, Inch	Power Jet, Inch	Accelerating Jet, Inch	Main Discharge Jet, Inch	Economizer Jet, Inch
HERCULES *(Continued)*												
JXC	455	8367	1¼	.9448	.0452	.0452	.0255	.0275	None	None	None	None
JXC	20-BV-10	8428	1¼	1.1023	.0373	.0452	.0236	None	.0491	.0255	None	None
JXC	23-AV-11	8588	1¼	1.1417	.0354	.0452	.0236	None	.0334	.0275	None	None
JXC	28-BV-10	8773	1¼	1.0629	.0491	None	.0255	None	.0334	.0236	.1278	None
JXC	28-BV-10RL	8775	1¼	1.0629	.0491	None	.0255	None	.0334	.0236	.1278	None
JXC	28-BV-10	9023	1¼	1.0629	.0491	None	.0255	None	.0334	.0236	.1278	None
JXC	28-BV-10RL	9026	1¼	1.0629	.0472	None	.0255	None	.0295	.0236	.1278	None
JXC	28-BV-12	9059	1½	1.1811	.0551	None	.0295	None	.0314	.0236	.1475	None
JXC	28-BV-10	9068	1¼	1.1417	.0530	None	.0295	None	.0295	.0236	.1475	None
JXC	28-BV-10RL	9069	1¼	1.1417	.0530	None	.0295	None	.0295	.0236	.1475	None
JXC	28-BV-10	9073	1¼	1.1417	.0530	None	.0295	None	.0295	.0236	.1475	None
JXC	28-AV-11	9287	1¼	1.1417	.0530	None	.0295	None	.0295	.0236	.1475	None
JXC	28-BV-12	9310	1½	1.1417	.0530	None	.0255	None	.0255	.0314	.1475	None
JXC	455-1R	9448	1¼	.9448	.0452	.0412	.0236	.0255	None	None	None	None
JXC	28-BV-10R	9450	1¼	1.0629	.0472	None	.0255	None	.0295	.0236	.1278	None
JXC	IN-167SJ	9574	1¾	1.2204	.0551	None	.0255	None	.0491	.0295	.1377	None
JXC	455	9660	1¼	1.0629	.0491	.0472	.0215	.0275	None	None	None	None
JXD	455-2	6836	1¼	.9448	.0472	.0452	.0275	.0255	None	None	None	None
JXD	124½-TOP	7069	1	.7086	.0334	.0373	.0215	None	None	None	None	None
JXD	IN-185EFx1	7129	1¼	1.1811	.0570	.0452	.0314	None	.0314	.0215	None	None
JXD	IN-185EFx1	7130	1¼	1.1417	.0530	.0433	.0275	None	None	.0255	None	None
JXD	IN-186Ex2	7193	1¾	1.1811	.0570	.0452	.0314	None	.0314	.0215	None	None
JXD	455	7380	1¼	1.0236	.0472	.0472	.0275	.0215	None	None	None	None
JXD	155	7399	1¼	.9448	.0472	.0452	.0275	.0255	None	None	None	None
JXD	IN-186Ex1	7407	1¾	1.1811	.0551	.0433	.0275	None	.0412	.0215	None	None
JXD	20-BV-12	7596	1½	1.0236	.0314	.0433	.0255	None	.0491	.0255	None	None
JXD	455	7617	1¼	.9448	.0472	.0452	.0275	.0255	None	None	None	None
JXD	20-BV-11	7708	1¼	1.0236	.0314	.0433	.0255	None	.0491	.0255	None	None
JXD	20-B-10	7745	1¼	1.0629	.0334	.0452	.0255	None	.0354	.0255	None	None
JXD	455-1	7880	1¼	.9448	.0452	.0412	.0236	.0255	None	None	None	None
JXD	455	8060	1¼	.8661	.0452	.0452	.0275	.0215	None	None	None	None
JXD	20-AV-11	8063	1¼	1.0236	.0334	.0472	.0255	None	.0491	.0255	None	None
JXD	23-AV-12	8079	1½	1.1417	.0373	.0491	.0236	None	.0334	.0275	None	None
JXD	20-AV-11	8101	1¼	1.1417	.0433	.0452	.0255	None	.0354	.0255	None	None
JXD	455	8133	1¼	.9055	.0452	.0452	.0275	.0236	None	None	None	None
JXD	20-BV-10	8177	1¼	1.1023	.0373	.0452	.0236	None	.0491	.0255	None	None
JXD	23-AV-11	8303	1¼	1.1811	.0373	.0472	.0255	None	.0314	.0275	None	None
JXD	20-BV-10	8428	1¼	1.1023	.0373	.0452	.0236	None	.0491	.0255	None	None
JXD	95-G	8540	1¼	.9842	.0511	.0452	.0236	None	None	None	None	None
JXD	28-BV-10	8773	1¼	1.0629	.0491	None	.0255	None	.0334	.0236	None	None
JXD	28-BV-10RL	8775	1¼	1.0629	.0491	None	.0255	None	.0334	.0236	None	None
JXD	455	8805	1¼	1.0236	.0472	.0472	.0275	.0215	None	None	None	None
JXD	456	8914	1½	1.0236	.0530	.0491	.0295	.0255	None	None	None	None
JXD	456-1	8944	1½	.9842	.0412	.0452	.0255	.0334	None	None	None	None
JXD	456-1RL	8982	1½	.9842	.0412	.0452	.0255	.0334	None	None	None	None

① Outline number stamped on small metal disc, usually on the fuel bowl cover. ② See drawings for other flange dimensions.

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SPECIFICATIONS

HERCULES *(Continued)*

Engine Model	Carburetor Model	Outline Number ①	Carburetor Size, Inches ②	Main Venturi Diameter, Inches	Main Jet, Inch	Compensator, Inch	Idling Jet, Inch	Power and Accelerating Jet, Inch	Power Jet, Inch	Accelerating Jet, Inch	Main Discharge Jet, Inch	Economizer Jet, Inch
JXD	28-BV-10	9023	1¼	1.0629	.0491	None	.0255	None	.0334	.0236	.1278	None
JXD	28-BV-10RL	9026	1¼	1.0629	.0472	None	.0255	None	.0295	.0236	.1278	None
JXD	28-BV-12RL	9053	1½	1.1023	.0511	None	.0255	None	.0334	.0255	.1278	None
JXD	28-BV-12	9059	1½	1.1811	.0551	None	.0295	None	.0314	.0236	.1475	None
JXD	28-BV-10	9068	1¼	1.1417	.0530	None	.0295	None	.0295	.0236	.1475	None
JXD	28-BV-10RL	9069	1¼	1.1417	.0530	None	.0295	None	.0295	.0236	.1475	None
JXD	28-BV-10	9073	1¼	1.1417	.0530	None	.0295	None	.0295	.0236	.1475	None
JXD	28-BV-12	9076	1½	1.1023	.0511	None	.0255	None	.0334	.0255	.1278	None
JXD	28-AV-11	9287	1¼	1.1417	.0530	None	.0295	None	.0295	.0236	.1475	None
JXD	95-G	9302	1¼	.9842	.0511	.0452	.0236	None	None	None	None	None
JXD	456-1R	9495	1½	.9842	.0412	.0452	.0255	.0334	None	None	None	None
JXD	28-BV-12R	9503	1½	1.1023	.0511	None	.0255	None	.0334	.0255	.1278	None
JXD	IN-167-SJ	9574	1¾	1.2204	.0551	None	.0255	None	.0491	.0295	.1377	None
JXD	28-AV-11	9627	1¼	1.1023	.0511	None	.0255	None	.0275	.0255	.1475	None
JXD	455	9660	1¼	1.0629	.0491	.0472	.0215	.0275	None	None	None	None
JXD	28-BV-12	9727	1½	1.1417	.0511	None	.0255	None	.0255	.0334	.1278	None
JXE-3	28-BV-10	9049	1¼	1.0629	.0511	None	.0295	None	.0295	.0236	.1278	None
JXE-3	28-BV-10	9056	1¼	1.0629	.0511	None	.0295	None	.0295	.0236	.1278	None
JXE-3	455	9252	1¼	.9448	.0433	.0433	.0215	.0275	None	None	None	None
JXF	455-1	7880	1¼	.9448	.0452	.0412	.0255	.0275	None	None	None	None
JXF	28-BV-10	9023	1¼	1.0629	.0491	None	.0255	None	.0334	.0236	.0278	None
JXG	455-1	7880	1¼	.9448	.0452	.0412	.0255	.0275	None	None	None	None
JXG	28-BV-10R	9450	1¼	1.0629	.0472	None	.0255	None	.0295	.0236	.1278	None
OOA	154	6196	1	.7086	.0295	.0314	.0255	.0215	None	None	None	None
OOA	124½-TP	7174	1	.7086	.0334	.0334	.0236	None	None	None	None	None
OOA	124½-TP	7176	1	.6299	.0314	.0295	.0196	None	None	None	None	None
OOA	124½-TOP	8298	1	.6299	.0314	.0295	.0196	None	None	None	None	None
OOA	124½-TO	8772	1	.6692	.0334	.0354	.0236	None	None	None	None	None
OOB	154	6581	1	.8661	.0373	.0393	.0236	.0236	None	None	None	None
OOB	IN-185EFx1	7487	1¼	1.0236	.0354	.0354	.0255	None	.0393	.0196	None	None
OOB	IN-185Ex1	7581	1¼	1.0236	.0314	.0354	.0255	None	.0354	.0196	None	None
OOB	20-BVX-9	7754	1¼	.9842	.0314	.0373	.0255	None	.0452	.0255	None	None
OOB	20-BVX-9	8093	1¼	.9842	.0314	.0433	.0255	None	.0452	.0255	None	None
OOB	124½-TOX	8109	1¼	.8267	.0354	.0433	.0255	None	None	None	None	None
OOB	20-AV-10	8464	1¼	.9842	.0314	.0433	.0255	None	.0452	.0255	None	None
OOC	94-OG	6819	1	.7874	.0412	.0452	.0196	None	None	None	None	None
OOC	94-OG	7692	1	.7874	.0412	.0452	.0196	None	None	None	None	None
OOC	124½-TOP	7759	1	.7874	.0393	.0373	.0236	None	None	None	None	None
OX	155	6330	1¼	.8267	.0373	.0393	.0275	.0295	None	None	None	None
OX	124½-TX	6731	1¼	.8661	.0412	.0412	.0236	None	None	None	None	None
OX	95-G	6801	1¼	.8661	.0412	.0433	.0236	None	None	None	None	None
OX	124½-TOX	7676	1¼	.8661	.0412	.0412	.0236	None	None	None	None	None
OX	124½-TOX	8119	1¼	.8661	.0412	.0412	.0236	None	None	None	None	None
OX	124½-TOX	8362	1¼	.8661	.0452	.0412	.0236	None	None	None	None	None
OXC	155	5699	1¼	.9448	.0452	.0452	.0275	.0255	None	None	None	None

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SPECIFICATIONS

HERCULES *(Continued)*

Engine Model	Carburetor Model	Outline Number ①	Carburetor Size, Inches ②	Main Venturi Diameter, Inches	Main Jet, Inch	Compensator, Inch	Idling Jet, Inch	Power and Accelerating Jet, Inch	Power Jet, Inch	Accelerating Jet, Inch	Main Discharge Jet, Inch	Economizer Jet, Inch
OXC	155	6066	1¼	.9448	.0433	.0393	.0275	.0255	None	None	None	None
OXC	155	6072	1¼	.9448	.0433	.0393	.0275	.0255	None	None	None	None
OXC	155	6453	1¼	.8267	.0373	.0393	.0275	.0295	None	None	None	None
OXC	155	6507	1¼	.9448	.0433	.0393	.0275	.0255	None	None	None	None
OXC	124½-TX	6731	1¼	.9055	.0433	.0433	.0236	None	None	None	None	None
OXC	455	7415	1¼	.9448	.0452	.0452	.0275	.0255	None	None	None	None
OXC	455	7601	1¼	.9448	.0433	.0393	.0275	.0255	None	None	None	None
OXC	455	7609	1¼	.7874	.0373	.0373	.0255	.0255	None	None	None	None
OXC	124½-TOX	7705	1¼	.9055	.0452	.0433	.0236	None	None	None	None	None
OXC	124½-TOX	8021	1¼	.9055	.0433	.0433	.0236	None	None	None	None	None
OXC	124½-TOX	8326	1¼	.9055	.0472	.0433	.0236	None	None	None	None	None
OXC	455	9237	1¼	.9448	.0452	.0452	.0275	.0255	None	None	None	None
QXA-3	20-AVX-9	7659	1¼	.9842	.0295	.0452	.0255	None	.0472	.0255	None	None
QXA-5	124½-TOX	7760	1¼	.7480	.0393	.0354	.0236	None	None	None	None	None
QXB	324½-XO	8494	1¼	.8661	.0354	.0393	.0255	.0314	None	None	None	None
QXB	455	9239	1¼	.8267	.0412	.0373	.0275	None	None	None	None	None
QXB	124½-TOX	9277	1¼	.8267	.0412	.0452	.0215	None	None	None	None	None
QXB-3	20-AVX-9	7659	1¼	.9842	.0295	.0452	.0255	None	.0472	.0255	None	None
QXB-3	23-AV-10	7842	1¼	1.0236	.0334	.0452	.0236	None	.0236	.0255	None	None
QXB-3	20-AVX-9	8012	1¼	1.0236	.0314	.0433	.0215	None	.0472	.0215	None	None
QXB-3	20-BVX-9	8017	1¼	.9842	.0314	.0433	.0255	None	.0452	.0255	None	None
QXB-3	20-AVX-9	8053	1¼	.9448	.0275	.0393	.0275	None	.0472	.0255	None	None
QXB-3	20-BVX-9	8093	1¼	.9842	.0314	.0433	.0255	None	.0452	.0255	None	None
QXB-3	28-BVX-9	8776	1¼	1.0236	.0472	None	.0275	None	.0275	.0236	.1278	None
QXB-3	20-AVX-9	8809	1¼	.9842	.0295	.0412	.0215	None	.0393	.0236	None	None
QXB-3	28-BVX-9	9008	1¼	1.0236	.0472	None	.0275	None	.0275	.0255	.1278	None
QXB-3	28-BVX-9RL	9011	1¼	1.0236	.0472	None	.0275	None	.0275	.0255	.1278	None
QXB-3	28-AVX-9	9055	1¼	1.0236	.0472	None	.0275	None	.0275	.0236	.1278	None
QXB-3	28-BVX-9R	9501	1¼	1.0236	.0472	None	.0275	None	.0275	.0236	.1278	None
QXB-5	124½-TOX	7936	1¼	.8267	.0412	.0452	.0215	None	None	None	None	None
QXB-5	124½-TOX	8003	1¼	.8267	.0412	.0452	.0215	None	None	None	None	None
QXB-5	124½-TOX	8095	1¼	.8267	.0412	.0452	.0215	None	None	None	None	None
QXB-5	124½-TOXP	8120	1¼	.8267	.0412	.0452	.0215	None	None	None	None	None
QXB-5	124½-TOX	8701	1¼	.8267	.0412	.0452	.0215	None	None	None	None	None
QXB-5	124½-TOX	8790	1¼	.8267	.0412	.0452	.0215	None	None	None	None	None
QXB-5	124½-TOX	8939	1¼	.8267	.0412	.0452	.0215	None	None	None	None	None
QXB-5	124½-TOX	8998	1¼	.8267	.0412	.0452	.0215	None	None	None	None	None
QXB-5	124½-TOX	9159	1¼	.7086	.0334	.0354	.0215	None	None	None	None	None
QXB-5	62-AJX-9	9245	1¼	.9842	.0570	None	.0295	None	None	None	.1181	.0354
QXB-5	124½-TOX	9319	1¼	.8267	.0412	.0452	.0215	None	None	None	None	None
QXB-5	124½-TOX	9433	1¼	.8267	.0412	.0452	.0215	None	None	None	None	None
QXC-3	23-AV-10	7842	1¼	1.0236	.0334	.0452	.0236	None	.0236	.0255	None	None
QXC-3	20-AVX-9	8401	1¼	1.0236	.0314	.0491	.0236	None	.0472	.0177	None	None
QXC-3	28-BVX-9	8776	1¼	1.0236	.0472	None	.0275	None	.0275	.0236	.1278	None
QXC-3	20-AVX-9	8786	1¼	1.0236	.0334	.0433	.0215	None	.0393	.0177	None	None

① Outline number stamped on small metal disc, usually on the fuel bowl cover. ② See drawings for other flange dimensions.

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SPECIFICATIONS

HERCULES *(Continued)*

Engine Model	Carburetor Model	Outline Number ①	Carburetor Size, Inches ②	Main Venturi Diameter, Inches	Main Jet, Inch	Compensator, Inch	Idling Jet, Inch	Power and Accelerating Jet, Inch	Power Jet, Inch	Accelerating Jet, Inch	Main Discharge Jet, Inch	Economizer Jet, Inch
QXC-3	455	8799	1¼	.7874	.0373	.0354	.0215	.0215	None	None	None	None
QXC-3	28-BVX-9	9006	1¼	1.0236	.0472	None	.0275	None	.0275	.0236	.1278	None
QXC-3	28-BVX-9	9008	1¼	1.0236	.0472	None	.0275	None	.0275	.0255	.1278	None
QXC-3	28-BVX-9RL	9011	1¼	1.0236	.0472	None	.0275	None	.0275	.0255	.1278	None
QXC-3	28-AVX-9	9055	1¼	1.0236	.0472	None	.0275	None	.0275	.0236	.1278	None
QXC-3	455	9166	1¼	.8661	.0412	.0393	.0215	.0215	None	None	None	None
QXC-3	28-BVX-9R	9501	1¼	1.0236	.0472	None	.0275	None	.0275	.0236	.1278	None
QXC-5	324½-XO	8553	1¼	.8267	.0452	.0452	.0215	.0275	None	None	None	None
QXC-5	324½-XO	8593	1¼	.8267	.0334	.0393	.0215	.0295	None	None	None	None
QXC-5	62-AX-9	8625	1¼	.9842	.0570	None	.0295	None	None	.0354	.1181	None
QXC-5	455	9295	1¼	.8267	.0412	.0452	.0215	None	None	None	None	None
QXC-5	455-C	9457	1¼	.7874	.0373	.0412	.0275	.0215	None	None	None	None
QXC-5	28-AVX-9	9458	1¼	.9448	.0412	None	.0236	None	.0215	.0215	.1278	None
QXD-3	28-AV-10	9482	1¼	1.0629	.0491	None	.0295	None	.0295	.0236	.1475	None
QXD-3	455	9552	1¼	.9842	.0472	.0393	.0215	.0255	None	None	None	None
RXB	96½-XG	6756	1¾	1.1417	.0570	.0648	.0255	None	None	None	None	None
RXB	IN-167	7351	1¾	1.3385	.0511	.0491	.0295	.0334	None	None	None	None
RXB	IN-167	7694	1¾	1.3385	.0551	.0551	.0295	.0354	None	None	None	None
RXB	IN-167	7874	1¾	1.2598	.0452	.0452	.0314	.0433	None	None	None	None
RXB	457-2	8416	1¾	1.1811	.0570	.0551	.0314	.0275	None	None	None	None
RXB	20-AVX-12	8510	1¾	1.2204	.0412	.0511	.0275	None	.0393	.0255	None	None
RXB	IN-167SJ	9657	1¾	1.3385	.0629	None	.0354	None	.0295	.0393	.0984	None
RXC	157	6109	1¾	1.2204	.0609	.0590	.0314	.0373	None	None	None	None
RXC	156	6128	1½	1.0629	.0511	.0511	.0275	.0255	None	None	None	None
RXC	156	6400	1½	1.1811	.0609	.0590	.0314	.0373	None	None	None	None
RXC	157	6604	1¾	1.2204	.0609	.0590	.0314	.0373	None	None	None	None
RXC	457-2	6841	1¾	1.2204	.0609	.0590	.0314	.0373	None	None	None	None
RXC	IN-167	7351	1¾	1.3779	.0570	.0570	.0295	.0354	None	None	None	None
RXC	457	7456	1¾	1.2204	.0609	.0590	.0314	.0373	None	None	None	None
RXC	457	7472	1¾	1.2204	.0609	.0590	.0314	.0373	None	None	None	None
RXC	457	7749	1¾	1.2204	.0609	.0590	.0314	.0373	None	None	None	None
RXC	IN-167	7871	1¾	1.2598	.0393	.0748	.0255	.0433	None	None	None	None
RXC	IN-167	7874	1¾	1.2992	.0530	.0511	.0314	.0433	None	None	None	None
RXC	IN-167	8020	1¾	1.3779	.0570	.0570	.0295	.0354	None	None	None	None
RXC	457	8384	1¾	1.3779	.0708	.0688	.0275	.0255	None	None	None	None
RXC	IN-167SJ	9664	1¾	1.3385	.0648	None	.0314	None	.0314	.0472	.1181	None
RXC	457-2	9797	1¾	1.2992	.0629	.0629	.0314	.0491	None	None	None	None
RXC	IN-167SJ	9840	1¾	1.3385	.0648	None	.0354	None	.0295	.0393	.0885	None
RXLC	IN-167SJ	9256	1¾	1.4173	.0629	None	.0255	None	.0295	.0491	.0885	None
RXLD	IN-167	7874	1¾	1.3385	.0551	.0511	.0314	.0452	None	None	None	None
RXLD	457-2	8416	1¾	1.2598	.0609	.0590	.0275	.0295	None	None	None	None
RXLD	IN-167	9137	1¾	1.4173	.0590	.0609	.0275	.0433	None	None	None	None
RXLD	IN-167SJ	9411	1¾	1.3385	.0570	None	.0255	None	.0393	.0472	.1475	None
RXLD	IN-167SJ	9723	1¾	1.4173	.0688	None	.0275	None	.0295	.0491	.1475	None
WXA-2	156	6262	1½	.9055	.0433	.0412	.0295	.0236	None	None	None	None

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SPECIFICATIONS

HERCULES *(Continued)*

Engine Model	Carburetor Model	Outline Number ①	Carburetor Size, Inches ②	Main Venturi Diameter, Inches	Main Jet, Inch	Compensator, Inch	Idling Jet, Inch	Power and Accelerating Jet, Inch	Power Jet, Inch	Accelerating Jet, Inch	Main Discharge Jet, Inch	Economizer Jet, Inch
WXB	156	6261	1½	.9448	.0472	.0452	.0295	.0255	None	None	None	None
WXB	155	6598	1¼	.9448	.0472	.0452	.0295	.0236	None	None	None	None
WXB	456	7629	1½	.9448	.0472	.0452	.0295	.0255	None	None	None	None
WXB	456	7912	1½	.9448	.0472	.0452	.0295	.0255	None	None	None	None
WXC	156	5883	1½	1.0236	.0491	.0491	.0295	.0255	None	None	None	None
WXC	156	6468	1½	1.0236	.0491	.0491	.0295	.0255	None	None	None	None
WXC	156	6701	1½	1.0236	.0472	.0491	.0295	.0255	None	None	None	None
WXC	456	7403	1½	1.0236	.0491	.0491	.0295	.0255	None	None	None	None
WXC	20-BV-12	8318	1½	1.0629	.0373	.0472	.0275	None	.0412	.0255	None	None
WXC-2	156	6255	1½	1.0236	.0472	.0491	.0295	.0255	None	None	None	None
WXC-2	156	6480	1½	1.0236	.0472	.0491	.0295	.0255	None	None	None	None
WXC-2	456–2	6838	1½	1.0236	.0472	.0491	.0295	.0295	None	None	None	None
WXC-2	456	7919	1½	1.0236	.0491	.0452	.0275	.0275	None	None	None	None
WXC-2	20-BV-12	8082	1½	1.1417	.0393	.0491	.0275	None	.0530	.0275	None	None
WXC-3	156	5720	1½	1.0236	.0491	.0452	.0275	.0275	None	None	None	None
WXC-3	156	5882	1½	1.1023	.0530	.0530	.0295	.0255	None	None	None	None
WXC-3	156	6413	1½	1.0236	.0491	.0491	.0295	.0255	None	None	None	None
WXC-3	456-2	6838	1½	1.1023	.0551	.0530	.0295	.0255	None	None	None	None
WXC-3	96-AG	6857	1½	1.0629	.0609	.0491	.0255	None	None	None	None	None
WXC-3	156	6917	1½	1.0236	.0491	.0452	.0275	.0314	None	None	None	None
WXC-3	IN-186Ex1	6955	1¾	1.1811	.0590	.0472	.0275	None	.0334	.0275	None	None
WXC-3	IN-186Ex2	7193	1¾	1.1811	.0609	.0472	.0275	None	.0354	.0275	None	None
WXC-3	456	7326	1½	1.0236	.0491	.0452	.0275	.0275	None	None	None	None
WXC-3	456	7799	1½	1.0236	.0491	.0452	.0275	.0275	None	None	None	None
WXC-3	IN-167	7874	1¾	1.2992	.0472	.0472	.0314	.0452	None	None	None	None
WXC-3	456	8045	1½	1.1023	.0530	.0530	.0295	.0255	None	None	None	None
WXC-3	456	8363	1½	1.0236	.0530	.0452	.0275	.0275	None	None	None	None
WXC-3	23-BVX-12	8570	1½	1.2598	.0412	.0511	.0275	None	.0393	.0275	None	None
WXC-3	28-AV-12	9561	1½	1.2992	.0609	None	.0295	None	.0393	.0236	.1475	None
WXC-3	28-AV-12	9726	1½	1.2204	.0609	None	.0255	None	.0275	.0275	.1475	None
WXC-3	456–1R	9780	1½	1.0236	.0491	.0472	.0275	.0275	None	None	None	None
WXLC	IN-186Ex1	7198	1¾	1.2204	.0570	.0412	.0295	None	.0334	.0275	None	None
WXLC3	IN-156-B	6250	1½	1.1811	.0530	.0511	.0255	.0314	None	None	None	None
WXLC3	IN-186Ex1	7161	1¾	1.2598	.0590	.0412	.0295	None	.0334	.0275	None	None
WXLC3	IN-167	7874	1¾	1.2992	.0472	.0472	.0314	.0452	None	None	None	None
WXLC3	20-AV-12	8140	1½	1.2598	.0472	.0530	.0275	None	.0551	.0275	None	None
WXLC3	23-BV-12	8379	1½	1.0629	.0393	.0412	.0275	None	.0275	.0275	None	None
WXLC3	20-BV-12	8414	1½	1.1417	.0393	.0491	.0275	None	.0530	.0275	None	None
WXLC3	456–2	8635	1½	1.1023	.0511	.0551	.0255	.0236	None	None	None	None
WXLC3	456	8898	1½	1.0236	.0491	.0452	.0275	None	None	None	None	None
WXLC3	28-AV-12	9614	1½	1.2598	.0609	None	.0295	None	.0373	.0236	.1475	None
WXLC3	457–2R	9747	1¾	1.1417	.0530	.0472	.0314	.0354	None	None	None	None
WXLC3	457–1	9813	1¾	1.1417	.0530	.0472	.0314	.0354	None	None	None	None
YXC	157	6149	1¾	1.1811	.0590	.0570	.0295	.0275	None	None	None	None
YXC	IN-167	7709	1¾	1.2204	.0412	.0629	.0255	.0373	None	None	None	None

① Outline number stamped on small metal disc, usually on the fuel bowl cover. ② See drawings for other flange dimensions.

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SPECIFICATIONS

Engine Model	Carburetor Model	Outline Number ①	Carburetor Size, Inches ②	Main Venturi Diameter, Inches	Main Jet, Inch	Compensator, Inch	Idling Jet, Inch	Power and Accelerating Jet, Inch	Power Jet, Inch	Accelerating Jet, Inch	Main Discharge Jet, Inch	Economizer Jet, Inch
HERCULES *(Continued)*												
YXC	456	7894	1½	.9842	.0472	.0452	.0295	.0275	None	None	None	None
YXC-2	156	5720	1½	1.1023	.0491	.0551	.0314	.0236	None	None	None	None
YXC-2	157	6303	1¾	1.1811	.0511	.0551	.0314	.0334	None	None	None	None
YXC-2	457-1	6519	1¾	1.1811	.0590	.0551	.0275	.0295	None	None	None	None
YXC-2	IN-186EXx2	7113	1¾	1.2992	.0629	.0530	.0295	None	.0295	.0295	None	None
YXC-2	457	7769	1¾	1.1811	.0511	.0551	.0314	.0334	None	None	None	None
YXC-2	457	7994	1¾	1.1811	.0511	.0551	.0314	.0334	None	None	None	None
YXC-2	IN-167	8436	1¾	1.4566	.0551	.0551	.0275	.0452	None	None	None	None
YXC-2	IN-167SJ	9664	1¾	1.3384	.0648	None	.0314	None	.0314	.0472	.1181	None
YXC-3	157	6160	1¾	1.1811	.0590	.0570	.0295	.0275	None	None	None	None
YXC-3	157	6364	1¾	1.1811	.0590	.0570	.0295	.0275	None	None	None	None
YXC-3	157	6495	1¾	1.2204	.0629	.0590	.0275	.0334	None	None	None	None
YXC-3	456	7414	1½	1.0236	.0491	.0472	.0295	.0275	None	None	None	None
YXC-3	457	7690	1¾	1.2204	.0629	.0590	.0275	.0334	None	None	None	None
YXC-3	IN-167	7874	1¾	1.3779	.0491	.0530	.0314	.0491	None	None	None	None
YXC-3	IN-167	7906	1¾	1.3385	.0551	.0648	.0255	.0491	None	None	None	None
YXC-3	457	7923	1¾	1.1811	.0590	.0590	.0295	.0314	None	None	None	None
YXC-3	457	8344	1¾	1.1811	.0590	.0590	.0295	.0314	None	None	None	None
YXC-3	457-2	8416	1¾	1.1811	.0609	.0570	.0295	.0275	None	None	None	None
INTERNATIONAL												
FAB-241	23-AV-11	7962	1¼	1.1811	.0373	.0452	.0255	None	.0334	.0275	None	None
FAB-241	28-AV-11	9461	1¼	1.1417	.0472	None	.0275	None	.0236 .0354④	.0255	.1181	None
FAB-244	IN-185½-EI	7142	1¼	1.2204	.0530	.0412	.0255	None	.0412	.0295	None	None
FAB-244	IN-185-½EI	7221	1¼	1.2204	.0551	.0412	.0255	None	.0412	.0295	None	None
FAB-244	23-AV-11	8057	1¼	1.0629	.0314	.0452	.0255	None	.0314	.0275	None	None
FAB-244	23-AV-11	8419	1¼	1.0629	.0314	.0452	.0236	None	.0314	.0275	None	None
FAB-259	23-AV-11	8011	1¼	1.1811	.0354	.0491	.0255	None	.0314	.0275	None	None
FAB-259	28-AV-11	9460	1¼	1.1811	.0530	None	.0275	None	.0236 .0334④	.0255	.1181	None
FAB-259	63-AW-10	9533	1¼	1.1023	.0472	None	.0275	None	.0215	.0373	.1377	None
FAB-259	63-AW-10R	9589	1¼	1.1023	.0472	None	.0275	None	.0373	.0215	.1377	None
FAC-241	28-AV-11R	9680	1¼	1.1417	.0472	None	.0275	None	.0236 .0354④	.0255	.1181	None
FAC-241	28-AV-11	9708	1¼	1.1417	.0472	None	.0275	None	.0236 .0354④	.0255	.1181	None
FAC-241	28-AV-11	9800	1¼	1.1417	.0452	None	.0275	None	.0295 .0452④	.0255	.1181	None
FAC-259	28-AV-11R	9704	1¼	1.1811	.0530	None	.0275	None	.0236 .0334④	.0255	.1181	None
FAC-259	28-AV-11	9709	1¼	1.1811	.0530	None	.0275	None	.0236 .0334④	.0255	.1181	None
FAC-259	28-AV-11	9798	1¼	1.1811	.0530	None	.0275	None	.0236 .0393④	.0255	.1181	None

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SPECIFICATIONS

INTERNATIONAL *(Continued)*

Engine Model	Carburetor Model	Outline Number ①	Carburetor Size, Inches ②	Main Venturi Diameter, Inches	Main Jet, Inch	Compensator, Inch	Idling Jet, Inch	Power and Accelerating Jet, Inch	Power Jet, Inch	Accelerating Jet, Inch	Main Discharge Jet, Inch	Economizer Jet, Inch
FAC-259	63-AW-10	9812	1¼	1.1023	.0472	None	.0275	None	.0215	.0373	.1377	None
FAC-259	63-AW-11	9835	1¼	1.1811	.0491	None	.0255	None	.0314	.0472	.1574	None
FBB-279	255½	6668	1¼	1.1417	.0491	.0551	.0334	.0354	None	None	None	None
FBB-298	256-Y	6602	1¼	1.2204	.0491	.0570	.0334	.0433	None	None	None	None
FBB-298	23-AV-11	7959	1¼	1.1811	.0373	.0472	.0255	None	.0314	.0275	None	None
FBB-298	63-AW-11RL	8938	1¼	1.1417	.0511	None	.0255	None	.0236	.0314	.1574	None
FBB-298	63-AW-11RL	9169	1¼	1.1417	.0511	None	.0255	None	.0236	.0314	.1574	None
FBB-298	63-AW-11R	9522	1¼	1.1417	.0511	None	.0255	None	.0236	.0314	.1574	None
FBB-298	63-AW-11R	9523	1¼	1.1417	.0511	None	.0255	None	.0236	.0314	.1574	None
FBB-318	63-AW-11R	9486	1¼	1.1417	.0491	None	.0255	None	.0373	.0275	.1574	None
FBB-318	28-AV-11	9515	1¼	1.1811	.0511	None	.0275	None	.0236 .0373④	.0255	.1278	None
FBB-318	28-AV-11R	9516	1¼	1.1811	.0511	None	.0275	None	.0236 .0373④	.0255	.1278	None
FBB-361	23-AV-11	7960	1¼	1.2204	.0393	.0491	.0255	None	.0314	.0275	.1574	None
FBB-361	63-AW-11RL	9131	1¼	1.1811	.0530	None	.0255	None	.0215	.0314	.1574	None
FBB-361	63-AW-11RL	9258	1¼	1.1811	.0530	None	.0255	None	.0215	.0314	.1574	None
FBB-361	28-AV-11	9475	1¼	1.2204	.0511	None	.0295	None	.0275 .0393④	.0255	.1377	None
FBB-361	63-AW-11R	9478	1¼	1.1811	.0530	None	0255	None	.0215	.0314	.1574	None
FBB-361	63-AW-11R	9525	1¼	1.1811	.0530	None	.0255	None	.0215	.0314	.1574	None
FBB-401	23-AV-11	7961	1¼	1.2204	.0393	.0530	.0255	None	.0295	.0275	None	None
FBB-401	456-2	8470	1½	1.2204	.0570	.0551	.0393	.0334	None	None	None	None
FBB-401	63-AW-11RL	8937	1¼	1.2204	.0530	None	.0255	None	.0255	.0354	.1574	None
FBB-401	63-AW-11RL	9168	1¼	1.2204	.0530	None	.0255	None	.0255	.0354	.1574	None
FBB-401	28-AV-11	9459	1¼	1.2204	.0530	None	.0295	None	.0255 .0433④	.0255	.1377	None
FBB-401	63-AW-11R	9506	1¼	1.2204	.0530	None	.0255	None	.0354	.0255	.1574	None
FBB-401	63-AW-11R	9514	1¼	1.2204	.0530	None	.0255	None	.0255	.0354	.1574	None
FBB-450	456-2	8454	1½	1.2598	.0570	.0551	.0393	.0334	None	None	None	None
FBB-450	23-AV-12	8455	1½	1.2598	.0373	.0511	.0255	None	.0334	.0275	None	None
FBB-450	456-2RL	9315	1½	1.2598	.0570	.0551	.0393	.0334	None	None	None	None
FBB-450	28-AV-12	9510	1½	1.2598	.0570	None	.0295	None	.0255 .0393④	.0255	.1377	None
FBB-450	456-2R	9531	1½	1.2598	.0570	.0551	.0393	.0334	None	None	None	None
FBC-318	63-AW-11R	9486	1¼	1.1417	.0491	None	.0255	None	.0275	.0373	.1574	None
FBC-318	63-AW-11R	9520	1¼	1.1417	.0491	None	.0255	None	.0275	.0373	.1574	None
FBC-318	28-AV-11R	9701	1¼	1.1811	.0511	None	.0275	None	.0236 .0373④	.0255	.0278	None
FBC-318	28-AV-11	9714	1¼	1.1811	.0511	None	.0275	None	.0236 .0373④	.0255	.1278	None
FBC-361	28-AV-11R	9703	1¼	1.2204	.0511	None	.0295	None	.0275 .0393④	.0255	.1377	None

① Outline number stamped on small metal disc, usually on the fuel bowl cover. ② See drawings for other flange dimensions.

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SPECIFICATIONS

Engine Model	Carburetor Model	Outline Number ①	Carburetor Size, Inches ②	Main Venturi Diameter, Inches	Main Jet, Inch	Compensator, Inch	Idling Jet, Inch	Power and Accelerating Jet, Inch	Power Jet, Inch	Accelerating Jet, Inch	Main Discharge Jet, Inch	Economizer Jet, Inch
INTERNATIONAL			*(Continued)*									
FBC-361	28-AV-11	9715	1¼	1.2204	.0511	None	.0295	None	.0275 .0393④	.0255	.1377	None
FBC-361	28-AV-11R	9814	1¼	1.2204	.0511	None	.0295	None	.0275 .0393④	.0255	.1377	None
FBC-401	63-AW-11R	9506	1¼	1.2204	.0530	None	.0255	None	.0255	.0354	.1574	None
FBC-401	63-AW-11R	9514	1¼	1.2204	.0530	None	.0255	None	.0255	.0354	.1574	None
FBC-401	28-AV-11R	9702	1¼	1.2204	.0530	None	.0295	None	.0255 .0433④	.0255	.1377	None
FBC-401	28-AV-11	9716	1¼	1.2204	.0530	None	.0295	None	.0255 .0433④	.0255	.1377	None
FBC-450	28-AV-12R	9681	1½	1.2598	.0570	None	.0295	None	.0255 .0393④	.0255	.1377	None
FBC-450	28-AV-12	9717	1½	1.2598	.0570	None	.0295	None	.0255 .0393④	.0255	.1377	None
FC-132	TU-3½-XV	7467	⅞	.7480	.0314	.0255	.0236	None	None	None	None	None
FC-132	TU-3½-XI	8244	⅞	.7480	.0314	.0255	.0236	None	None	None	None	None
FC-132	TU-3½-XI	8280	⅞	.7480	.0314	.0255	.0236	None	None	None	None	None
FC-132	TU-3½-XV	9435	⅞	.7480	.0314	.0255	.0236	None	None	None	None	None
FDB	IN-166D	6807	1½	1.1417	.0373	.0530	.0255	.0393	None	None	None	None
FEB	IN-166D	6808	1½	1.2204	.0373	.0551	.0255	.0433	None	None	None	None
GRD175	28-BV-10	9625	1¼	.9448	.0354	None	.0255	None	.0236 .0314④	.0255	.0787	None
GRD175	28-BV-10R	9679	1¼	.9448	.0354	None	.0255	None	.0236 .0314④	.0255	.0787	None
GRD175	63-AW-10R	9740	1¼	.9448	.0393	None	.0236	None	.0236	.0314	.1574	None
GRD175	28-BV-10	9765	1¼	.9448	.0354	None	.0255	None	.0275 .0314④	.0255	.0787	None
GRD214	28-BV-10	9604	1¼	1.0236	.0412	None	.0275	None	.0236 .0393④	.0255	.0984	None
GRD214	28-BV-10R	9634	1¼	1.0236	.0412	None	.0275	None	.0236 .0393④	.0255	.0984	None
GRD214	28-BV-10	9677	1¼	1.0236	.0433	None	.0275	None	.0236 .0433④	.0255	.0984	None
GRD214	63-AW-10R	9741	1¼	.9842	.0393	None	.0255	None	.0236	.0354	.1574	None
GRD214	63-AW-10	9764	1¼	.9842	.0393	None	.0255	None	.0236	.0354	.1574	None
GRD233	28-BV-11	9624	1¼	1.1811	.0452	None	.0275	None	.0275 .0472④	.0255	.1181	None
GRD233	28-BV-11R	9633	1¼	1.1811	.0452	None	.0275	None	.0275 .0472④	.0255	.1181	None
GRD233	63-AW-11	9763	1¼	1.0629	.0433	None	.0275	None	.0255	.0373	.1574	None
GRD233	63-AW-10	9764	1¼	.9842	.0393	None	.0255	None	.0236	.0354	.1574	None
GRD233	63-AW-11	9836	1¼	1.0629	.0433	None	.0275	None	.0334	.0373	.1574	None
GRD233	63-AW-11R	9842	1¼	1.0629	.0433	None	.0275	None	.0255	.0373	.1574	None
HD-174	23-AVX-9	8471	1¼	.9448	.0295	.0354	.0236	None	.0295	.0255	None	None
HD-174	28-AV-10	8587	1¼	.9448	.0433	None	.0255	None	.0236	.0255	.1181	None

Continued on next page

SPECIFICATIONS

Engine Model	Carburetor Model	Outline Number ①	Carburetor Size, Inches ②	Main Venturi Diameter, Inches	Main Jet, Inch	Compensator, Inch	Idling Jet, Inch	Power and Accelerating Jet, Inch	Power Jet, Inch	Accelerating Jet, Inch	Main Discharge Jet, Inch	Economizer Jet, Inch
INTERNATIONAL *(Continued)*												
HD-174	28-AV-10	9015	1¼	.9448	.0433	None	.0255	None	.0236	.0255	.1181	None
HD-174	63-AW-10RL	9184	1¼	.9448	.0373	None	.0236	None	.0255	.0314	.1278	None
HD-174	63-AW-10	9238	1¼	.9448	.0373	None	.0236	None	.0255	.0314	.1278	None
HD-174	63-AW-10R	9465	1¼	.9448	.0373	None	.0236	None	.0255	.0314	.1278	None
HD-174	28-AV-10R	9483	1¼	.9448	.0354	None	.0255	None	.0255 .0314④	.0255	.1181	None
HD-213	IN-185-Ex1	7143	1¼	1.0236	.0354	.0393	.0236	None	.0393	.0196	None	None
HD-213	IN-185-Ex1	7379	1¼	1.0236	.0354	.0393	.0236	None	.0393	.0196	None	None
HD-213	IN-185-Ex1	7564	1¼	1.1417	.0491	.0433	.0236	None	.0452	.0236	None	None
HD-213	23-BV-10	7956	1¼	1.0236	.0295	.0433	.0236	None	.0314	.0255	None	None
HD-213	23-AV-10	7987	1¼	1.0236	.0295	.0393	.0255	None	.0334	.0255	None	None
HD-213	23-BV-10	8420	1¼	1.0629	.0295	.0393	.0236	None	.0275	.0196	None	None
HD-213	23-AV-10	8542	1¼	1.0236	.0295	.0393	.0255	None	.0334	.0255	None	None
HD-213	63-AW-10	9133	1¼	.9842	.0393	None	.0236	None	.0196	.0354	.1377	None
HD-213	63-AW-10RL	9138	1¼	.9842	.0393	None	.0236	None	.0196	.0354	.1377	None
HD-213	28-AV-10	9440	1¼	1.0236	.0412	None	.0275	None	.0236 .0334④	.0255	.0984	None
HD-213	63-AW-10R	9443	1¼	.9842	.0393	None	.0236	None	.0196	.0354	.1377	None
HD-213	28-AV-10R	9473	1¼	1.0236	.0412	None	.0275	None	.0236 .0334④	.0255	.0984	None
HD-232	80-BV-10	7770	1¼	1.0629	.0433	.0452	.0295	None	.0295	.0236	None	None
HD-232	23-AV-10	7963	1¼	1.1023	.0314	.0452	.0255	None	.0334	.0275	None	None
HD-232	82-BV-10	8236	1¼	1.1811	.0433	.0452	.0295	None	.0472	.0275	None	None
HD-232	23-AV-10	8452	1¼	1.0236	.0393	.0530	.0255	None	.0295	.0275	None	None
HD-232	23-AV-10	8708	1¼	1.1023	.0314	.0452	.0255	None	.0334	.0275	None	None
HD-232	82-BV-10	8810	1¼	1.0629	.0354	.0452	.0295	None	.0433	.0275	None	None
HD-232	23-AV-10	9285	1¼	1.1023	.0314	.0452	.0255	None	.0334	.0275	None	None
HD-232	28-BV-10	9311	1¼	1.1811	.0511	None	.0275	None	.0373	.0255	.1181	None
HD-232	28-AV-10	9439	1¼	1.1023	.0452	None	.0275	None	.0255 .0373④	.0255	.1181	None
HD-232	63-AW-10	9509	1¼	1.1023	.0452	None	.0255	None	.0373	.0215	.1377	None
LYCOMING												
ASD	IN-186Ex2	6834	1¾	1.1811	.0570	.0452	.0275	None	.0334	.0275	None	None
ASE	IN-186Ex2	6834	1¾	1.1811	.0570	.0452	.0275	None	.0334	.0275	None	None
MACK												
CT	457	9288	1¾	1.3385	.0551	.0590	.0295	.0393	None	None	None	None
CU	456–1	8184	1½	1.1023	.0530	.0530	.0255	.0255	None	None	None	None
EY	158	9463	2	1.4960	.0748	.0767	.0275	.0433	None	None	None	None

④ The smaller dimension is the constant flow orifice while the larger size is the additional flow orifice when the power jet valve is open.

① Outline number stamped on small metal disc, usually on the fuel bowl cover. ② See drawings for other flange dimensions.

SPECIFICATIONS

Engine Model	Carburetor Model	Outline Number ①	Carburetor Size, Inches ②	Main Venturi Diameter, Inches	Main Jet, Inch	Compensator, Inch	Idling Jet, Inch	Power and Accelerating Jet, Inch	Power Jet, Inch	Accelerating Jet, Inch	Main Discharge, Jet, Inch	Economizer Jet, Inch
REO												
GC-228	28-BV-11RL	9062	1¼	1.1023	.0491	None	.0215	None	.0275	.0275	.1475	None
GC-228	28-BV-11R	9543	1¼	1.1023	.0491	None	.0295	None	.0275	.0275	.1475	None
GC-245	28-BV-11RL	9062	1¼	1.1023	.0491	None	.0215	None	.0275	.0275	.1475	None
GC-245	28-BV-11R	9543	1¼	1.1023	.0491	None	.0295	None	.0275	.0275	.1475	None
GC-245	28-BV-11	9818	1¼	1.1023	.0491	None	.0295	None	.0275	.0275	.1475	None
GC-288	28-BV-12RL	9065	1½	1.1023	.0491	None	.0215	None	.0314	.0275	.1475	None
GC-288	28-BV-12R	9550	1½	1.1023	.0511	None	.0275	None	.0275	.0275	.1377	None
GC-288	28-BV-12	9820	1½	1.1023	.0511	None	.0275	None	.0275	.0275	.1377	None
GC-310	28-BV-12RL	9065	1½	1.1023	.0491	None	.0215	None	.0314	.0275	.1475	None
GC-310	28-BV-12R	9550	1½	1.1023	.0511	None	.0275	None	.0275	.0275	.1377	None
GC-310	28BV12CRD	9577	1½	1.1023	.0511	None	.0295	None	.0314	.0275	.1475	None
GC-310	28-BV-12	9820	1½	1.1023	.0511	None	.0275	None	.0275	.0275	.1377	None
GC-310	28-BV-12	9826	1½	1.1811	.0570	None	.0295	None	.0354	.0275	.1475	None
WAUKESHA												
FC, FK	93½-OG	6384	⅞	.6299	.0314	.0314	.0177	None	None	None	None	None
FC, FK	324½	6695	1	.7480	.0275	.0314	.0236	.0236	None	None	None	None
FC, FK	193½	7260	⅞	.6299	.0314	.0314	.0177	None	None	None	None	None
FC, FK	193½	7266	⅞	.6299	.0314	.0314	.0177	None	None	None	None	None
FC, FK	TU-3½-XI	7392	⅞	.7480	.0354	.0236	.0236	None	None	None	None	None
FC	TU-3½-XV	7467	⅞	.7480	.0314	.0255	.0236	None	None	None	None	None
FC	124½-T	7888	1	.7480	.0314	.0373	.0236	None	None	None	None	None
FC, FK	93½-OG	7996	⅞	.6299	.0314	.0314	.0177	None	None	None	None	None
FC, FK	193½	8241	⅞	.6299	.0314	.0354	.0255	None	None	None	None	None
FC	TU-3½-XI	8244	⅞	.7480	.0314	.0255	.0236	None	None	None	None	None
FC	TU-3½-XI	8280	⅞	.7480	.0314	.0255	.0236	None	None	None	None	None
FC	TU-3½-XV	9435	⅞	.7480	.0314	.0255	.0236	None	None	None	None	None
FK	TU-3½-XI	7511	⅞	.7480	.0354	.0236	.0236	None	None	None	None	None
FK	TU-3½-XV	7577	⅞	.7480	.0314	.0255	.0236	None	None	None	None	None
XAH	124½-T	6682	1	.8661	.0393	.0393	.0236	None	None	None	None	None
XAH	TU-4V	7352	1	.9842	.0511	.0236	.0236	None	None	None	None	None
XAH	TU-4V	7396	1	.9842	.0530	.0236	.0236	None	None	None	None	None
XAH	TU-4V	7474	1	.9842	.0511	.0236	.0236	None	None	None	None	None
XAH	TU-4V	7476	1	.9842	.0530	.0236	.0236	None	None	None	None	None
XAH	124½-TO	8068	1	.7480	.0472	.0551	.0236	None	None	None	None	None
6BA	157	5981	1¾	1.2598	.0648	.0629	.0295	.0275	None	None	None	None
6BA	157	5981X1	1¾	1.2598	.0648	.0629	.0295	.0275	None	None	None	None
6BA	IN-185½Ex1	7512	1¾	1.1023	.0551	.0452	.0275	None	.0314	.0275	None	None
6BA	457	7817	1¾	1.2598	.0648	.0629	.0295	.0275	None	None	None	None
6BA	457	7818	1¾	1.2598	.0648	.0629	.0295	.0275	None	None	None	None
6BA	457-2	8081	1¾	1.2204	.0590	.0609	.0295	.0295	None	None	None	None
6BK	IN-186-Ex2	6834X1	1¾	1.1811	.0570	.0334	.0275	None	.0334	.0275	None	None
6BK	IN-186-Ex2	6995	1¾	1.1811	.0590	.0452	.0275	None	.0334	.0275	None	None
6BK	IN-186-Ex2	7008	1¾	1.1811	.0590	.0452	.0275	None	.0334	.0275	None	None

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SPECIFICATIONS

Engine Model	Carburetor Model	Outline Number ①	Carburetor Size, Inches ②	Main Venturi Diameter, Inches	Main Jet, Inch	Compensator, Inch	Idling Jet, Inch	Power and Accelerating Jet, Inch	Power Jet, Inch	Accelerating Jet, Inch	Main Discharge Jet, Inch	Economizer Jet, Inch
WAUKESHA *(Continued)*												
6BK	95-G	7037	1¼	.9842	.0530	.0452	.0215	None	None	None	None	None
6BK	155	7194	1¼	.9448	.0472	.0472	.0255	.0255	None	None	None	None
6BK	IN-186Ex1	7261	1¾	1.1811	.0491	.0412	.0295	None	.0334	.0275	None	None
6BK	155	7264	1¼	.9448	.0472	.0472	.0255	.0255	None	None	None	None
6BK	IN-186Ex1	7418	1¾	1.1811	.0551	.0452	.0275	None	.0295	.0275	None	None
6BK	455	7805	1¼	.9448	.0472	.0472	.0255	.0255	None	None	None	None
6BK	23-AV-12	7878	1½	1.1811	.0373	.0491	.0275	None	.0314	.0255	None	None
6BK	23-BV-12	7928	1½	1.1811	.0373	.0491	.0275	None	.0314	.0255	None	None
6BK	23-BV-12	8274	1½	1.1811	.0393	.0491	.0275	None	.0314	.0255	None	None
6BK	23-BV-12	8299	1½	1.1811	.0452	.0491	.0275	None	.0314	.0255	None	None
6BK	23-AV-12	8325	1½	1.1811	.0373	.0491	.0275	None	.0314	.0255	None	None
6BK	455	8391	1¼	.9448	.0472	.0472	.0255	.0255	None	None	None	None
6BK	23-AV-12	8506	1½	1.1417	.0393	.0452	.0275	None	.0334	.0275	None	None
6BK	455	8641	1¼	.9448	.0472	.0472	.0255	.0255	None	None	None	None
6BK	456-2	8666	1½	1.0629	.0511	.0511	.0295	.0295	None	None	None	None
6BK	456B	8894	1½	1.0236	.0530	.0511	.0275	.0295	None	None	None	None
6BK	28-BV-12	9573	1½	1.1811	.0629	None	.0236	None	.0334	.0255	.1475	None
6BL	IN-185Ex1	6829	1¼	1.2204	.0530	.0412	.0255	None	.0452	.0255	None	None
6BL	IN-186-Ex2	6834XI	1¾	1.1417	.0551	.0452	.0275	None	.0314	.0275	None	None
6BL	155	7264	1¼	.9448	.0472	.0472	.0255	.0255	None	None	None	None
6BL	IN-186Ex1	7533	1¾	1.1417	.0570	.0452	.0275	None	.0314	.0275	None	None
6BL	20-BV-11	7540	1¼	1.0629	.0354	.0511	.0275	None	.0452	.0255	None	None
6BL	455	7636	1¼	.9448	.0472	.0472	.0255	.0255	None	None	None	None
6BL	455	7805	1¼	.9448	.0472	.0472	.0255	.0255	None	None	None	None
6BL	23-BV-12	7958	1½	1.0629	.0334	.0452	.0255	None	.0255	.0236	None	None
6BL	23-AV-11	8041	1¼	1.0629	.0334	.0452	.0255	None	.0255	.0275	None	None
6BL	23-AV-12	8325	1½	1.1811	.0373	.0491	.0275	None	.0314	.0255	None	None
6BL	456-2	8666	1½	1.0629	.0511	.0511	.0295	.0295	None	None	None	None
6BL	455	8891	1¼	.9448	.0472	.0472	.0255	.0255	None	None	None	None
6BL	455	9559	1¼	.9448	.0472	.0472	.0255	.0255	None	None	None	None
6BM	IN-185½Ex1	7497	1¼	1.2204	.0530	.0412	.0275	None	.0452	.0255	None	None
6BM	23-BV-12	7928	1½	1.1811	.0373	.0491	.0275	None	.0314	.0255	None	None
6BM	23-AV-12	8505	1½	1.1417	.0373	.0452	.0275	None	.0314	.0275	None	None
6BM	456-2	8666	1½	1.0629	.0511	.0511	.0295	.0295	None	None	None	None
6BZ	23-AV-12	8325	1½	1.1811	.0373	.0491	.0275	None	.0314	.0255	None	None
6BZ	23-AV-12	8506	1½	1.1417	.0393	.0452	.0275	None	.0334	.0275	None	None
6BZ	28-AV-12	8523	1½	1.2598	.0412	.0511	.0275	None	.0334	.0255	None	None
6BZ	23-AV-12	8563	1½	1.2598	.0412	.0511	.0275	None	.0334	.0255	None	None
6BZ	455	8705	1¼	1.0236	.0530	.0511	.0255	.0255	None	None	None	None
6MK	156	6129	1½	1.0629	.0530	.0530	.0295	.0255	None	None	None	None
6MK	96-AG	7149	1½	1.1023	.0609	.0472	.0236	None	None	None	None	None
6MK	IN-186-Ex1	7526	1¾	1.2598	.0511	.0472	.0354	None	.0491	.0295	None	None
6MK	456-2	7610	1½	1.0236	.0491	.0511	.0295	.0255	None	None	None	None

① Outline number stamped on small metal disc, usually on the fuel bowl cover. ② See drawings for other flange dimensions.

Continued on next page

SPECIFICATIONS

WAUKESHA *(Continued)*

Engine Model	Carburetor Model	Outline Number ①	Carburetor Size, Inches ②	Main Venturi Diameter, Inches	Main Jet, Inch	Compensator, Inch	Idling Jet, Inch	Power and Accelerating Jet, Inch	Power Jet, Inch	Accelerating Jet, Inch	Main Discharge Jet, Inch	Economizer Jet, Inch
6MK	456	7639	1½	1.0629	.0530	.0530	.0295	.0255	None	None	None	None
6MK	455–2	7679	1¼	.9842	.0511	.0491	.0275	.0255	None	None	None	None
6MK	20-BV-12	7716	1½	1.1417	.0334	.0452	.0255	None	.0688	.0275	None	None
6MK	456	7814	1½	1.0236	.0551	.0511	.0275	.0255	None	None	None	None
6MK	456	7815	1½	1.0236	.0551	.0511	.0275	.0255	None	None	None	None
6MK	23-AV-12	7918	1½	1.2598	.0412	.0491	.0275	None	.0334	.0255	None	None
6MK	20-BV-12	8054	1½	1.1417	.0393	.0472	.0275	None	.0551	.0275	None	None
6MK	456–2	8262	1½	1.1023	.0590	.0551	.0255	.0255	None	None	None	None
6MK	23-AV-11RL	8929	1¼	1.2598	.0393	.0491	.0295	None	.0334	.0255	None	None
6MKR	IN-167	7351	1¾	1.2992	.0491	.0491	.0275	.0433	None	None	None	None
6MKR	20-BV-12	8054	1½	1.1417	.0393	.0472	.0275	None	.0551	.0275	None	None
6MKR	IN-167	9401	1¾	1.2204	.0491	.0530	.0275	.0433	None	None	None	None
6MKR	28-BV-12R	9564	1½	1.1417	.0551	None	.0255	None	.0334	.0275	.1377	None
6ML	156	5980	1½	1.0236	.0551	.0511	.0275	.0255	None	None	None	None
6ML	156	5980X1	1½	1.0236	.0551	.0511	.0275	.0255	None	None	None	None
6ML	155	6640	1¼	.9842	.0472	.0491	.0295	.0255	None	None	None	None
6ML	156	6654	1½	1.0629	.0530	.0530	.0295	.0255	None	None	None	None
6ML	156	6709	1½	1.0629	.0530	.0530	.0295	.0255	None	None	None	None
6ML	456	7626	1½	1.0629	.0530	.0530	.0295	.0255	None	None	None	None
6ML	455	7807	1¼	.9842	.0472	.0491	.0295	.0255	None	None	None	None
6ML	456	7814	1½	1.0236	.0551	.0511	.0275	.0255	None	None	None	None
6ML	456	7815	1½	1 0236	.0551	.0511	.0275	.0255	None	None	None	None
6MS	155	6237	1¼	.9842	.0472	.0491	.0295	.0255	None	None	None	None
6MS	455–1	7632	1¼	.9842	.0472	.0491	.0295	.0255	None	None	None	None
6MS	455–2	7635	1¼	.9842	.0472	.0491	.0295	.0255	None	None	None	None
6MS	455–2	7679	1¼	.9842	.0511	.0491	.0275	.0255	None	None	None	None
6MS	455	7807	1¼	.9842	.0472	.0491	.0295	.0255	None	None	None	None
6MZ	456–2	7610	1½	1.0236	.0491	.0511	.0295	.0255	None	None	None	None
6MZ	456–2	7678	1½	1.0629	.0530	.0530	.0354	.0255	None	None	None	None
6MZ	20-BV-12	7716	1½	1.1417	.0334	.0452	.0255	None	.0688	.0275	None	None
6MZ	456	7812	1½	1.0629	.0590	.0570	.0295	.0255	None	None	None	None
6MZ	20-BV-12	8054	1½	1.1417	.0393	.0472	.0275	None	.0551	.0275	None	None
6MZ	23-AV-12	8086	1½	1.1811	.0373	.0491	.0275	None	.0314	.0255	None	None
6MZ	456–2	8262	1½	1.1023	.0590	.0551	.0255	.0255	None	None	None	None
6MZ	IN-167	8278	1¾	1.2992	.0472	.0452	.0236	.0452	None	None	None	None
6MZ	23-AV-12	8360	1½	1.1811	.0393	.0491	.0275	None	.0314	.0255	None	None
6MZ	23-AV-12	8563	1½	1.2598	.0412	.0511	.0275	None	.0334	.0255	None	None
6MZ	IN-167	8801	1¾	1.2992	.0491	.0491	.0275	.0433	None	None	None	None
6MZR	IN-167	7351	1¾	1.2204	.0412	.0472	.0295	.0393	None	None	None	None
6MZR	456	7812	1½	1.0629	.0590	.0570	.0295	.0255	None	None	None	None
6MZR	IN-167	8278	1¾	1.2992	.0472	.0452	.0236	.0452	None	None	None	None
6MZR	23-AV-12	8337	1½	1.0629	.0393	.0393	.0275	None	.0275	.0255	None	None
6MZR	IN-167	8778	1¾	1.2204	.0412	.0472	.0295	.0393	None	None	None	None
6MZR	IN-167	8801	1¾	1.2992	.0491	.0491	.0275	.0433	None	None	None	None
6MZR	IN-167SJ	9652	1¾	1.2598	.0609	None	.0354	None	.0354	.0433	.1377	None

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SPECIFICATIONS

Engine Model	Carburetor Model	Outline Number ①	Carburetor Size, Inches ②	Main Venturi Diameter, Inches	Main Jet, Inch	Compensator, Inch	Idling Jet, Inch	Power and Accelerating Jet, Inch	Power Jet, Inch	Accelerating Jet, Inch	Main Discharge Jet, Inch	Economizer Jet, Inch
WAUKESHA *(Continued)*												
6RB	158	6291	2	1.4566	.0688	.0767	.0295	.0295	None	None	None	None
6RB	458	6521	2	1.3779	.0727	.0688	.0314	.0354	None	None	None	None
6RB	158	6805	2	1.4960	.0807	.0748	.0295	.0295	None	None	None	None
6RB	458	7637	2	1.2598	.0629	.0609	.0295	.0295	None	None	None	None
6RB	458	7700	2	1.4960	.0826	.0787	.0354	.0354	None	None	None	None
6RB	458	7823	2	1.4960	.0807	.0748	.0295	.0295	None	None	None	None
6RB	458	7824	2	1.4566	.0688	.0767	.0295	.0295	None	None	None	None
6RB	458	7868	2	1.4960	.0807	.0748	.0295	.0295	None	None	None	None
6RBR	458	6521	2	1.3779	.0727	.0688	.0314	.0354	None	None	None	None
6RBR	458	7700	2	1.4960	.0826	.0787	.0354	.0354	None	None	None	None
6SRK	157	6451	1¾	1.1811	.0570	.0609	.0295	.0295	None	None	None	None
6SRK	157	7217	1¾	1.1811	.0570	.0609	.0295	.0295	None	None	None	None
6SRK	IN-167	7351	1¾	1.2992	.0472	.0452	.0236	.0452	None	None	None	None
6SRK	IN-167	7597	1¾	1.2992	.0472	.0452	.0236	.0452	None	None	None	None
6SRK	457-2	7614	1¾	1.1811	.0570	.0609	.0295	.0295	None	None	None	None
6SRK	458	7637	2	1.2598	.0629	.0609	.0295	.0295	None	None	None	None
6SRK	457-2	7687	1¾	1.1417	.0590	.0551	.0295	.0295	None	None	None	None
6SRK	457-2	7772	1¾	1.2992	.0629	.0629	.0295	.0354	None	None	None	None
6SRK	457	7819	1¾	1.1811	.0570	.0609	.0295	.0295	None	None	None	None
6SRK	457	7820	1¾	1.1811	.0570	.0609	.0295	.0295	None	None	None	None
6SRK	IN-167	8278	1¾	1.2992	.0472	.0452	.0236	.0452	None	None	None	None
6SRK	IN-167	9137	1¾	1.4173	.0590	.0609	.0275	.0433	None	None	None	None
6SRKR	IN-167	7351	1¾	1.2992	.0472	.0452	.0236	.0452	None	None	None	None
6SRKR	IN-167	7597	1¾	1.2992	.0472	.0452	.0236	.0452	None	None	None	None
6SRKR	456-2	7678	1½	1.2598	.0590	.0590	.0314	.0412	None	None	None	None
6SRKR	457-2	7687	1¾	1.1417	.0590	.0551	.0295	.0295	None	None	None	None
6SRKR	IN-167	8278	1¾	1.2992	.0472	.0452	.0236	.0452	None	None	None	None
6SRKR	IN-167-SJ	9825	1¾	1.3385	.0688	None	.0314	None	.0354	.0472	.1377	None
6SRL	IN-167	7597	1¾	1.2992	.0472	.0452	.0236	.0452	None	None	None	None
6SRL	456-2	7667	1½	1.0629	.0511	.0530	.0295	.0255	None	None	None	None
6SRL	456-2	7678	1½	1.0629	.0530	.0530	.0354	.0255	None	None	None	None
6SRL	456-2	7696	1½	1.0629	.0511	.0530	.0295	.0255	None	None	None	None
6SRL	456	7811	1½	1.0629	.0530	.0530	.0295	.0255	None	None	None	None
6SRL	456-2	8262	1½	1.1417	.0609	.0570	.0255	.0255	None	None	None	None
6SRL	IN-167	8278	1¾	1.2992	.0472	.0452	.0236	.0452	None	None	None	None
6SRLR	IN-167	7351	1¾	1.2992	.0570	.0530	.0275	.0373	None	None	None	None
6SRLR	456-2	7678	1½	1.0629	.0530	.0530	.0354	.0255	None	None	None	None
6SRLR	IN-167	8278	1¾	1.2992	.0472	.0452	.0236	.0452	None	None	None	None
6SRS	156	6104	1½	1.0629	.0530	.0530	.0295	.0255	None	None	None	None
6SRS	456-2	7678	1½	1.0629	. 530	.0530	.0354	.0255	None	None	None	None
6SRS	456	7689	1½	1.0629	.0530	.0530	.0295	.0255	None	None	None	None
6WAK	158-MV	9094	2	.9055	.0648	.0866	.0295	.0215	None	None	None	None
6-90	456-2	7762	1½	1.1023	.0530	.0530	.0236	.0275	None	None	None	None

① Outline number stamped on small metal disc, usually on the fuel bowl cover. ② See drawings for other flange dimensions.

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SPECIFICATIONS

Engine Model	Carburetor Model	Outline Number ①	Carburetor Size, Inches ②	Main Venturi Diameter, Inches	Main Jet, Inch	Compensator, Inch	Idling Jet, Inch	Power and Accelerating Jet, Inch	Power Jet, Inch	Accelerating Jet, Inch	Main Discharge, Jet, Inch	Economizer Jet, Inch
WAUKESHA	*(Continued)*											
6-90	456	7813	1½	1.1023	.0551	.0530	.0236	.0275	None	None	None	None
6-90	456-2	8262	1½	1.1023	.0551	.0530	.0236	.0275	None	None	None	None
6-110	IN-186EXx2	7032	1¾	1.4173	.0688	.0433	.0314	None	.0393	.0275	None	None
6-110	IN-167	7351	1¾	1.4173	.0551	.0530	.0255	.0412	None	None	None	None
6-110	IN-167	7763	1¾	1.3779	.0491	.0511	.0275	.0433	Nnoe	None	None	None
6-110	IN-167	7845	1¾	1.2992	.0570	.0530	.0275	.0373	None	None	None	None
6-110	IN-167	7846	1¾	1.2204	.0570	.0491	.0275	.0373	None	None	None	None
6-110	IN-167-G	7848	1¾	1.2992	.0570	.0530	.0275	.0373	None	None	None	None
6-110	IN-167	8278	1¾	1.2992	.0472	.0452	.0236	.0452	None	None	None	None
6-125	IN-166-D	6821	1½	1.0236	.0295	.0491	.0255	.0393	None	None	None	None
6-125	IN-166-DG	6977	1½	1.0236	.0295	.0491	.0255	.0393	None	None	None	None
6-125	IN-166-D	7376	1½	1.0236	.0295	.0491	.0255	.0393	None	None	None	None
6-125	IN-166-D	7391	1½	1.0236	.0295	.0491	.0255	.0393	None	None	None	None
6-125	IN-167	8042	1¾	1.3385	.0530	.0551	.0334	.0472	None	None	None	None
6-125	IN-167	8104	1¾	1.2204	.0570	.0629	.0275	.0275	None	None	None	None
6-125	IN-167	8278	1¾	1.2992	.0472	.0452	.0236	.0452	None	None	None	None
WHITE												
1A	458	8111	2	1.2992	.0688	.0688	.0314	.0393	None	None	None	None
2A	455	8146	1¼	.8661	.0412	.0412	.0236	.0215	None	None	None	None
4A	455	7900	1¼	.9448	.0412	.0433	.0295	.0275	None	None	None	None
5A-580	458	7898	2	1.4173	.0708	.0727	.0334	.0433	None	None	None	None
5A-580	458	7899	2	1.4566	.0708	.0688	.0334	.0433	None	None	None	None
5A-580	458	7901	2	1.3779	.0669	.0688	.0334	.0393	None	None	None	None
5A-580	458	7902	2	1.3779	.0669	.0688	.0334	.0393	None	None	None	None
7A	457	7910	1¾	1.2598	.0570	.0530	.0295	.0354	None	None	None	None
8A	IN-185Ex1	6939	1¼	1.1811	.0511	.0412	.0295	None	.0334	.0236	None	None
9A	20-AV-11	7522	1¼	1.1023	.0412	.0433	.0255	None	.0452	.0275	None	None
11A-270	20-AV-11	7521	1¼	1.1023	.0412	.0433	.0255	None	.0452	.0275	None	None
11A-270	755½-P	8069	1¼	1.0236	.0472	.0511	.0314	.0295	None	None	None	None
11A-270	755½-P	8264	1¼	1.0236	.0452	.0452	.0255	.0295	None	None	None	None
11A-270	20-AV-11	8285	1¼	1.1023	.0393	.0433	.0255	None	.0393	.0275	None	None
11A-270	20-AV-11	8342	1¼	1.1023	.0393	.0433	.0255	None	.0393	.0275	None	None
11A-270	20-AV-11	8730	1¼	1.1417	.0393	.0452	.0255	None	.0412	.0275	None	None
11A-270	755½-P	8823	1¼	1.1023	.0491	.0472	.0255	.0354	None	None	None	None
11A-270	755½-P	9298	1¼	1.1023	.0491	.0472	.0255	.0354	None	None	None	None
11A-270	755½-P	9446	1¼	1.1023	.0491	.0472	.0255	.0354	None	None	None	None
12AB	20-BV-10	7950	1¼	1.0629	.0334	.0433	.0255	None	.0491	.0295	None	None
13A-303	20-AV-11	8248	1¼	1.1023	.0412	.0433	.0255	None	.0433	.0275	None	None
14A-396	157	7559	1¾	1.1023	.0491	.0511	.0255	.0334	None	None	None	None
15A-460	457	8502	1¾	1.2598	.0511	.0648	.0295	.0393	None	None	None	None
15A-460	457	8504	1¾	1.2598	.0511	.0648	.0295	.0393	None	None	None	None
15A-460	457	8639	1¾	1.3779	.0609	.0708	.0236	.0433	None	None	None	None

Continued on next page

SPECIFICATIONS

Engine Model	Carburetor Model	Outline Number ①	Carburetor Size, Inches ②	Main Venturi Diameter, Inches	Main Jet, Inch	Compensator, Inch	Idling Jet, Inch	Power and Accelerating Jet, Inch	Power Jet, Inch	Accelerating Jet, Inch	Main Discharge Jet, Inch	Economizer Jet, Inch
WHITE *(Continued)*												
16A-318	755½-P	7555	1¼	1.1023	.0511	.0511	.0314	.0314	None	None	None	None
16A-318	20-AV-11	8248	1¼	1.1023	.0412	.0433	.0255	None	.0433	.0275	None	None
16A-318	755½-P	8263	1¼	1.1023	.0511	.0511	.0255	.0314	None	None	None	None
16A-318	20-AV-11	8731	1¼	1.1811	.0393	.0412	.0255	None	.0491	.0275	None	None
16A-318	755½-P	8865	1¼	1.1811	.0491	.0452	.0255	.0472	None	None	None	None
18A-434	457	7910	1¾	1.2598	.0570	.0530	.0295	.0354	None	None	None	None
21A-250	23-AV-10	8125	1¼	1.0629	.0354	.0393	.0255	None	.0255	.0255	None	None
25A-529	457	8639	1¾	1.3779	.0609	.0708	.0236	.0433	None	None	None	None
30A-318	755½-P	7555	1¼	1.1023	.0511	.0511	.0314	.0314	None	None	None	None
30A-318	20-AV-11	8248	1¼	1.1023	.0412	.0433	.0255	None	.0433	.0275	None	None
30A-318	755½-P	8263	1¼	1.1023	.0511	.0511	.0255	.0314	None	None	None	None
30A-318	20-AV-11	8731	1¼	1.1811	.0393	.0412	.0255	None	.0491	.0275	None	None
30A-318	755½-P	8865	1¼	1.1811	.0491	.0452	.0255	.0472	None	None	None	None
205	324½-XO	8494	1¼	.8661	.0354	.0393	.0255	.0314	None	None	None	None
221	324½-XO	8593	1¼	.8267	.0334	.0393	.0215	.0295	None	None	None	None
WHITE HORSE												
32A	28BVX-9CRL	9061	1¼	.9055	.0393	None	.0275	None	.0215	④	.1278	None
32A	28BVX9CR	9556	1¼	.9055	.0393	None	.0275	None	.0215	None	.1278	None
35A	28BVX9CR	9766	1¼	.9055	.0433	None	.0236	None	.0215	.0236	.0984	None

① Outline number stamped on small metal disc, usually on the fuel bowl cover. ② See drawings for other flange dimensions.

④ Jet is installed but may be either plugged or not drilled.

ZENITH CONVERSION TABLE

Jet No.	Millimeters	Inches	Jet No.	Millimeters	Inches	Jet No.	Millimeters	Inches	Jet No.	Millimeters	Inches
9	.45	.0177	27	1.35	.0530	45	2.25	.0885	63	3.15	.1239
10	.50	.0196	28	1.40	.0551	46	2.30	.0905	64	3.20	.1259
11	.55	.0215	29	1.45	.0570	47	2.35	.0924	65	3.25	.1278
12	.60	.0236	30	1.50	.0590	48	2.40	.0944	66	3.30	.1299
13	.65	.0255	31	1.55	.0609	49	2.45	.0963	67	3.35	.1318
14	.70	.0275	32	1.60	.0629	50	2.50	.0984	68	3.40	.1338
15	.75	.0295	33	1.65	.0648	51	2.55	.1003	69	3.45	.1357
16	.80	.0314	34	1.70	.0669	52	2.60	.1023	70	3.50	.1377
17	.85	.0334	35	1.75	.0688	53	2.65	.1042	71	3.55	.1396
18	.90	.0354	36	1.80	.0708	54	2.70	.1062	72	3.60	.1417
19	.95	.0373	37	1.85	.0727	55	2.75	.1081	73	3.65	.1436
20	1.00	.0393	38	1.90	.0748	56	2.80	.1102	74	3.70	.1456
21	1.05	.0412	39	1.95	.0767	57	2.85	.1121	75	3.75	.1475
22	1.10	.0433	40	2.00	.0787	58	2.90	.1141	76	3.80	.1496
23	1.15	.0452	41	2.05	.0807	59	2.95	.1160	77	3.85	.1515
24	1.20	.0472	42	2.10	.0826	60	3.00	.1181	78	3.90	.1535
25	1.25	.0491	43	2.15	.0845	61	3.05	.1200	79	3.95	.1554
26	1.30	.0511	44	2.20	.0866	62	3.10	.1220	80	4.00	.1574

ZENITH SETTINGS

Carburetor Series	Economizer (Power Jet) Number	Accelerating Pump Piston Travel, Inches	Float Setting, Inches	Fuel Level Inches ①	Idle Screw Setting, Turns Open	Power Jet Piston to Operate at, Inches Vacuum	Main Jet Number and Setting ②
20 ⑥	C97-1 ③	25/64 ⑩	1½	25/32	1	4 to 6 ⑪	1 ⑫
20 ⑦	C97-2 ③	5/16 ⑩	1½	25/32	1	4 to 6 ⑪	1 ⑫
23 ⑥	C97-1 ⑧	25/64 ⑩	1½	25/32	1	4 to 6 ⑪	1 Turn C71-12
23 ⑦	C97-2 ⑧	5/16 ⑩	1½	25/32	1	4 to 6 ⑪	1 Turn C71-12
28 ⑥	C97-1 ⑧	5/16 ⑬	1½	25/32	1	4 to 6 ⑪	1 Turn C71-22
28 ⑦	C97-2 ⑧	5/16 ⑬	1½	25/32	1	4 to 6 ⑪	1 Turn C71-22
61	None	None	1 5/32	7/16	1	None	2 Turns C71-21
62	None	None	1 39/64	29/32	1	None	2 Turns C71-21 ⑭
63-10	C97-15 ③	⑬	1 39/64	55/64	1	5 to 6 ⑤	2 Turns C71-24
63-11, 12	C97-10 ⑧	⑬	1 39/64	55/64	1	5 to 6 ⑤	2 Turns C71-25
80	C97-7 ③	③	1½	25/32	¾	4 to 6 ⑪	1½ Turns C71-12
82	C97-7 ③	③	1½	25/32	¾	4 to 6 ⑪	1½ Turns C71-12
93½	None	None	¼	35/64	1½	None	1 Turn C71-5
94	None	None	1 23/32	5/8	1¼	None	1½ Turns C71-5
95G	None	None	1 23/32	5/8	1	None	1½ Turns D6069
96	None	None	1 39/64	5/8	1¼	None	1 Turn C46-30
98	None	None	1 13/16	5/8	1¼	None	1 Turn C46-30
124½	None	None	⑮	35/64	1	None	1 Turn C71-5
150	C97-10 ③	⑤	2⅛	5/8	1	5 to 6 ⑤	1½ Turns ⑯
161	None	None	1 5/32	7/16	1	None	2 Turns C71-21
193½	None	None	¼	35/64	1½	None	1 Turn C71-5
324½	C97-15 ③	⑤	⑮	35/64	1	5 to 6 ⑤	1 Turn C71-5
450	C97-10 ③	⑤	2⅛	5/8	1	5 to 6 ⑤	1½ Turns ⑯
550	C97-10 ③	⑤	2⅛	5/8	1	5 to 6 ⑤	1½ Turns ⑯
755½	C97-10 ③	⑤	2⅛	33/64	1	5 to 6 ⑤	1½ Turns C71-5
756	C97-10 ③	⑤	2⅛	33/64	1	5 to 6 ⑤	1½ Turns C71-5
IN158	C97-10 ③	③	2 25/64	5/8	1	5 to 6 ⑤	1½ Turns D6682
IN167	C97-10 ③	③	2⅛	5/8	1¼	5 to 6 ⑤	1½ Turns C71-5
IN180 ⑥	C97-13 ⑧	27/64 ⑨	1 13/32	43/64	1	6 to 8	1¼ Turns C71-5
IN180 ⑦	D8038 ③	27/64 ⑨	1 13/32	43/64	1	6 to 8	1¼ Turns C71-5
TU	None	None	1⅛	9/16	¾	None	④

① Fuel level measurement is taken from the surface of the bowl—without gasket.

② Some of these units are equipped with fixed main jets. If an adjustable jet is desired, the part number and turns to open are given.

③ Not adjustable.

④ If an adjustable main jet is to be installed, the new type fuel bowl cover must also be used.

⑤ Power jet piston, economizer piston and accelerating piston is one and the same assembly—not adjustable.

⑥ With vacuum-operated power jet system.

⑦ With mechanically-operated power jet system.

⑧ Not adjustable. Some applications use a constant feed power jet valve with a sized hole through the valve needle. With this type, the size marked on the valve must be specified.

⑨ Pump piston travel may be lengthened or shortened by changing pump stroke spacer (part No. CR-37).

⑩ To change stroke, pump piston, lever and link must be changed.

⑪ Part No. C91-1 with bronze spring is generally used. A stronger brass spring (Part No. C91-2) is used on some units.

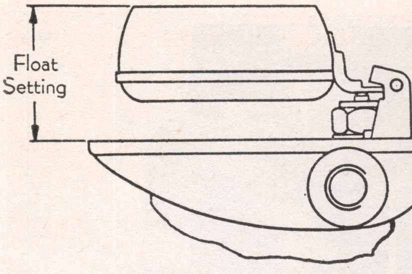
⑫ For early production units, use C71-1, size 7/16″ by 20 late production, C71-12, size ½ by 20.

⑬ To change stroke, pump piston must be removed. There are 3 grooves on the piston rod, the center groove gives ¾ stroke and is the standard setting, the end groove gives the shortest stroke and the third groove the longest.

⑭ Carburetor No. 62-AJ-12 uses Part No. 71-25 main jet adjustment assembly.

⑮ Four types of floats used: use fuel level setting for best results.

⑯ Main jet number C71-3 is used on 157, 158, 455, 457, 458, 557 and 558 units. Jet number C71-5 used on 154, 155, 156, 554, 555 and 556. Jet number C71-6 is used on 456 carburetors.



FLOAT SETTING

Carburetor	Inches
20, 23, 28 Series	1½
20-16	2 3/32
22AX8 (C85-19 and C85-68 floats)	1 9/16
51 Series	1½
61 and 161 Series	1 5/32
62 Series	1 39/64
63-10, 11, 12 Series	1 39/64
63-14, 16 Series	1 57/64
80-82 Series	1½
88ADA11, 89ADA11	2 3/32
94, 94½, 114½	1 23/32
96, 96½	1 39/64
98	1 13/16
124½, 324½ (C85-47 float & baffle)	1 1/16
124½, 324½ (D9138 float)	1 7/32
95G	1 23/32
IN180 Series	1 13/32
TU4C	1⅛

ZENITH 20 SERIES

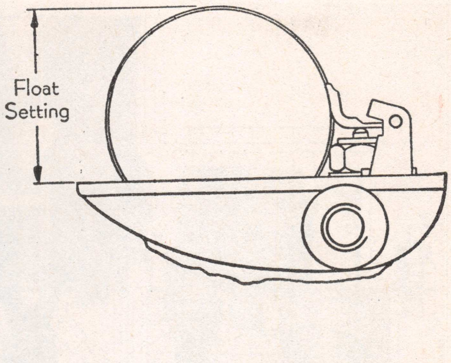
This carburetor is a downdraft, single-barrel type, with a mechanically-operated accelerating pump and a manifold vacuum-controlled power system. In some carburetors of this series, the power-jet system is mechanically operated by an arm attached to the accelerating pump rod. A removable venturi tube adjusts the air capacity. A secondary venturi is also used. The regular Zenith system of fuel jets is used, both the main jet and the compensator jet supplying fuel at intermediate speeds. The main jet is located at the lower end of the discharge channel and its fuel is discharged through a slot in the secondary venturi. This jet is more effective at high speed. The compensator jet is located in the fuel bowl. Fuel from this jet flows into a well, where it is mixed with air admitted by a well vent, and discharged into the air stream. This jet is more effective at low speed. The idle jet receives its fuel from the compensator channel and is mixed with air, admitted and regulated by the idle adjusting needle. The mixture then passes down a channel to the priming plug and is discharged into the manifold. The power jet system is controlled by manifold vacuum acting upon a vacuum piston. At normal speeds, the vacuum is high and the piston is kept in an up position, allowing a power jet valve to remain closed. On a heavy pull, with wide-open throttle, manifold vacuum drops and allows the power jet piston to lower and open the power jet valve. This allows additional fuel to flow through the power jet, located beneath the power jet valve, to supply a richer mixture for full power.

The accelerating pump is operated from the throttle shaft. When the throttle is opened, the pump piston moves down. When closing the throttle, the pump piston moves up, and draws fuel into the cylinder through the check valve below the piston. As the piston moves downward, the fuel is forced past a needle valve and through the accelerating jet, into the air stream. Located above the needle valve is a disc check valve which admits air to the accelerating jet channel when the fuel from the pump cylinder has been discharged.

Adjustments: To install the main jet, proceed as follows: Place main jet gasket, cap jet base, with larger end down, cap jet calibration, cap jet tip and cap jet tip gasket, in position on the main jet (in the order named). Hold the bowl upright and install the above group as one unit. If main jet adjustment is used, set one turn open. The power jet seats in the housing, and the copper gasket is placed on top of the jet and then the power jet valve should be tightened firmly in place, but not tight enough to crush the soft copper gasket.

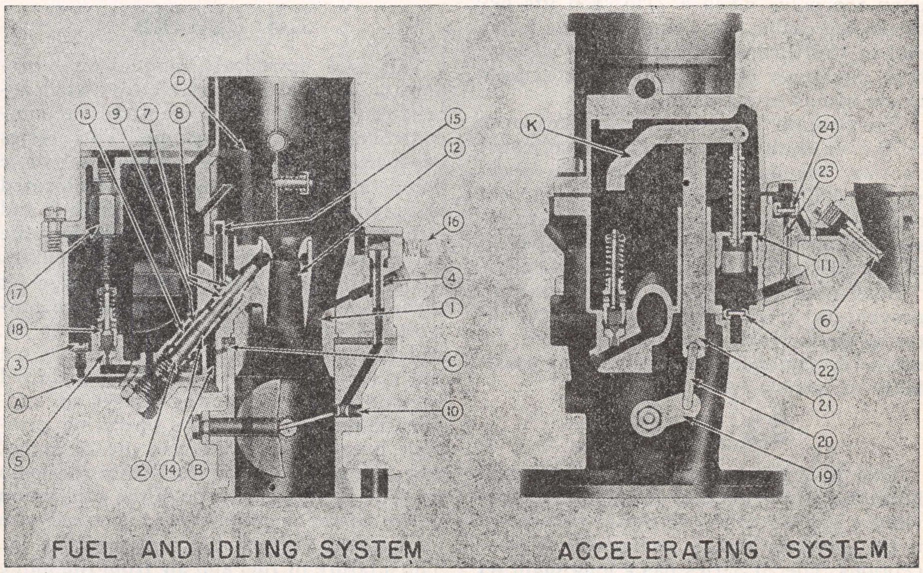
Float height setting should be checked with the cover assembly held upside down and only the weight of the float holding the needle closed. The float setting is 1½ inches. The fuel level in the bowl should be 25/32 of an inch.

The idling adjusting needle is an air adjustment, turning out, or anti-clockwise, admits more air and allows a leaner mixture. Turning in admits less air or a richer mixture. A preliminary setting should be one turn from its seat.



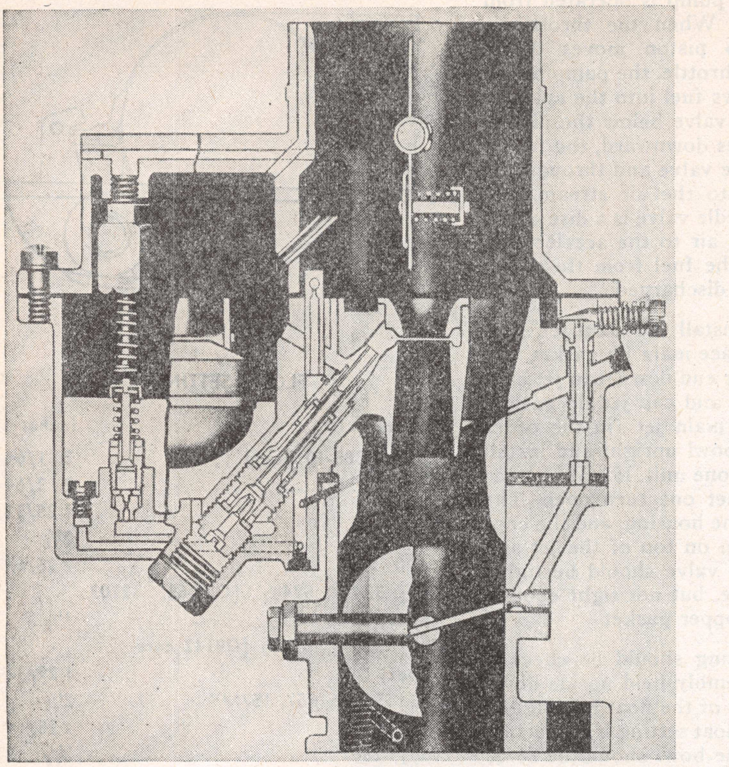
FLOAT SETTING

Carburetor	Inches
22AX8 (C85-10 float)	2 1/64
26DB12	2 3/64
50AY12	1 25/32
52A14	2⅛
54A20	2 25/64
124½, 324½, 524½ (C85-65, 32103 float)	1½
124½, 324½, 524½ (D9142 cork float)	1 29/32
154, 155, 156, 157, 157MV	2⅛
158, 158MV	2 25/64
255½, 256Y	2⅛
455, 456, 457	2⅛
458	2 25/64
755½, 756	2⅛
IN158	2 25/64
IN166D	2 1/16
IN167, IN167SJ	2⅛
TU3, TU3½, TU4	1 13/32

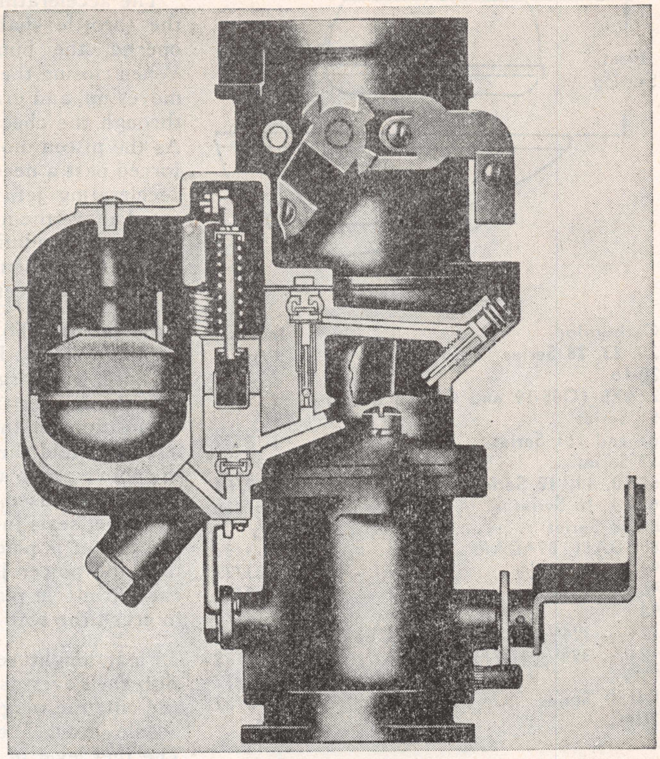


ZENITH 20 SERIES

Left view: A—Compensator channel. B—Compensator channel to well. C—Compensator to idle channel. D—Vacuum piston channel. 1—Main venturi tube. 2—Main jet. 3—Compensator. 4—Idle jet. 5—Power jet. 7—Cap jet calibration. 8—Cap jet tip. 9—Cap jet base. 10—Priming plug. 12—Scondary venturi. 13—Well. 14—Annulus. 15—Ventilating hole. 16—Idling adjusting needle. 17—Power jet vacuum piston. 18—Power jet valve.
Right view: K—Piston arm. 6—Accelerating jet. 11—Pump. 19—Pump lever. 20—Pump link. 21—Accelerating pump rod. 22—Check valve. 23—Needle valve. 24—Check valve.



ZENITH 23 SERIES. Jet system.



ZENITH 23 SERIES. Accelerating system.

The accelerating pump does not have provision for seasonal changes. The distance the pump piston travels can be changed by replacing the spacer. Most carburetors use the ¾ stroke spacer, and this allows about 5/16 of an inch piston travel from closed throttle. On the throttle-operated power valve, the arm just starts to open the valve when a 7/16" rod fits between the carburetor barrel and the lower end of the throttle plate. On the vacuum type the power jet piston operates at four to six inches of manifold vacuum.

The position of the throttle cracker lever on the air shutter shaft should be adjusted so that opening the throttle wide open, while holding the air shutter closed, will open the air shutter just far enough to insert a number 26 drill between the upper lip of the air shutter and the air intake body.

Bowl Vent Tube (C77-8) was designed to prevent dirt from defective air cleaners entering the bowl through the bowl vent. Its use is recommended where there is a possibility of trouble from this source.

23 SERIES

This is a single-barrel, downdraft carburetor, and the general description as previously applied to the 20 Series carburetor is the same for the 23 Series with two exceptions. The 20 Series has a long main jet which holds the cap jet base, cap jet calibration and the cap jet tip in place. The 23 Series has a short main jet which sets against a gasket and the cap jet base retainer. Another slight difference is in the accelerating system. A pump refill check valve ball and weight is used in the 23 Series in place of the needle check valve as used in the 20 Series.

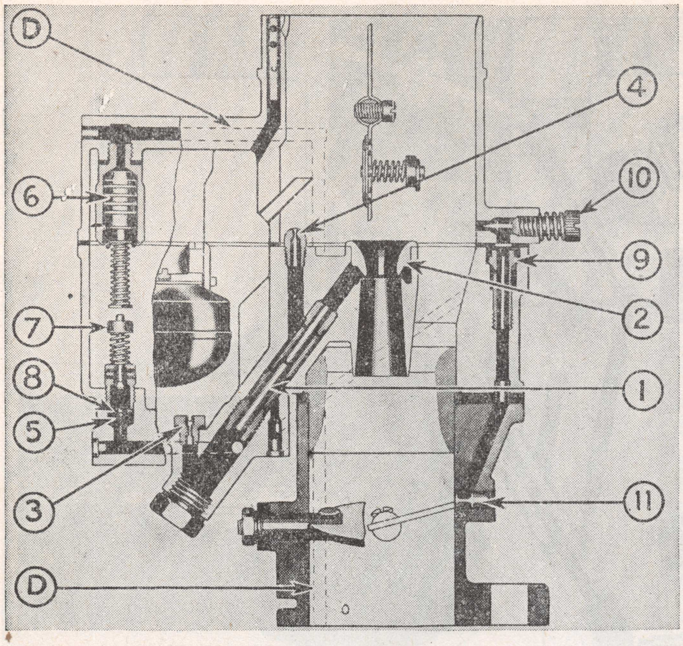
Main jet installation: Place gasket, cap jet base, cap jet calibration, cap jet tip and gasket in place (in order named) on the cap jet base retainer. Hold the bowl upright and install the group as one assembly. Then install main jet and gasket. For all other adjustments proceed as described for the 20 Series.

28 SERIES

This is a downdraft, single-barrel carburetor, with a mechanically-operated accelerating pump and a manifold vacuum-controlled power-jet system. This series construction was also applied to some double barrel units. The main jet is located in the bowl and fuel passes through it and into the main discharge jet and out into the air stream through the secondary venturi. Air is admitted to the main discharge jet through the well vent. A sized orifice controls the air admitted to the discharge jet, which in turn controls the flow of fuel from the main and power jets. When manifold vacuum drops, the power jet system supplies additional fuel. The operating principle is the same as used in the 20 Series. The idling jet receives fuel from the main jet. The fuel passes through the calibration in the side of the idle jet, and is mixed with air passing through the center of the jet. The mixture of fuel and air from the idling jet is discharged through the priming plug. The pump piston is actuated by throttle movement. As the throttle opens, the pump piston is pushed downward. This forces fuel past the ball check valve and through the pump jet into the air stream. The air vent check valve admits ventilation from the bowl and eliminates direct suction on the fuel through the pump jet.

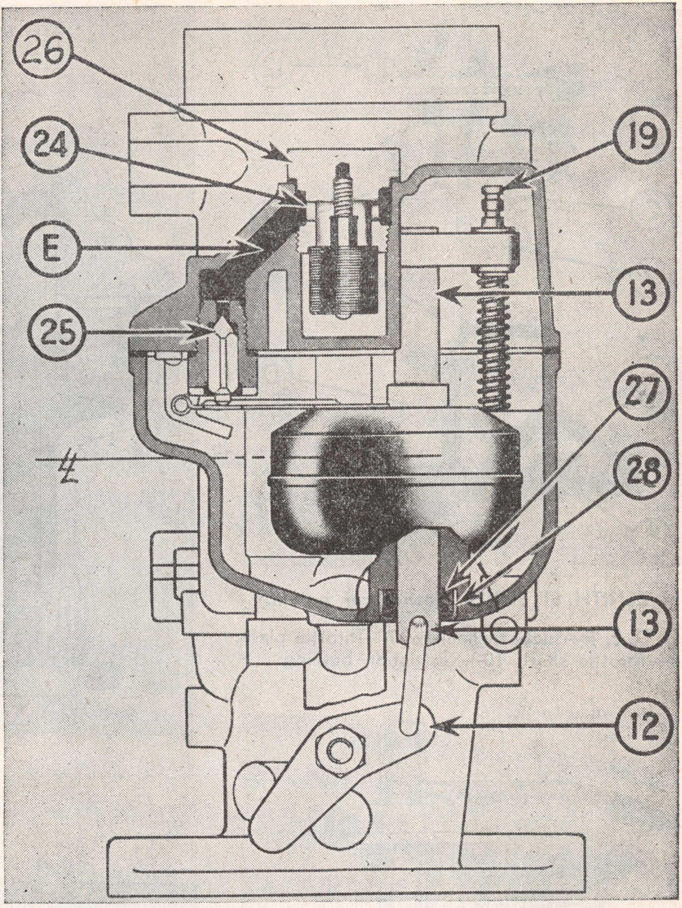
Adjustments: Float Setting should be checked by holding cover assembly upside down. With the weight of the float holding the needle valve seated, the distance from the far side of the float to the housing should be 1½ inches. The **fuel level** in the bowl, with normal pump pressure should be 25/32". A star is stamped on the head of the **main jet** to prevent confusing it with the compensating jets used in previous models. The calibration length of the main jet is longer than that of a compensator and a compensator must not be used as a substitute because it changes the metering characteristics of the carburetor. If the **power jet** or gasket sticks in place, strike the underside of the bowl at a point near the power jet channel with the handle end of a screw driver to jar the parts loose. No gasket is used under the power jet. The copper gasket is between the power jet and the power valve. The power jet valve should be firmly in place but not tight enough to crush the soft copper gasket. There is an opening in the corner of the bowl back of the power jet valve. This is for production convenience and is not a fuel passage. It does not connect with any other channel. Sometimes a special combined power jet and power jet valve assembly is used. This part is stamped with two calibrated sizes, the larger size being the calibration of what would ordinarily be the power jet, and the smaller size the calibration of the power jet valve assembly. The power jet **vacuum piston** should start to open the power jet valve at six inches of manifold vacuum.

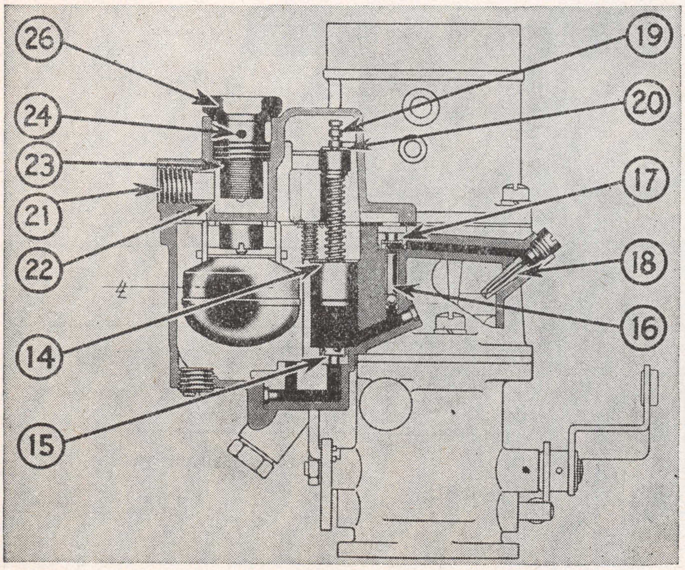
The accelerating jet and the pump spring control the rate of acceleration discharge. The **stroke of the pump is controlled by**



ZENITH 28 SERIES. Fuel and idling systems.

D—Vacuum piston channel. 1—Main discharge jet. 2—Secondary venturi. 3—Main jet. 4—Well vent. 5—Power jet. 6—Power jet piston. 7—Power jet valve. 8—Copper gasket. 9—Idle jet. 10—Idle adjusting needle. 11—Priming plug.





ZENITH 28 SERIES. Filter and pump system.

14—Pump piston. 15—Check valve. 16—Ballcheck valve. 17—Air vent check valve. 18—Accelerating jet. 19—Pump piston rod. 20—Hairpin clip. 21—Fuel inlet. 22—Sump. 23—Filter element. 24—Inlet hole in filter head. 26—Filter head.

←

ZENITH 28 SERIES. Fuel inlet and pump link.

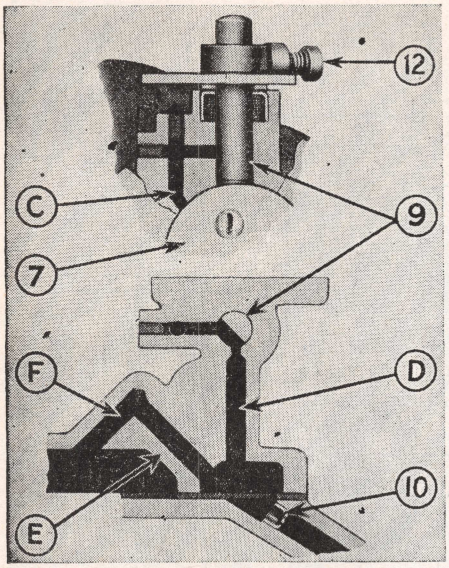
E—Inlet fuel channel. 12—Pump lever. 13—Pump rod. 19—Pump piston rod. 24—Inlet opening in filter head. 25—Fuel valve. 26—Filter head. 27—Pump rod packing. 28—Packing retainer.

the position of the pump rod in relation to the pump piston rod. The stroke can be varied by changing the position of the hairpin clip on the pump piston rod. The upper groove allows a minimum, or half stroke. The center groove allows an intermediate or ¾ stroke, and the lower groove allows maximum, or full stroke. The pump piston travel from closed throttle to the seating of the piston, in the center groove position is 5/16 of an inch. Later carburetors use an accelerating discharge jet which is pressed into the housing. Some carburetors also use packing at the pump rod. Use a small flat end drift and a light hammer to drive the retainer cup and packing into place.

The **idle adjusting needle** is an air adjustment. Turning the adjusting screw out, or anti-clockwise, admits more air and makes the idle mixture leaner. Turning in or clockwise, admits less air and makes the idle richer. One turn off its seat is the average setting. There is a small drilling (size .8 M/M) through the thin section of wall between the air stream and the idling channel just beside the head of the idling jet. This hole admits a fixed quantity of air in addition to that supplied by the idling adjustment. This small channel must be clean.

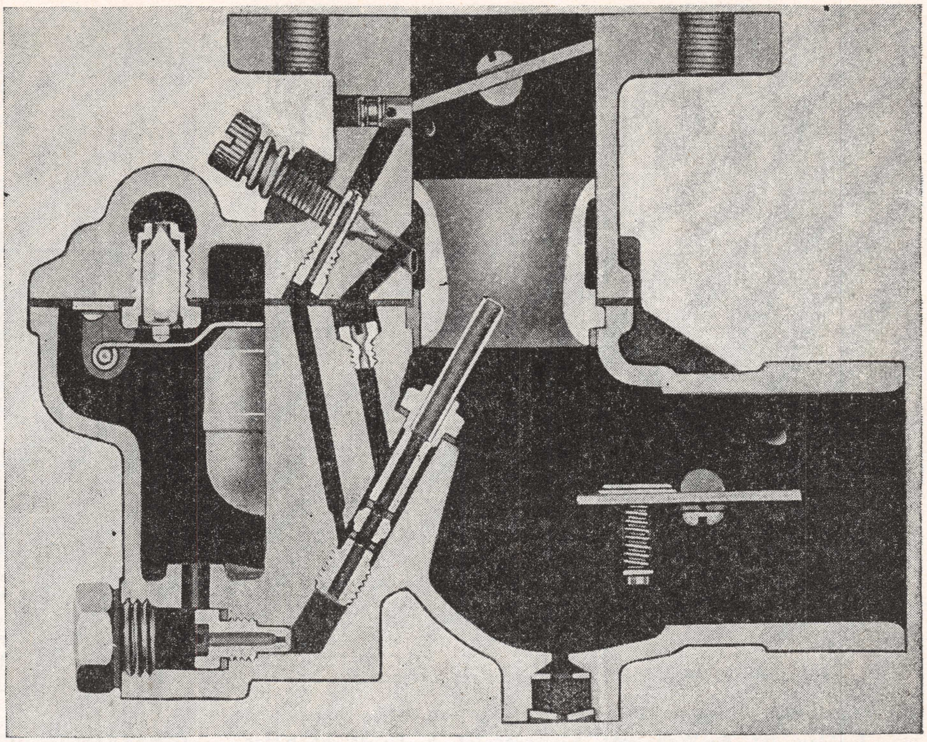
61, 62, 161 SERIES

This is a single-barrel, updraft carburetor with an economizer system regulated automatically by the position of the throttle shaft. When the throttle plate is about ¼ open, a strong suction acts through a set of channels, thus holding back the fuel in the bowl and causing a lean mixture through the part-throttle operation. The bowl ventilation from the intake of the carburetor is restricted by a bushing, thus preventing bowl ventilation from overcoming the suction from the channels. For full-power operation, at wide-open throttle, this

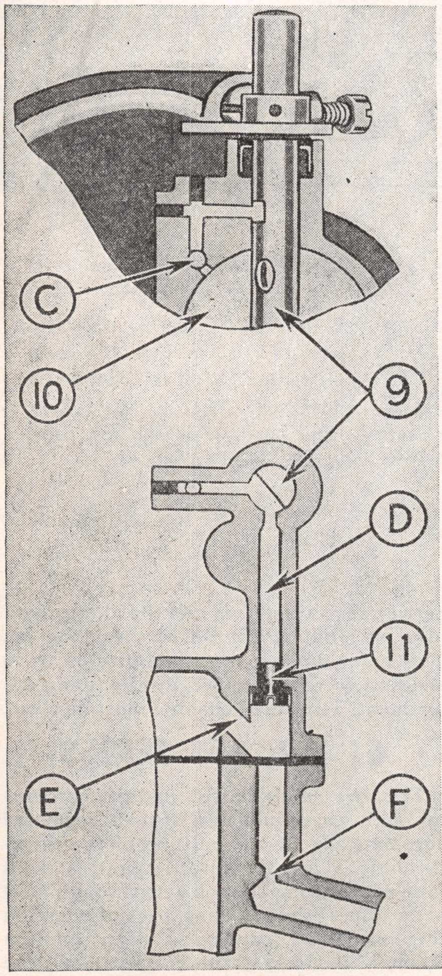


ZENITH 61 SERIES. Economizer system.

C, D, E, F—Suction channels. **7**—Throttle plate. **9**—Throttle shaft. **10**—Restriction bushing.

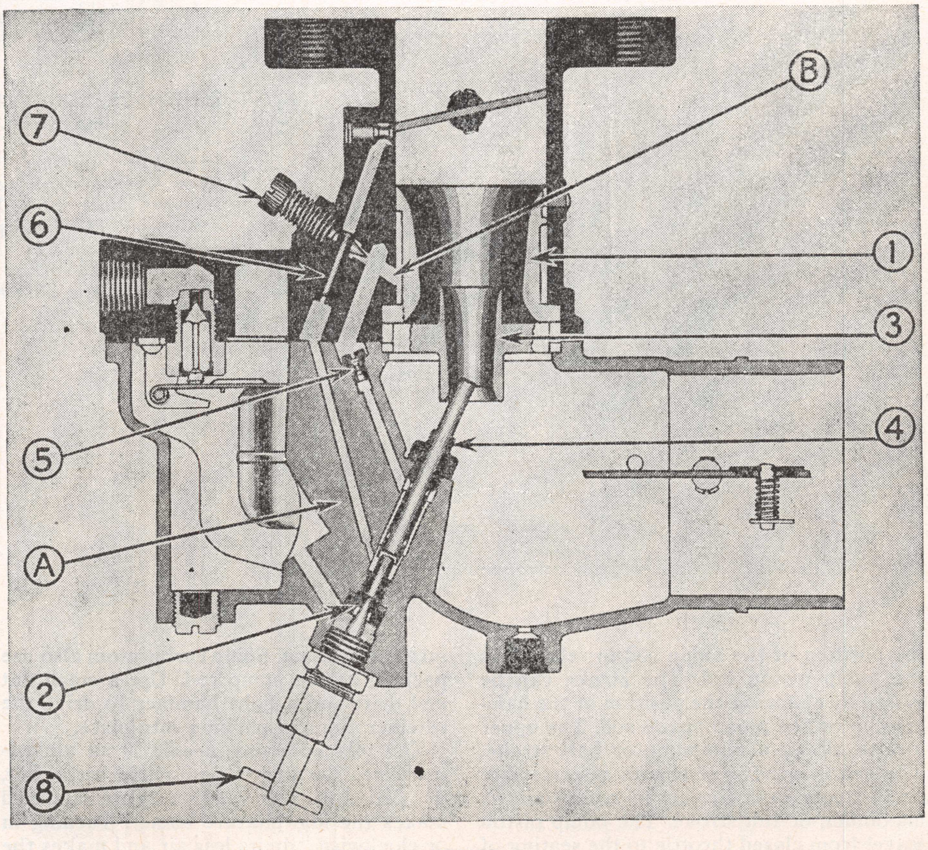


ZENITH 61 and 161 SERIES. Jet system.



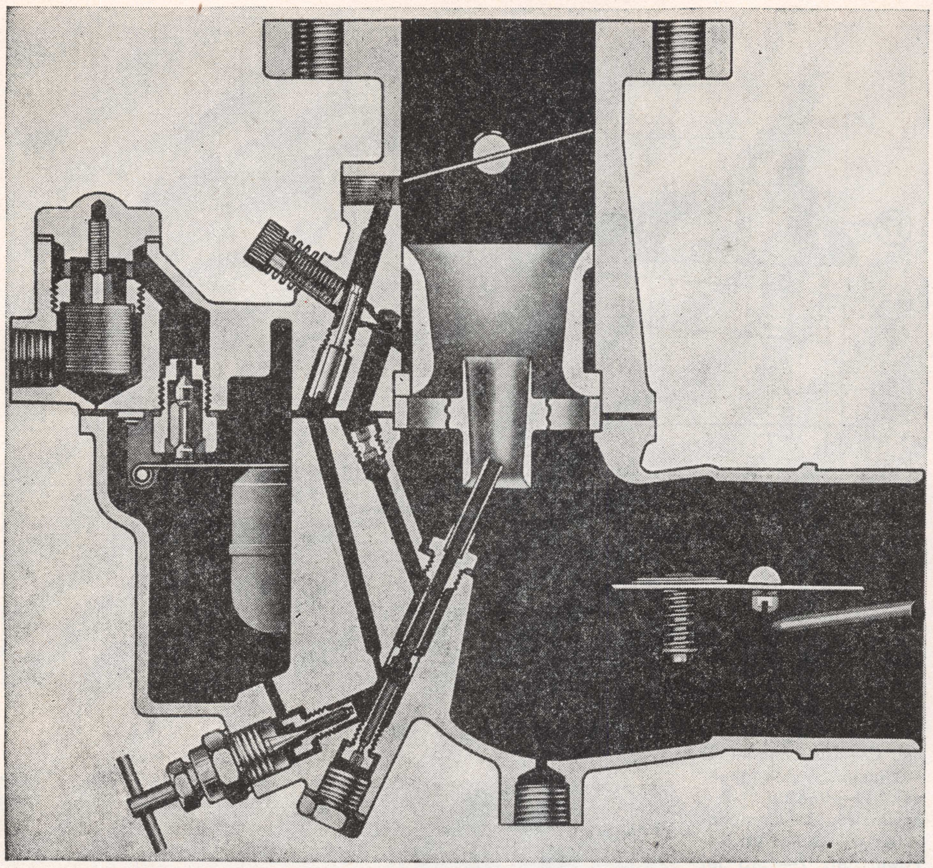
ZENITH 62 SERIES. Economizer system.

C, D, E, F—Suction channels. 9—Throttle shaft (closed throttle). 10—Throttle plate. 11—Economizer jet.



ZENITH 62 SERIES. Jet system.

A—Idle channel. B—Idle air inlet channel. 1—Venturi. 2—Main jet. 3—Secondary venturi. 4—Main discharge jet. 5—Well vent. 6—Idle jet. 7—Idle adjusting needle. 8—Main jet adjustment.



ZENITH 63 SERIES. Jet system.

suction is cut off, due to the position of the slot in the throttle shaft, and permits the full flow of fuel necessary for full power.

Main Jet System: Fuel from the bowl flows through the main jet and through the main discharge jet and into the air stream. The compensating system consists of the main discharge jet and the well vent. The flow of fuel from the main jet is controlled by the size of the main discharge jet. The mixture delivered through the main discharge jet may be made richer by either increasing the size of the main discharge jet or by decreasing the well vent.

Idling System: The idle jet is located in the upper housing and receives its fuel from the main discharge jet through an upright channel. The fuel is metered through the idling jet, and is mixed with air, which is admitted from behind the venturi. The idle adjusting needle controls the amount of air which is admitted to the idling system. The idle mixture is then discharged through the priming plug.

63 SERIES

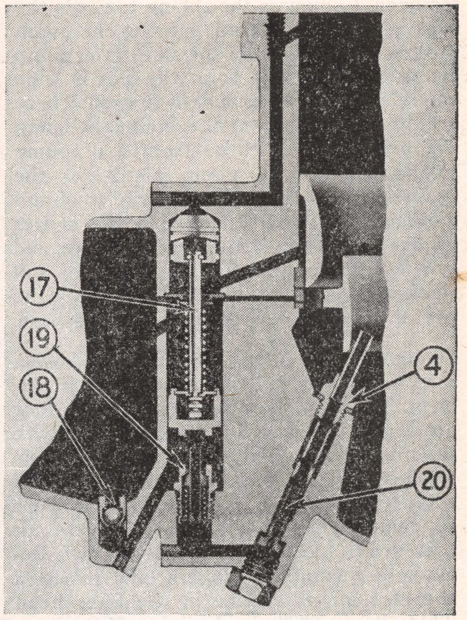
This series is a single-barrel, updraft carburetor with a manifold vacuum controlled power and accelerating system. A removable venturi tube measures the volume of air which passes through the carburetor.

Main Jet System: Fuel from the bowl passes through the main jet into the main discharge jet, where it is mixed with air admitted by the well vent and discharged into the air stream at the point of greatest suction, in the secondary venturi. The flow of fuel from the main jet is controlled by the size of the well vent and the size of the main discharge jet. The mixture delivered through the main discharge jet may be made richer by either increasing the size of the main discharge jet or by decreasing the size of the well vent.

Idling System: The idle jet is located in the upper body and receives fuel from the main discharge channel through an upright channel. The fuel is measured through the idle jet and is mixed with air admitted from behind the venturi. The mixture is then discharged into the air stream through the priming plug. The idle adjusting needle controls the amount of air which is admitted into the idle system.

Power and Accelerating System: When manifold vacuum drops, the vacuum pump and piston assembly moves downward in its cylinder. This forces the intake check valve to close and the power jet valve to open. Fuel flows through the power valve and through the power jet and is discharged into the air stream through the main discharge jet.

Adjustments: Float height setting is measured from the gasket surface or parting line of the float chamber cover to the bottom of the float at the center, with the fuel valve in seated position (holding the float chamber cover upside down). This distance should measure 1-39/64 inches and at three pounds or slightly lower pump pressure should allow a fuel bowl level of 55/64 of an inch.



ZENITH 63 SERIES. Power and accelerating system.
4—Main discharge jet. 17—Vacuum pump assembly. 18—Check valve. 19—Power jet valve. 20—Power jet.

Main Jet Setting: The main jet determines the maximum amount of fuel which may be obtained for high speed operation. The main jet adjustment (if used) reduces this amount if it is turned toward its seat. Ordinarily this adjustment has no effect after it is 2½ turns off its seat. Open the throttle about one quarter and loosen the packing nut on the main jet adjustment. Turn the adjustment to the right, or clockwise, until the engine speed is noticeably reduced, and then turn the adjustment slowly to the left, or anti-clockwise, until the engine runs smoothly and as fast as the throttle position will permit. Hold the needle adjustment in this position and tighten the packing nut. Compensation is controlled by the well vent. A richer mixture, at high speeds, is obtained with a smaller well vent and a leaner mixture with a larger well vent. If the mixture suddenly becomes too rich at high speeds, examine the well vent and make sure that it is not obstructed.

The idle adjusting needle is an air adjustment and admits more or less air to the idle mixture, depending on the amount of opening. For a preliminary adjustment, turn the needle into its seat and open one full turn. Turning the adjustment out, or anticlockwise admits more air, and therefore a leaner low speed mixture. Turning the adjustment in, or clockwise admits less air and allows a richer mixture. An average setting, slightly on the rich side for good pick up, is ¾ of a turn open.

Accelerating pump adjustment is provided in the form of three grooves on the pump piston rod. The carburetor must be opened up and the vacuum pump piston assembly removed. Compress the spring towards the vacuum piston to permit moving the pump rod to the outer end of the slot in the pump piston base. At this point the slot is wide enough to permit removal of the rod. There are three grooves near the end of the pump rod providing for three lengths of pump stroke. Install the pump piston in the groove nearest the end of the rod to obtain minimum or a half stroke, in the center groove for intermediate, or a ¾ stroke, and in the third groove for maximum, or full stroke of the pump. The spring holds the rod in the center of the pump piston base.

Strainer: Some models of this series have a screen strainer and some have a filter element. To clean the filter, remove the filter head, and unscrew the filter element with the fingers only. This allows the individual washers to be separated from each other slightly. Wash with gasoline, using a brush to remove the gum. Use moderate air pressure to blow out the loosened dirt. Reassemble, using the fingers only to screw the element into place in the filter head. This allows .002" spacings for filtering.

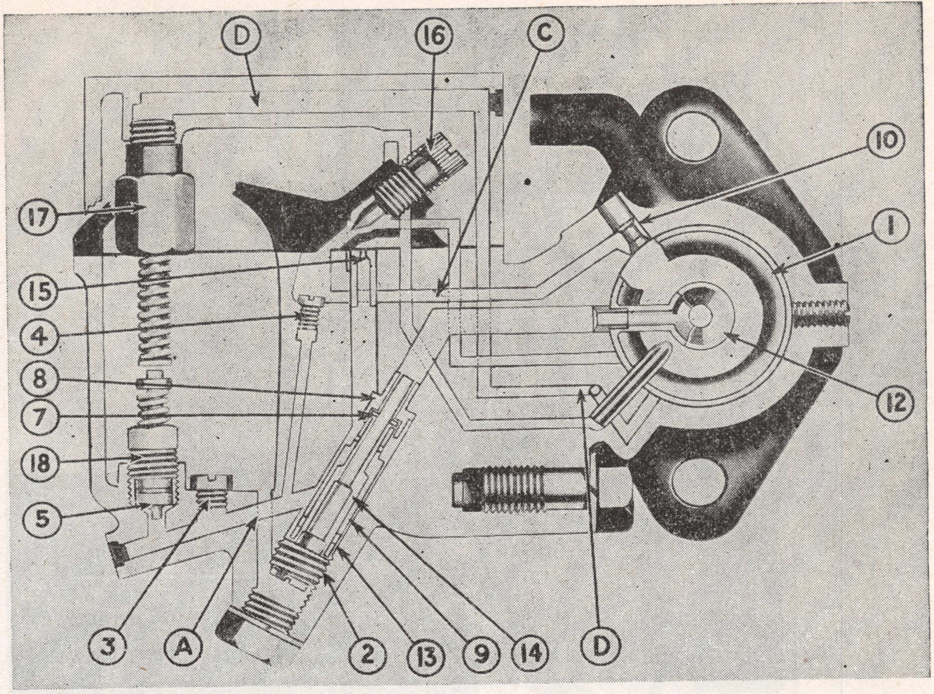
80 & 82 SERIES

These are single-barrel, side-draft carburetors for horizontal mounting. The fuel bowl is assembled on the side of the carburetor barrel and the air intake valve is on the same level as the throttle valve. A removable venturi tube is used to adjust the air capacity to the size of the engine. A mechanically-operated accelerating-pump system and a vacuum-controlled power-jet system is used in this series.

Main Jet System: Fuel flows from the bowl through the main jet and is discharged into the air stream through a discharge nozzle in the 80 Series, and through a secondary venturi in the 82 Series. The compensator jet meters its fuel into an air bled well, the air being admitted and measured by a well vent. From the well, the fuel mixture passes through holes in the cap jet base and into the annulus between the cap jet base and the main jet, then through the cap jet calibration and the cap jet tip and to the discharge nozzle, out into the air stream. The compensator is most effective at low speed. The main jet is most effective at high speed.

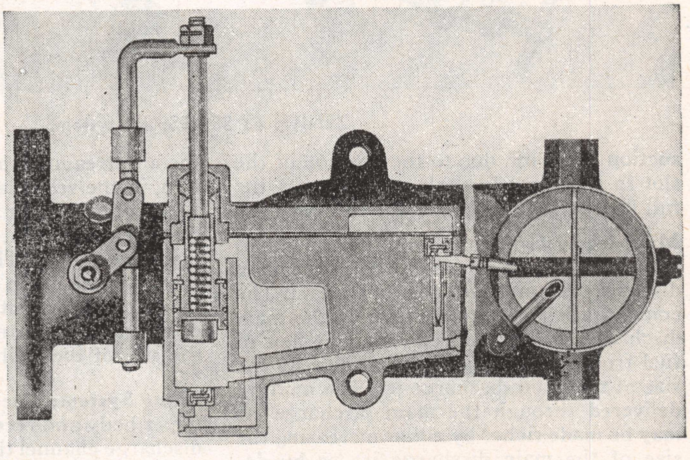
The **Power Jet System** is controlled by a piston, operated by manifold vacuum. At low-speed lugging, with wide-open throttle, manifold vacuum is low and allows the power jet vacuum piston to move downward in its cylinder. This action opens the power jet valve and allows additional fuel to flow through the power jet, and into the discharge channel. At normal driving speeds, the manifold vacuum is sufficient to overcome the spring tension and hold the power jet vacuum piston up, thus keeping the power jet valve closed and cutting off this extra supply of fuel.

The **Idling Jet** receives its fuel from the compensator channel, and after passing through the idle jet calibration, the fuel is mixed with air, the amount of air being regulated by the idling adjusting needle. This mixture then passes through channels to the priming plug and is discharged into the air stream when the throttle plate is closed far enough to cause a strong suction at this point.



ZENITH 82BV10 SERIES. Typical of 80BV10.

A—Compensator channel. C—Idle channel. D—Vacuum piston channel. 1—Venturi. 2—Main jet. 3—Compensator. 4—Idling jet. 5—Power jet. 7—Cap jet calibration. 8—Cap jet tip. 9—Cap jet base. 10—Priming plug. 12—Discharge nozzle. 13—Well. 14—Annulus. 15—Ventilating hole. 16—Idle adjusting needle. 17—Power jet vacuum piston. 18—Power jet valve.



ZENITH 80BV10. Accelerating system.

The **accelerating pump piston** is actuated by the movement of the throttle. When the throttle is opened, the pump piston is moved downward in its cylinder. Fuel from the carburetor bowl has previously entered the cylinder through the intake check valve. As the pump piston starts its downward stroke it applies a pressure upon the fuel which closes the intake check valve and causes displacement of the fuel from the pump cylinder through the needle valve. This closes the air intake check valve, causing the fuel to be discharged into the air stream through the accelerating jet. When the fuel has been discharged from the pump cylinder, there is no longer any pressure against the needle valve, or the air check valve. Therefore the needle valve drops back on its seat and the air check valve opens. This admits air and eliminates any direct suction on the fuel.

Adjustments: Examine throttle body and bowl for bent flanges, and file if necessary to permit full contact between the two flange faces. Most of the models of this series have three hex head cap screws installed from the throttle body side, and one round head screw installed from the bowl side of the flange. Early models having three bowl-to-throttle body assembly screws should be returned to the factory to have the parts machined for the fourth assembly screw. Very early models of this series which have only two assembly screws can be exchanged through the distributor for the latest model. For 82 Series having a removable well vent use a 3/16 wrench. The 80 Series well vent should not be removed.

In some cases, the power jet or copper gasket may stick in the housing, and if this happens, turn the bowl upside down and strike the housing with the handle end of a screw driver at the point the jet is located. No gasket is used between the power jet and the housing, the copper gasket is between the power jet and the power jet valve. The power jet valve should be screwed firmly in place, but not tight enough to crush the soft copper gasket. The power jet vacuum piston operates on four to six inches of manifold vacuum.

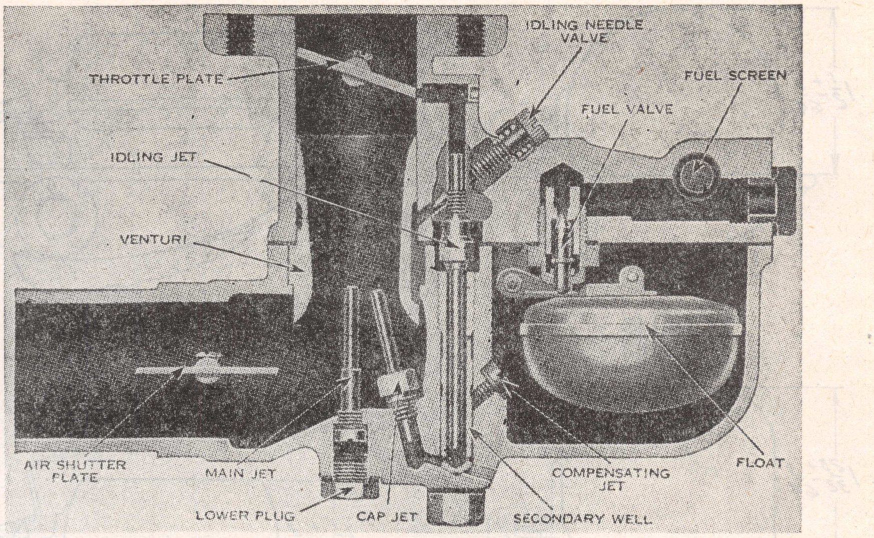
Float Setting is checked by holding bowl cover assembly upside down, and setting the distance from the flange face of the housing to the far side of the float to 1½ inches. Another check can be made between the flange face and the near side of the float, this is 7/16 of an inch. The weight of the float should hold the needle valve seated. The fuel level in the bowl should be 25/32 of an inch with normal pump pressure.

Accelerating Pump external spring was not used on all models. On the spring type, hold the pump rod and spring down about half way to make it easy to connect the pump lever link, then move the throttle until the slot in the pump lever lines up with the flats on the throttle shaft. No provision is made for seasonal adjustment.

Idle adjusting screw is an air adjustment and turning out, or anti-clockwise, admits more air and allows a leaner idle mixture. Turning in, or clockwise, admits less air, and a richer mixture.

90 SERIES

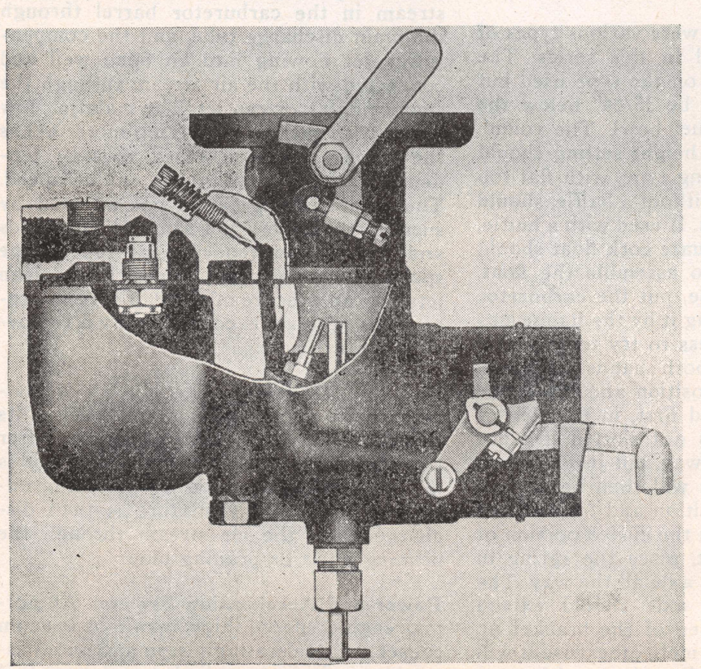
Included in this series is a large variety of sizes and types, but the operating principle is the same. This is an updraft, single-barrel carburetor. The Zenith compound nozzle system of carburetion is used. This consists of two jets, one the main jet, which in affected by suction, and flows a constantly increasing amount as the suction increases, and the other, the compensating jet, which flows the same amount under all suction, as it empties into a well open to atmosphere. In combination, the rich and lean jets produce an average mixture of correct proportion. A venturi tube measures the air admitted to the engine.



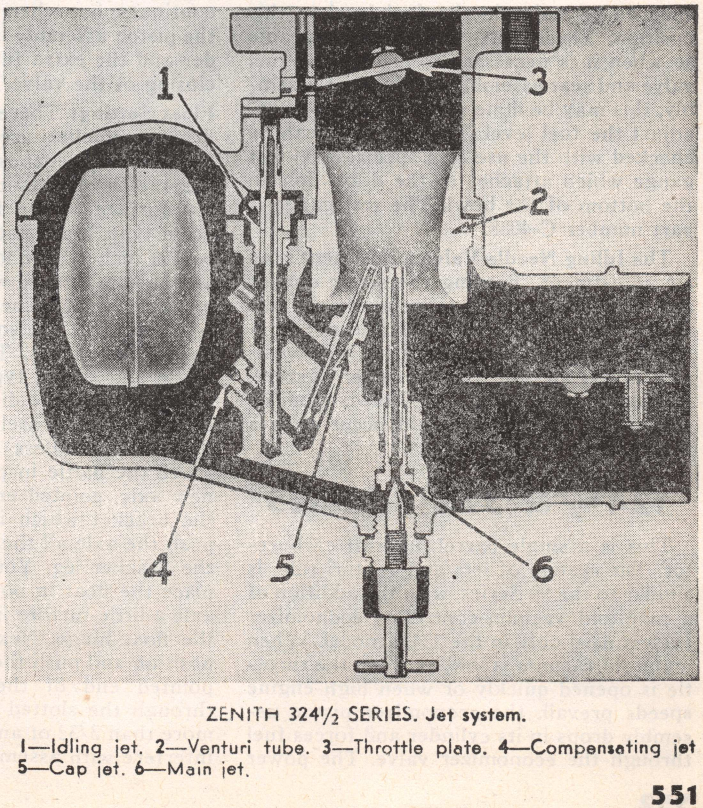
ZENITH 90 SERIES.

Intermediate and High Speed System: The main jet is located in the air stream its tip is at the point of highest suction. Fuel enters it through a passage in the fuel bowl. The compensating jet is located in the fuel bowl and admits fuel into a well which is open to atmosphere. The mixture from this well is discharged into the air stream through a cap jet, located next to the main jet. The main jet is most effective at high engine speeds, and the compensator jet is most effective at low engine speeds.

Low Speed System: The idle jet is fastened into the upper body and receives its fuel from the compensating well. After the fuel passes through the idle jet it is mixed with air, admitted and controlled by the idling needle valve. This air and fuel mixture is then discharged into the intake manifold through the priming holes.

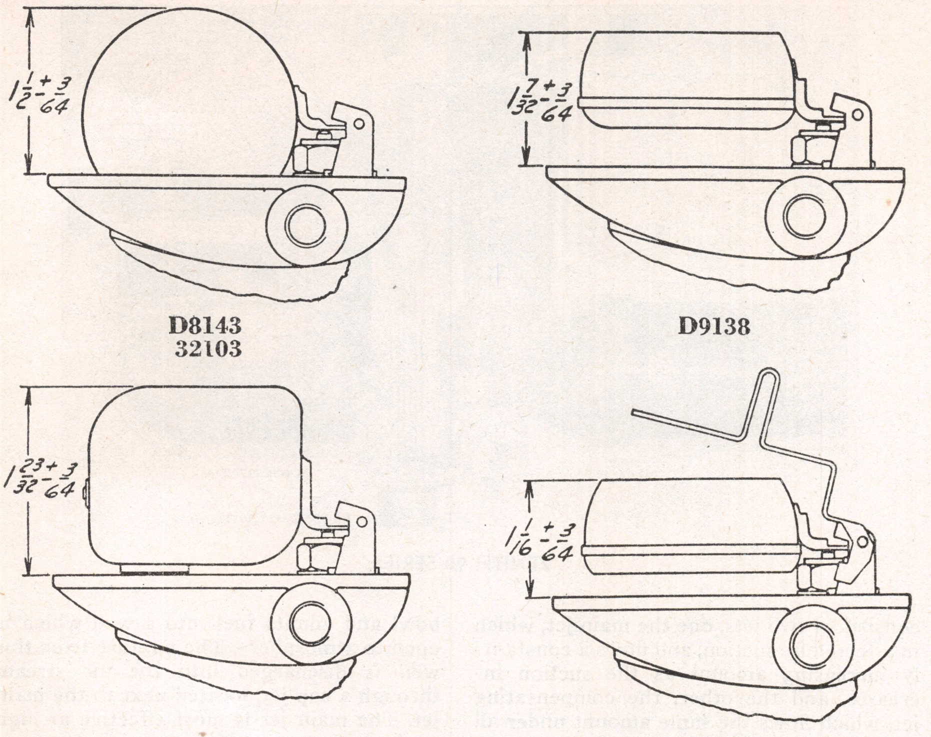


ZENITH 124½ SERIES



ZENITH 324½ SERIES. Jet system.

1—Idling jet. 2—Venturi tube. 3—Throttle plate. 4—Compensating jet 5—Cap jet. 6—Main jet.


$1\frac{1}{2}\pm\frac{3}{64}$
$1\frac{7}{32}\pm\frac{3}{64}$
$1\frac{23}{32}\pm\frac{3}{64}$
$1\frac{1}{16}\pm\frac{3}{64}$

D8143
32103

D9138

D9142

32121

ZENITH 124½ and 324½ Float settings.

Float dimensions for fuel level. Floats 32013 and D8143 are alike except D8143 has a tubular float axle bearing the full width of the hinge, 32121 and D9138 are alike except 32121 is placed higher on the hinge and requires the use of 32118 Float Spring, and in some cases, 32117 Float Baffle as well. D9142 is a special cork float used in outline 7347. FOR SERVICE WORK we suggest the use of group 32123, which includes 32121 Float, 32118 Float Spring, 30144 Float Axle and 32117 Float Baffle, in all cases except when replacing D9143 Cork Float.

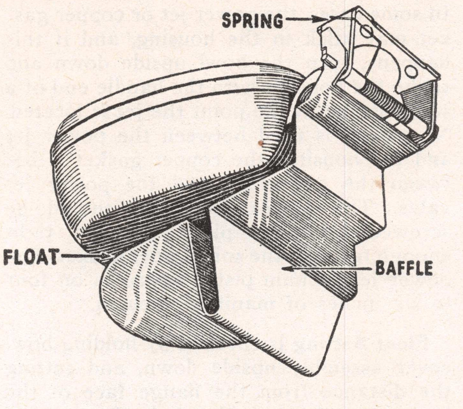
Adjustments: Fuel Level in the 90 Series carburetors is ⅝ of an inch below the top edge of the bowl. The weight of the float and location of the fuel valve and seat are such as to maintain the fuel level in this position. These parts are interchangeable so when it is necessary to change the fuel valve and seat assembly, or the float assembly, this may be done without having to readjust the fuel level. The fuel level can be checked with the use of a special level test gauge which attaches to the drain hole in the bottom of the bowl. The test gauge is part number C-4088.

The Idling Needle Valve adjustment is an air adjustment. Turning the screw out, or anti-clockwise, admits more air to the idle system and therefore allows a leaner mixture. Turning the screw in, or clockwise, admits less air, and gives a richer mixture. A good starting point is 1½ turns from its seat. Best operation should occur with a 1¼ opening.

124½ & 324½ SERIES

This is a single-barrel, updraft carburetor. The system of jets and venturi tube is similar to the 90 Series, with the addition of a manifold vacuum-controlled economizer system used only in the 324½ model. When manifold vacuum is low, as when the throttle is opened quickly or when high engine speeds prevail, the economizer piston assembly drops in its cylinder and forces fuel through the economizer valve. The power and accelerating jet measures the rate of discharge of this fuel which passes into the air stream through the discharge tube. As long as the vacuum is low, this flow of fuel continues, but when the vacuum increases, the piston assembly is drawn up in its cylinder and the extra fuel is eliminated by the closing of the valve.

Float Setting: There were various types of float assemblies used in this series. The float setting depends on the type used but the fuel level should be 35/64" below the top surface of the fuel bowl. The round, drum type, brass flat height setting should be 1½ inches. The long type, with flat top and bottom, if used without a baffle, should measure 1-7/32 inches. If used with a baffle, 1-1/16 inches. The square cork float should be 1-23/32 inches. To assemble the float, baffle and spring type, put the carburetor barrel in a vise, holding it by the flange, upside down. It is useless to try to assemble these parts unless both hands are free. Place the baffle in position and insert the new axle, pointed end first, in that leg of the bracket which is not slotted. Do not push the axle all the way, but just through the bracket leg. You will then be able to place the float in position and to push the axle a little further in the curled portion of the float hinge. Next, place the spring in position and push the axle all the way. The pointed end of the axle should extend through the slotted leg of the bracket no more than 3/32 of an inch, otherwise it will interfere with assembling the bowl later.



ZENITH 124½ and 324½.

Group 32123, shown above, is assembled on a dummy bracket in exactly the way they should be assembled in the carburetor. Study it carefully. Note the spiral spring; the hooked end around the bracket and the straight end above the float hinge. This gives about ¼ turn wind, which is sufficient.

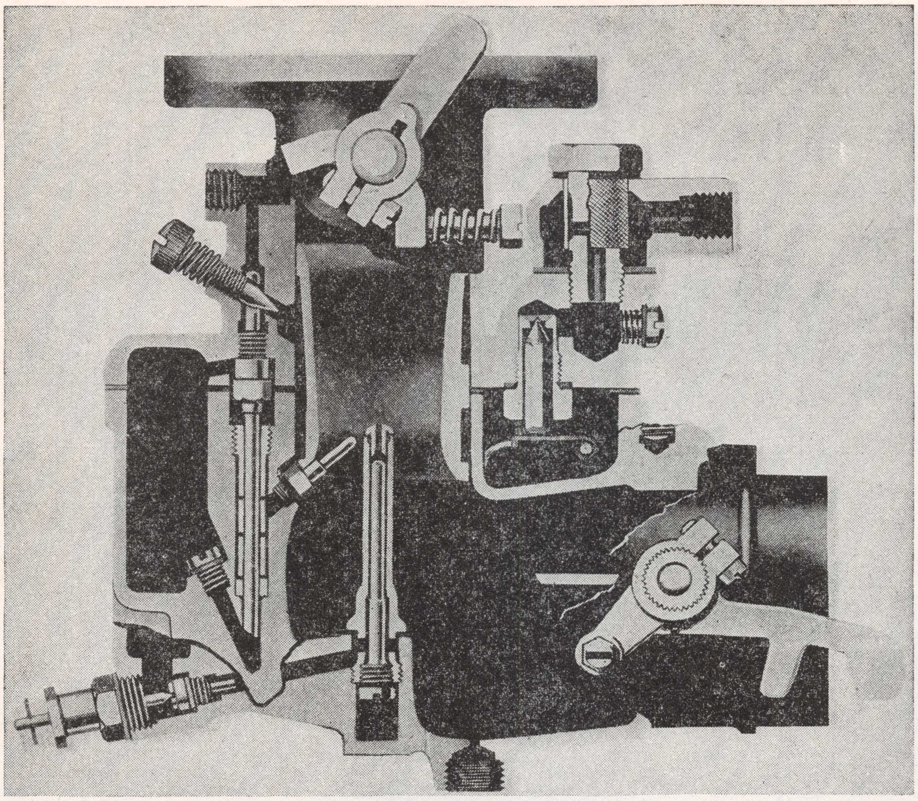
Idle adjusting needle is an air adjustment, turning adjustment out, admits more air and gives a leaner idle mixture. Turning adjustment in, admits less air, therefore allows a richer mixture. Turn adjusting needle in to its seat and then open one full turn for a preliminary setting.

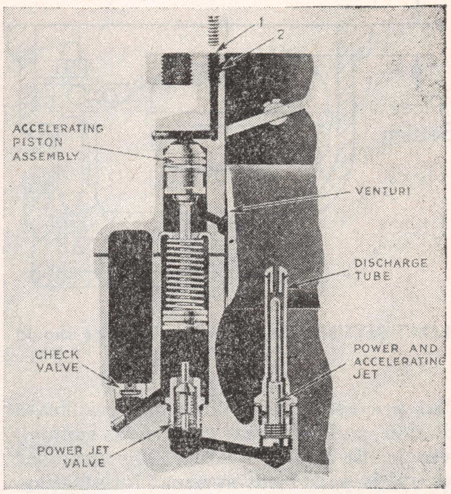
150, 450 & 550 SERIES

This series is single-barrel, updraft type carburetor, with a manifold vacuum-controlled power and accelerating system. The Zenith compound nozzle system of carburetion is used in all these models. This consists of two jets, the main jet, directly connecting fuel in the bowl with the air stream in the carburetor barrel through the main discharge tube, and the compensating jet flowing into an open well and connected with the air stream through the supplemental, or cap jet. The main jet flow varies with suction, delivering more fuel as the engine speed increases, thus its tendency is to richness at top engine speed. The compensating jet is not affected by suction, thus flows the same at all speeds and has a lean tendency at top engine speed. In combination, the rich and lean jets give an average mixture of correct proportions. The air is controlled by a removable venturi tube.

Low Speed System: The idle jet is fastened in the upper housing, and receives its fuel from the compensator channel. After the fuel passes through the idle jet, it is mixed with air admitted by the idling adjusting needle. This mixture is then discharged into the air stream through the priming holes or priming plug.

Power and Acceleration System: At normal engine speeds, high manifold vacuum causes an accelerating piston and pump assembly to rise in its cylinder, and draw fuel





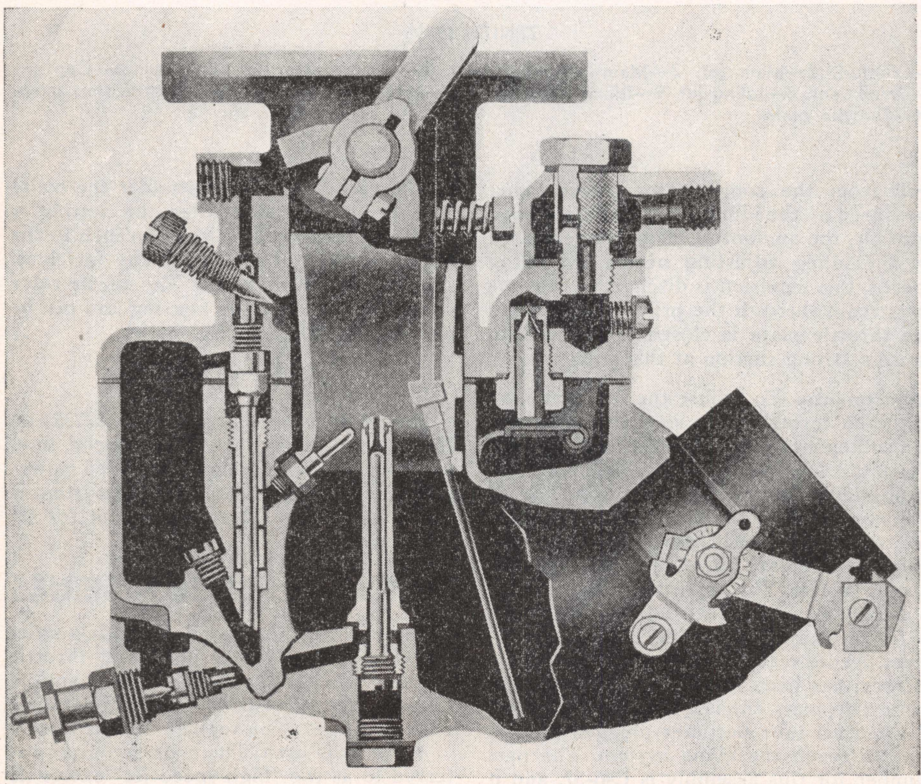
ZENITH 450 SERIES. Left: Jet system. Right Power and accelerating system.

into the pump cylinder through the intake check valve. As manifold vacuum drops, the pump piston moves downward, the fuel pressure forces the power jet valve to open and allow fuel to flow through to the power and accelerating jet, and out into the air stream.

Float Setting: Hold cover assembly upside down and measure the distance from the gasket surface of the housing (minus the gasket) to the furthest point of the float, with the weight of the float keeping the inlet needle valve against its seat. This distance should be 2⅛ inches on the 4, 5, 6 and 7 sizes, except 557. On model No. 557 and the 8 size carburetors it should measure 2-25/64 inches. The fuel level measurement in the bowl, with normal pump pressure, should be ⅝ of an inch below the gasket surface of the bowl housing. To remove the float axle, use a screw driver to push the axle through the slotted end of the hinge bracket and the fingers to remove it the rest of the way. When replaced, the float axle should extend uniformly at both sides of the hinge bracket and float should move freely on the axle. To determine whether the float is still free, after assembling the carburetor, turn it upside down suddenly and listen for the "bounce" of the float against the fuel valve. If it does not "bounce", float is rubbing and condition should be corrected.

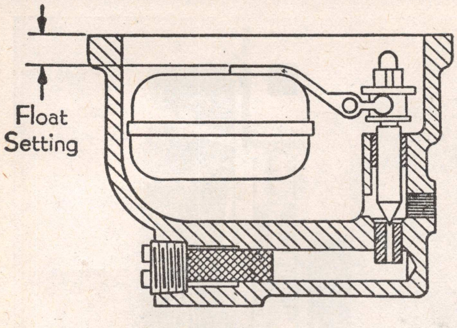
On some models, the discharge tube is pressed into the housing—do not attempt to remove this type. The others are threaded.

Spring Loaded Strangler Valve: The choke shaft is "off center" so that engine suction tends to pull it open. A spring tends to pull the choke plate shut, but except at cranking speeds the spring is the weaker of the two forces. Accordingly, as the engine is speeded up, or slows down, the choke plate opens and closes, always being in a position to deliver just the right amount of air



ZENITH 550 SERIES.

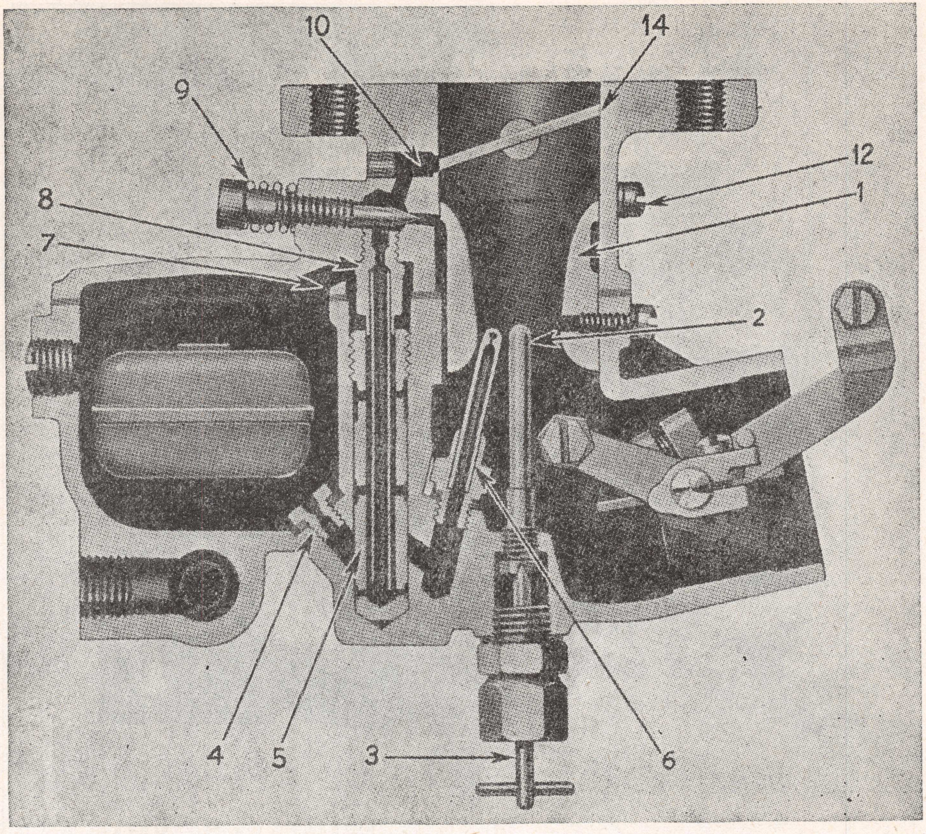
The Pick-up Tube prevents liquid fuel from accumulating in the carburetor Air Inlet. During starting, when the engine is cold and through the warming up period, fuel collects in the bottom of the carburetor and if not carried away would create a fire hazard. One end of the Pick-up Tube is located above the Throttle Plate, the other at the lowest point of the carburetor Air Intake. Fuel accumulating at this point is immediately picked up and discharged into the Intake Manifold and burned up. A metering orifice in the Suction Jet controls the discharge of the fuel, so an excessive quantity is not delivered to the engine.



FLOAT SETTING. Series 193½, Distance should be ¼"

This prevents overchoking and crankcase dilution and ensures continued running **even in the coldest weather.** The strangler **control is pulled out** as usual for starting. It is left alone or pushed in slightly until **the engine** warms up, then pushed in to **the open position.** No "jiggling" of the control is necessary.

Idling needle valve adjusting screw is an **air adjustment.** Turning it out, admits more **air to the idle system** and supplies a leaner **mixture** to the engine. Turning it in, admits **less air,** and therefore a richer mixture **is** supplied. Turn adjustment in till it **is seated,** then turn out one full turn. This **is** a good preliminary setting to warm up **the engine.** Good idle should occur within **a quarter turn either way.**



ZENITH 193½

1—Venturi. 2—Main jet. 3—Main jet adjustment. 4—Compensator jet. 5—Well. 6—Cap jet 7—Well vent. 8—Idling jet. 9—Idling adjusting needle. 10—Priming hole. 12—Throttle stop screw 14—Throttle plate.

193½ SERIES

This model is for small engine application. It is an updraft, single-barrel type. The re**movable venturi adjusts the air capacity to the size of the engine.** The fuel from the **bowl** is fed directly into the air stream **through** the main jet. The flow of this jet **being** directly controlled by suction, is **greater** at high speeds than at low speed, thus, this jet is sometimes referred to as the "high speed" jet. The main jet adjustment controls the amount of fuel passing through **the** main jet. Turning the adjustment out (counter-clockwise) will increase the **amount** of fuel passing through the main jet, while turning the adjustment in (clockwise) will decrease the amount of fuel passing through the main jet.

The fuel from the bowl also flows through the compensator into the well and **discharges** into the air stream through the **cap** jet. As the well is open to air, through a channel, the compensator is not subject to **direct** suction. Its flow of fuel is constant, **being** determined by the size of the jet and **the** fuel level in the bowl. It is most effec**tive** at low speeds. The cap jet is subject to **suction** but, of course, can flow only as **much fuel** as is supplied by the compen**sator.**

The idling system functions only on start**ing and idling.** When the throttle plate is **opened past** the idling position, the fuel re**verses** and discharges through the cap jet. **The idling jet** receives its fuel through the well from the compensator. After being measured by the idling jet, the fuel is mixed with air, the amount of air being regulated by the idling adjusting needle. At idling speeds, this emulsion is discharged into the air stream through the priming hole when the throttle plate is closed far enough to cause a strong suction at this point.

Adjustments: To adjust the idle, set stop screw on throttle lever so that engine will run sufficiently fast to keep it from stalling. Turn the idle adjusting needle in or out, until engine hits evenly, without rolling or skipping. Then back off on stop screw until desired engine speed is obtained. It may then be necessary to readjust the idle adjusting needle. The correct idle adjustment is usually found between 1 and 3 turns open of the idle adjusting needle. An idle adjustment needle seat assembly, supplied by the factory, has been found necessary. Due to carbon deposits, the idle air channel behind the venturi tube becomes plugged and no air can reach the idling system. The part number for this assembly is C46-37, and it prevents this condition by taking the idle air from outside the carburetor. In making a change over to this new type idle adjusting assembly, it is necessary that the idle air channel be plugged with lead shot.

Float setting is changed by moving the needle valve collar up or down on the needle valve. It is best to solder the **collar** slightly to the valve after the setting **is** made, which should be ¼ of an inch to **the** gasket surface of the bowl. The fuel **level** should be 35/64 of an inch. The needle **valve** seat is pressed into the housing and can **be** pulled out with a special puller.

750 SERIES

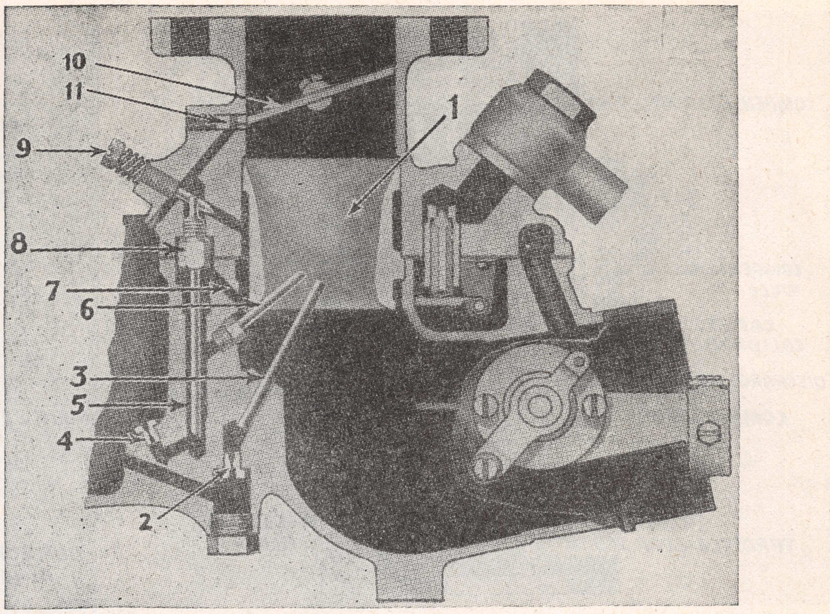
This model is popular in two sizes, 755 and 756, and is an updraft, single-barrel unit with a manifold vacuum-controlled power and accelerating system. The jet system is the same as the 150 series, except for jet locations.

IN-158 & IN-167 SERIES

These carburetors are downdraft, **single**-barrel types. The fuel bowl and **throttle** housing are as one casting. A **manifold** vacuum-controlled power and **accelerating** system is used. The regular Zenith **system** of fuel jets is used. The main jet, often **re**ferred to as the "high speed jet" exerts **its** principle influence at the higher **engine** speeds. It is a direct suction jet. Its fuel **is** discharged into the air stream, under a **de**flector in the IN-158, and through a slot **in** the secondary venturi in the IN-167. **Fuel** from the bowl passes through the compen**sator** jet and into a well which is open **to** atmosphere. In the IN-158, this **mixture is** discharged into the air stream through the cap jet, directly under the deflector. In the IN-167, this mixture passes through holes in the cap jet, into the annulus between the cap jet and the main jet, and is discharged into the air stream through a slot in the secondary venturi. The cap jet determines the rate of fuel discharge when progressing from an idling speed to a high engine speed. The compensator exerts its principal influence at low speeds.

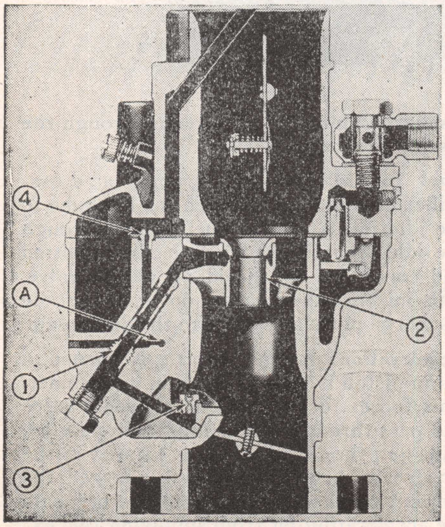
Power and Accelerating System: Full power, either for top speed or hard pulling, requires a richer mixture than part throttle operation. So does acceleration. This additional richness of mixture is provided by means of the accelerating and economizer system feeding through the power and accelerating jet. Under part throttle, the suction (or vacuum) below the throttle plate is higher than when the throttle is open. This suction holds up the piston assembly, the check valve is open and the economizer or power jet valve is closed, thus shutting off fuel from the power and accelerating jet.

When the throttle is opened, the suction falls, and so does the piston. The falling piston builds up a pressure below it, which forces the check valve to its seat, thus preventing the fuel from being forced back into the bowl. The piston falls on the power valve, pushing it open, and the fuel displaced by the piston is forced out through the power jet. This is the accelerating charge. If the throttle is held open, the piston will remain at the bottom, holding the power valve open. This allows fuel to continue flowing through the power and accelerating jet. This jet has a measuring hole in its tip which measures only enough additional fuel to develop full power. When the throttle is partly closed, the suction increases below it, the piston is drawn up to the top, the power valve closes and only a very economical amount of fuel can be fed to the engine.

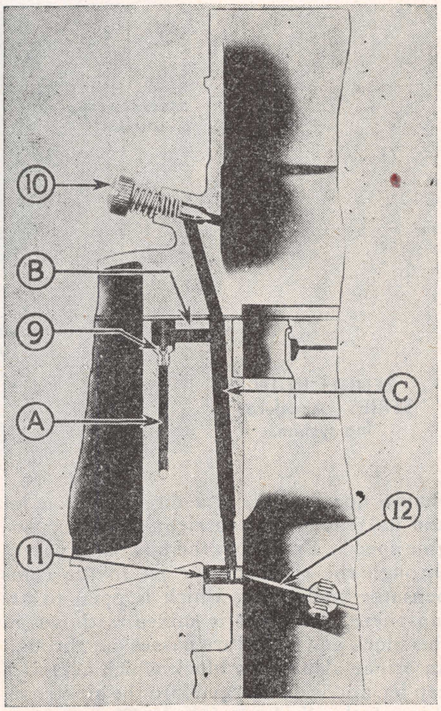


ZENITH 750 SERIES. Jet system.

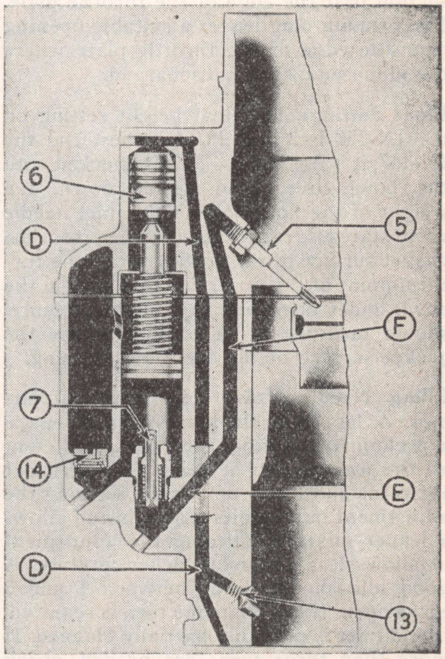
1—Venturi tube. 2—Main jet. 3—Discharge tube. 4—Compensating jet. 5—Well. 6—Cap jet. 7—Air vent channel. 8—Idling jet. 9—Idle adjusting needle. 10—Throttle plate. 11—Priming hole.



COMPENSATING SYSTEM



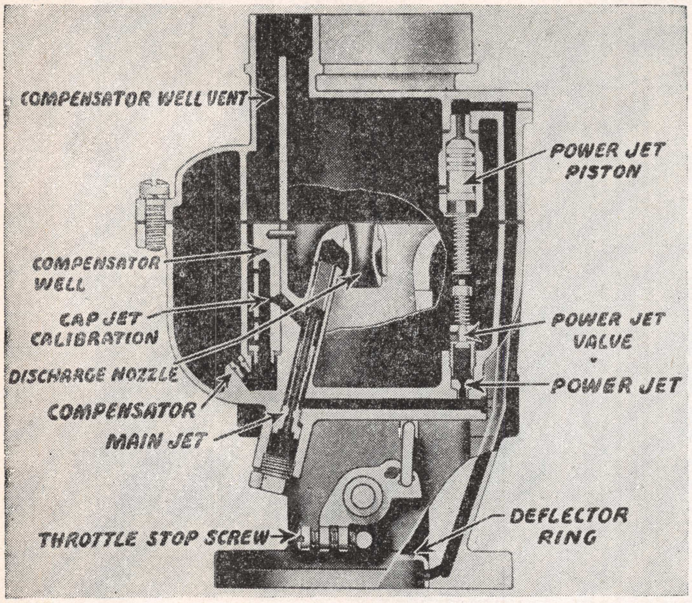
IDLING SYSTEM



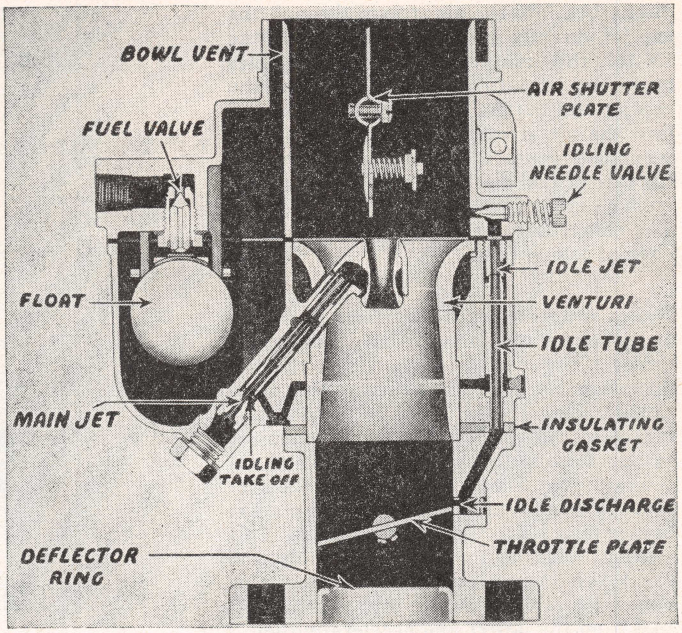
ACCELERATING SYSTEM

ZENITH IN-167 SERIES

1—Main jet. 2—Secondary venturi. 3—Compensator jet. 4—Well vent. 9—Idle jet. 10—Idle adjustment. 11—Priming plug. 12—Throttle plate. A—Idle fuel channel. B and C—Idle mixture channels. 5—Power jet. 6—Vacuum piston. 7—Power valve. 13—If no governor is used, this screw must be removed and hole left open. 14—Check valve. D—Vacuum channel. E and F—Discharge channel.


COMPENSATOR WELL VENT
POWER JET PISTON
COMPENSATOR WELL
CAP JET CALIBRATION
DISCHARGE NOZZLE
COMPENSATOR
MAIN JET
POWER JET VALVE
POWER JET
DEFLECTOR RING
THROTTLE STOP SCREW

ZENITH IN-180 SERIES. Power jet system.

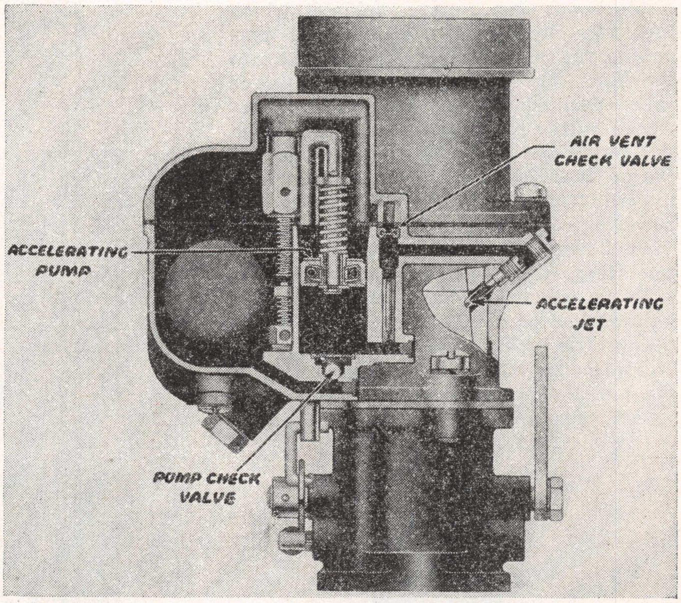

BOWL VENT
AIR SHUTTER PLATE
FUEL VALVE
IDLING NEEDLE VALVE
IDLE JET
FLOAT
VENTURI
IDLE TUBE
MAIN JET
INSULATING GASKET
IDLING TAKE OFF
IDLE DISCHARGE
THROTTLE PLATE
DEFLECTOR RING

ZENITH IN-180 SERIES. Idle system.

The Idling System consists of the idling jet which measures the fuel, and the idling adjusting needle which regulates the air. The idling jet receives its fuel from the compensator channel. The idling system functions only at idling and speeds below 18 to 20 miles per hour, when the throttle plate is almost closed and there is a strong suction past the edge of the throttle plate. The priming plug leaves a suitable opening near the edge of the throttle plate where the idling emulsion is discharged.

Float Setting: The float height setting on the IN-158 is 2 and 25/64 inches, and the IN-167, it is 2⅛ inches. This is checked with the bowl cover held upside down, the weight of the float holding the inlet needle valve stated. Measure the distance from the gasket surface of the bowl cover to the furthest point of the float. The fuel level in the bowl, under operating fuel pump pressure, should measure ⅝ of an inch below the gasket surface of the fuel bowl housing.

Idling Needle Valve adjustment admits more or less air to the idle system. To make a preliminary setting, turn the adjustment all the way in until it seats, then turn out 1¼ turns and warm up engine. Turning the adjustment out, admits more air and allows a leaner mixture. Turning the adjustment in allows less air and a richer mixture. A good idle should occur between 1 and 3 turns open. If less than one turn is required, the idle jet is probably partially clogged. If more than three turns are needed, check for a high fuel level, and spillover.


AIR VENT CHECK VALVE
ACCELERATING PUMP
ACCELERATING JET
PUMP CHECK VALVE

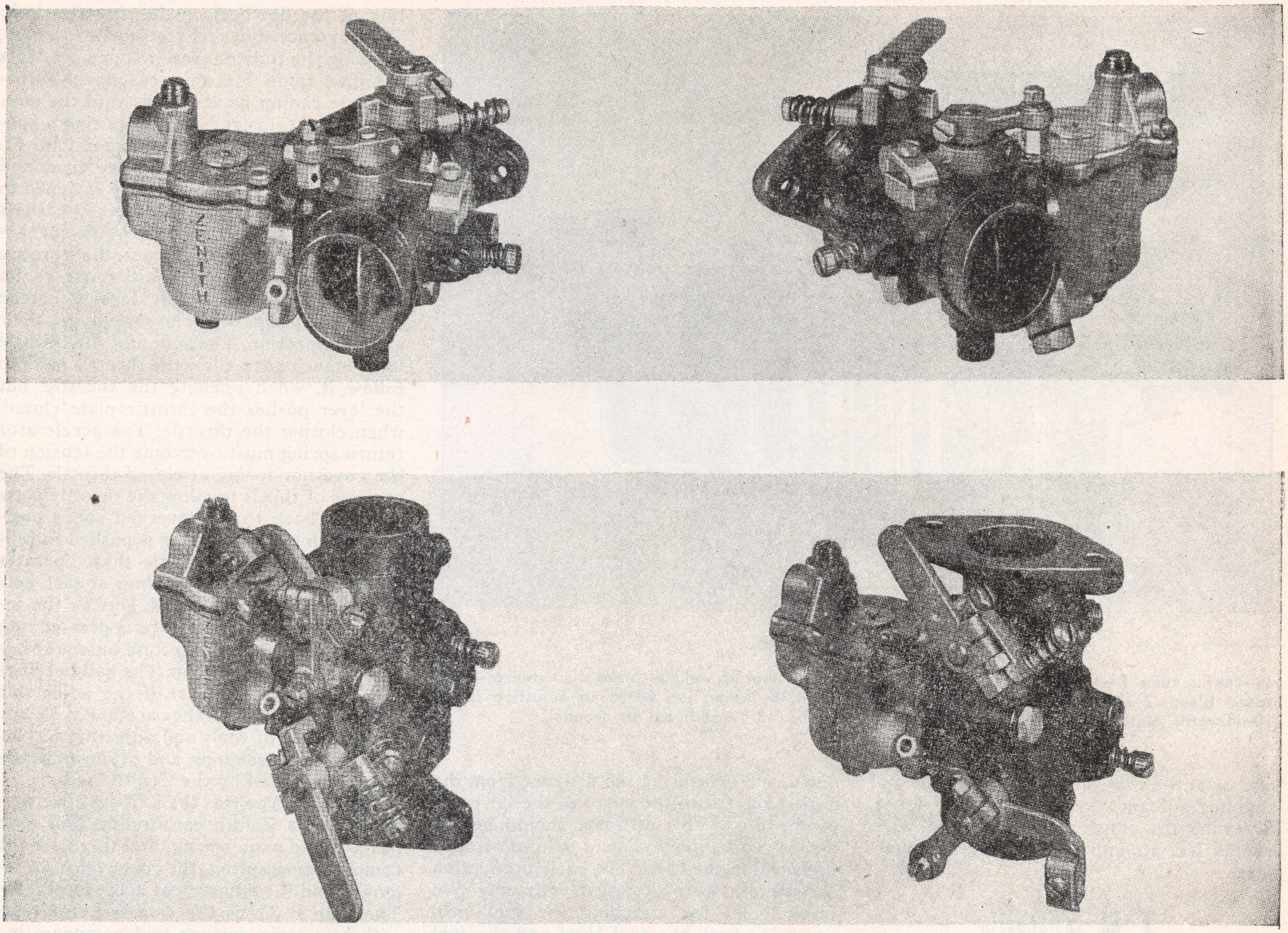
ZENITH IN-180 SERIES. Accelerating system.

IN-180 SERIES

This is a downdraft, single-barrel carburetor, with a mechanically-operated accelerating pump and a vacuum-controlled power jet system. The Zenith compound nozzle system is used. Fuel from the bowl passes through the main jet and is discharged into the air stream through the secondary venutri, which acts as a discharge nozzle. This is a direct suction jet and its tendency is to richness at top engine speeds. Fuel from the bowl also passes through the compensator jet to the compensator well block, which is open to atmosphere. The fuel is mixed with air in this block and a mixture passes out through an orifice also in the block which acts as a cap jet, and is discharged into the air stream through the discharge nozzle. The compensating jet, unaffected by suction, has a lean tendency at top engine speeds. In combination, the rich and lean jets give an average mixture of correct proportions. At normal engine speeds, with high manifold vacuum, the power piston is held in an up position. When the throttle is fully opened, and manifold vacuum drops, so does the piston and it holds open a power jet valve, which allows fuel to flow through a power jet and discharged into the air stream through the discharge nozzle.

Fuel for idle passes through a cross-drilled channel and through the idle tube to the idle jet. After the fuel passes through the idle jet it is mixed with air, admitted and controlled by the idling needle valve. This mixture then passes down to the idle discharge ports and out into the air stream.

Acceleration: As the throttle is opened, a pump piston is pushed down in its cylinder. This forces fuel to pass by a needle valve and pass through channeling to an accelerating jet, the tip of which is located in the air stream. After the fuel is discharged, the air vent check valve opens up and prevents the accelerating jet from supplying fuel except during the downward movement of the piston.



ZENITH TU SERIES IN VARIOUS ASSEMBLIES.

Upper Left: Horizontal type with fuel bowl on left side.
Upper Right: Horizontal type with fuel bowl on right side.
Lower Left: Down draft type.
Lower Right: Updraft type.

Float Setting: Hold the cover assembly upside down and observe the position of the float, which should be nearly parallel to the gasket surface of the cover. The proper distance from the gasket surface (minus the gasket), to the furthest tip of the float surface (not the soldered seam), should be 1-13/32 of an inch. A more important check could be made of the fuel level, at operating fuel pump pressure, which should be 43/64 of an inch.

On complaints of "lean" or "erratic running", these points should be checked. In the earlier production carburetors of this type, only three cover assembly screws were used. After considerable service, the bowl cover would warp and prevent a **gasket seal** between the fuel bowl and the upper body.

Leaking **vacuum piston** assemblies might also cause such a complaint, and should be replaced with a new one. In carburetors where the **bowl ventilating channel** is a 1/8 inch diameter hole, the complaint can very likely be overcome by increasing the size of the ventilating opening. The factory does not recommend drilling additional holes, because there would be great risk of spoiling the body casting, unless special fixtures were made to hold the casting and guide the drill. A special broach is supplied, with which this opening may be quickly enlarged. The broach is inserted in the casting above the present ventilating hole, and driven through with a hammer.

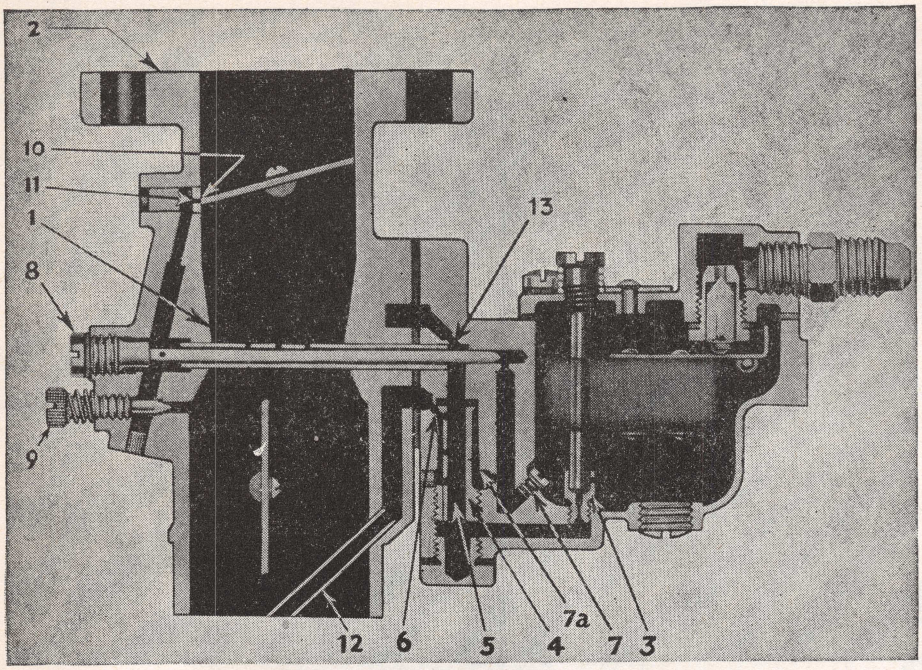
The first production carburetors of this series did not have a pilot bushing in the vacuum channel, to prevent leakage through the gasket. The bushing number is CR67-6 and the body should be drilled 5/32 of an inch in diameter and 7/64 of an inch deep.

Do not put **two compensating jets** in these carburetors. Some carburetors have the compensator screwed into a tapped hole in the fuel bowl. Others have the compensator screwed into the bottom of the compensator well block. Some service men, upon inspecting a carburetor of this series, have noticed a tapped hole in the fuel bowl. Assuming the compensator has been left out, they have inserted a jet in this opening, with the result that there are two jets in series. Use the leather gasket only when the compensator jet is installed in the **well** block. When the compensator jet is installed in the bowl, no well block **gasket is** required.

Be sure to install a **copper gasket when** replacing the **main jet**, being sure the old one is removed. Place the **power jet** in position with the head up, followed by the copper gasket and the power jet valve, which must be screwed down snugly, but not hard enough to squeeze the soft copper gasket out of shape.

Accelerating pump stroke can be changed internally by removing the pump stroke spacer, located below the leather pump piston assembly, and replacing with a longer or shorter spacer as desired. The spacer number is CR-37 and standard pump travel is 27/64 of an inch.

Idle Adjustment: Turn the idling needle valve in to the right until it is seated, and then back out one full turn, which should supply a normal idle mixture. This is an air adjustment, and screwing the adjustment



ZENITH TU 4 C MODEL.

1—Venturi tube. 2—Carburetor flange. 3—Main jet. 4—Metering well. 5—Sized diameter. 6—High speed bleed. 7—Well addition jet. 7A—Well reservoir. 8—Idling jet. 9—Idling adjusting screw. 10—Throttle plate. 11—Priming hole. 12—Balancing tube. 13—Additional air channel.

out, or anti-clockwise, admits more air and supplies a leaner mixture for low speed. Screwing the adjustment in, or clockwise, admits less air and supplies a richer mixture.

T U SERIES

These series carburetors are so designed that they may be assembled into various combinations, horizontal type, with fuel bowl on the left or on the right, downdraft or updraft type. Any one of these combinations can be converted from any other combination without additional parts.

A venturi tube is cast into the housing to measure the volume of air passed through the carburetor. The size is stamped on the face of the flange. The main jet feeds fuel through a channel into the metering well, and then out into the air stream. The diameter of the bore in the metering well regulates the suction transmitted to the main jet, and influences the mixture ratio at all speeds, except idling. The well addition jet controls the rate of fuel flow into the well reservoir, and provides fuel for idle recovery. The fuel in this reservoir is also available as an accelerating charge, when the throttle is opened quickly. The high speed bleed controls the rate of air flow into the metering well channels.

The idle jet receives its fuel from the well addition jet channel, and is mixed with air admitted by the idling adjusting screw. This mixture is then discharged into the air stream through the priming hole.

Adjustments: Float height setting is checked by holding fuel bowl cover upside down, and measuring the distance from the gasket surface of the cover to the far point of the float. This distance should be 1⅛ inches. This should allow a 9/16 of an inch fuel level in the bowl. The early production carburetors were designed with only two screw holes for attaching the fuel bowl cover. As both the fuel bowl and the fuel bowl cover were die castings, this design did not prevent warping of the cover. A change was made to provide four screws, and this assembly has given much better service.

The balancing tube is used on some installations and on other installations it is not used.

To apply a main jet, or high speed adjustment assembly to this series carburetor, the fuel bowl cover must be replaced with a special cover that supports the adjusting screw.

Idle adjustment controls the amount of air admitted to the idle system. Turn the screw in until it seats, and then turn out ¾ of a turn for a preliminary adjustment. Turning the screw out, admits more air to the idle mixture and makes it leaner. Turning the screw in, admits less air to the idle mixture and makes it richer.

GOV-U-RETOR

This is a carburetor and governor combination built up as one unit. One throttle shaft and plate assembly is used both for carburetion and governing purposes. The throttle plate does not open to a wide-open position, but is controlled by the special setting of the flywheel on the throttle shaft. The governor flywheel rests against a stop, allowing the throttle plate to open only to a specified angle. For this reason, the throttle plate cannot be removed, until the governor flywheel is removed, requiring a special flywheel puller, part number C161-77. The governor is of the velocity type, and the throttle lever is not directly fastened to the throttle shaft, but operates the shaft through an internal driver. With the accelerator rod removed from the throttle lever, the throttle plate will move to its open position, due to the tension of the governor spring, or springs, applying their governing action. The action of the throttle lever is such as to allow the throttle plate to **follow it**, when opening the throttle, but the lever **pushes** the throttle plate closed, when closing the throttle. The accelerator return spring must overcome the tension of the governor spring at closed throttle. The purpose of this is to allow the throttle plate to move back to its governed speed position, when the accelerator is pushed to full-open position. The throttle shaft operates on fourteen small ball bearings at each end. The shaft, being hardened, acts as the inner race, and one outer race is pressed into the housing, while the second outer race, is adjustable, and screws in. The ball bearings will all fall out of place if the adjustable race is unscrewed, as they are not in a cage. A special set of tools and adjusting blocks, and a special weighing and calibrating machine is supplied by the Zenith factory.

The C 300 type was the Leibing governor, applied to a Zenith carburetor. This type has a single main spring, and to adjust the compensating spring, the cover must be removed and the adjustment made internally. The type B 330 is the Gov-U-Retor type, with two main springs and compensating adjustment externally accessable. The latest types, B 350 and B 351, are a return to the first type, with a single main spring, but the addition of an externally accessable compensating spring adjustment.

Service: Under extreme conditions, carbon formation, caused by high temperatures "cooking" the oil vapors induced to the carburetor intake system from the breathing system and accumulating on the shaft, might eventually slow up the action of the governor. This condition can be remedied by squirting some solvent on the throttle shaft and into the ball races. This can be easily accomplished by removing the unit from the engine and by squirting the solvent from the flange opening. The use of a thick insulating gasket between the carburetor and manifold flange is recommended, as it will help considerably to minimize the "cooking" of oil fumes.

If trouble is experienced with the governed speed not staying put, requiring continual adjustment to keep the speed high enough, it is probably caused by the warping of the main spring block assembly. This part has been improved, and should be replaced.

Adjustments: To increase the governed speed, turn the main spring adjustment clockwise, or to the right. To decrease the

governed speed, turn the adjustment anti-clockwise, or to the left. Should a "surge" become apparent at the new speed setting, remove the compensating spring channel plug, (the type without the plug, remove the housing cover) and with a narrow screwdriver, turn the compensating spring adjusting screw ½ turn anti-clockwise. If a surge still exists, repeat this procedure until the surge is overcome. If, on the other hand, the governor does not respond quickly enough, and is considered "flat", turn the compensating spring adjustment ½ turn clockwise. This may be repeated carefully until a light surge results. Then, from that point, turn the compensating spring adjustment back ½ turn anti-clockwise.

If the compression of the compensating spring against the governor flywheel is too great, the governing action will be "flat", that is to say, the carburetor-governor throttle plate will move too slowly to the desired governed speed after the governor flywheel contacts the compensating spring. If the compression of the compensating spring against the governor flywheel is not sufficient, the governing action will be too "sharp" and sometimes will result in a "surging" or "hunting" action.

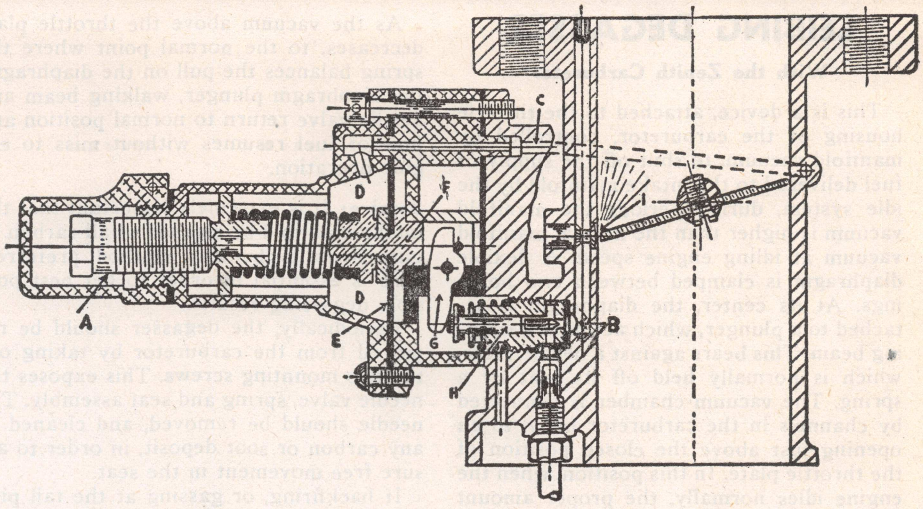
TO DETERMINE IF THE GOVERNOR REQUIRES AN INTERNAL ADJUSTMENT

The amount of adjustment of the compensating spring can easily be determined with the use of a vacuum gauge and as follows:

1. **Preferably, have the chassis loaded to rated load and make sure that all equipment such as air cleaner, carburetor, ignition, etc., is set to specifications.**
2. **Select a hard, flat-surfaced road.**
3. **Adjust the governor at the desired governing speed by means of the main speed adjusting screw, allowing the chassis to reach a settled governed speed, and record miles per hour at speedometer and vacuum reading at vacuum gauge.**
4. Determine the "trip" point of the governor. This is accomplished by keeping the accelerating pedal down and increasing the load by applying the brakes to bring the speed of the chassis at least ten miles per hour, lower than the governed speed. Release the load entirely and observe the vacuum reading at the point where the vacuum begins to increase rapidly. The point is called the "trip".
5. Once the governing speed has again been reached, increase the load **lightly** and **gradually,** always keeping the accelerating pedal down, and note the miles-per-hour drop in speed at the time the vacuum gauge reaches ½ inch of mercury higher than the "trip" point determined in operation No. 4.

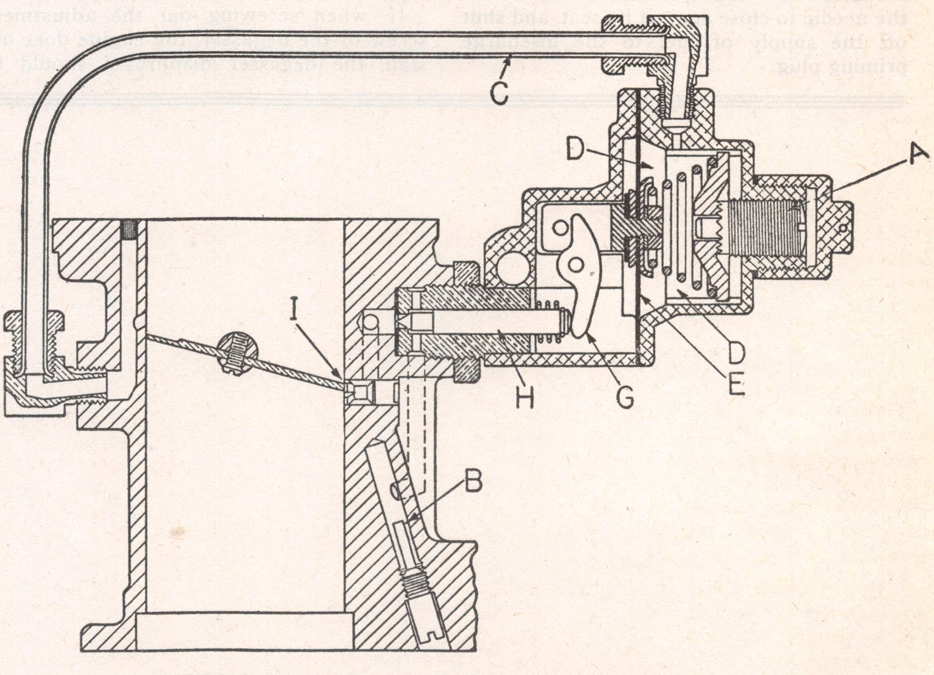
Example: Test No. 3 indicated a 12 inches of mercury manifold vacuum reading at forty miles-per-hour governed speed.

Test No. 4 indicated a 5 inches of mercury **manifold vacuum reading at the "trip" point of the governor.**



LEIBING DEGASSER, MODEL A. Used with Zenith Carburetor.

A—Adjustment. B—Idle jet. C—Passage. D—Chamber. E—Diaphragm. F—Plunger. G—Walking beam. H—Needle valve. I—Idle discharge ports.



LEIBING DEGASSER, MODEL B. Used with Zenith carburetor.

A—Adjustment. B—Idling jet. C—Channel. D—Vacuum chamber. E—Diaphragm. G—Walking beam. H—Needle valve. I—Idle discharge ports.

Test No. 5. **The load should then be increased from governed speed until the vacuum gauge drops down to a 5½ inches** of mercury vacuum reading.

If the miles-per-hour drop between test No. 3 and test No. 5 is from three to four miles, the governing action is considered commercially satisfactory. If the miles-per-hour drop is in excess of four miles, the governing action is considered "flat" and the compensating spring adjusting screw should be adjusted, turning same clockwise about a half turn. Repeat test No. 5 and continue the adjustment until the speed drop between governed speed and full load does not exceed four miles per hour.

If the action of the governor is too sharp, a "surge" or "hunt" might result. The compensating spring adjusting screw should be adjusted counter-clockwise until a steady governing action is obtained as mentioned in above paragraph.

NOTE—The adjustment of the compensating spring will slightly change the governed speed. Consequently, same should be rechecked and reset by means of the main adjusting screw following the final adjustment of the compensating spring.

LEIBING DEGASSER

With the Zenith Carburetor

This is a device, attached to the throttle housing of the carburetor, controlled by manifold vacuum, to shut off the supply of fuel delivered to the intake manifold by the idle system, during periods the manifold vacuum is higher than the normal manifold vacuum at idling engine speed. A flexible diaphragm is clamped between two housings. At its center, the diaphragm is attached to a plunger, which actuates a walking beam. This bears against a needle valve, which is normally held off its seat by a spring. The vacuum chamber is connected by channels in the carburetor body, to an opening just above the closed position of the throttle plate. In this position, when the engine idles normally, the proper amount of fuel is drawn through the idling jet and the priming plug. During deceleration, the abnormally high vacuum is transmitted through the channels, to the vacuum chamber, and draws the diaphragm and plunger back against the tension of the spring. This actuates the walking beam, which causes the needle to close against its seat, and shut off the supply of fuel to the discharge priming plug.

As the vacuum above the throttle plate decreases, to the normal point where the spring balances the pull on the diaphragm, the diaphragm plunger, walking beam and needle valve return to normal position and flow of fuel resumes without miss to engine operation.

Service: It is extremely important that the intake manifold be cleaned of all carbon or gum deposits by any method preferred. This is essential in order to get best possible degassing results.

Periodically, the degasser should be removed from the carburetor by taking out the two mounting screws. This exposes the needle valve, spring and seat assembly. The needle should be removed, and cleaned of any carbon or soot deposit, in order to assure free movement in the seat.

If backfiring, or gassing at the tail pipe is noticed, it indicates a leakage of fuel through the idle system on deceleration. This should be taken care of when the degasser is removed, and the needle out of the seat, by tightening the seat against the fibre gasket. The needle, then, should be lightly tapped in place, to assure a perfect seat.

If, when screwing out the adjustment screw of the degasser, the engine does not stall, the degasser diaphragm should be inspected for leaks. If found leaking, diaphragm should be replaced. After reassembling, make sure walking beam is perfectly free in the housing.

Adjustment: Before starting the engine, make sure the adjustment is completely closed, by screwing in the adjusting screw as far as possible. This makes the degasser inoperative, and the idle speed and mixture of the carburetor can then be adjusted in the usual manner.

After engine is up to normal temperature, and idling has been adjusted in the usual manner, turn the degasser adjusting screw out, anti-clockwise, with the engine running at idle speed. When the engine stalls, turn the adjustment in clockwise six to ten notches.

Start the engine again and increase speed to approximately 2,000 RPM, then close the throttle quickly, allowing the engine to decelerate to idle speed. If engine stalls, and does not resume idling normally, screw in one notch at a time, and repeat this operation, until the engine ceases stalling after quick deceleration. Correct adjustment has been found to be approximately six to ten notches clockwise on degasser adjustment from stalling position.

CARTER AUTOMATIC CHOKES

CARTER

CLIMATIC CONTROL

The operation of this choke is governed by intake manifold vacuum and exhaust manifold temperature.

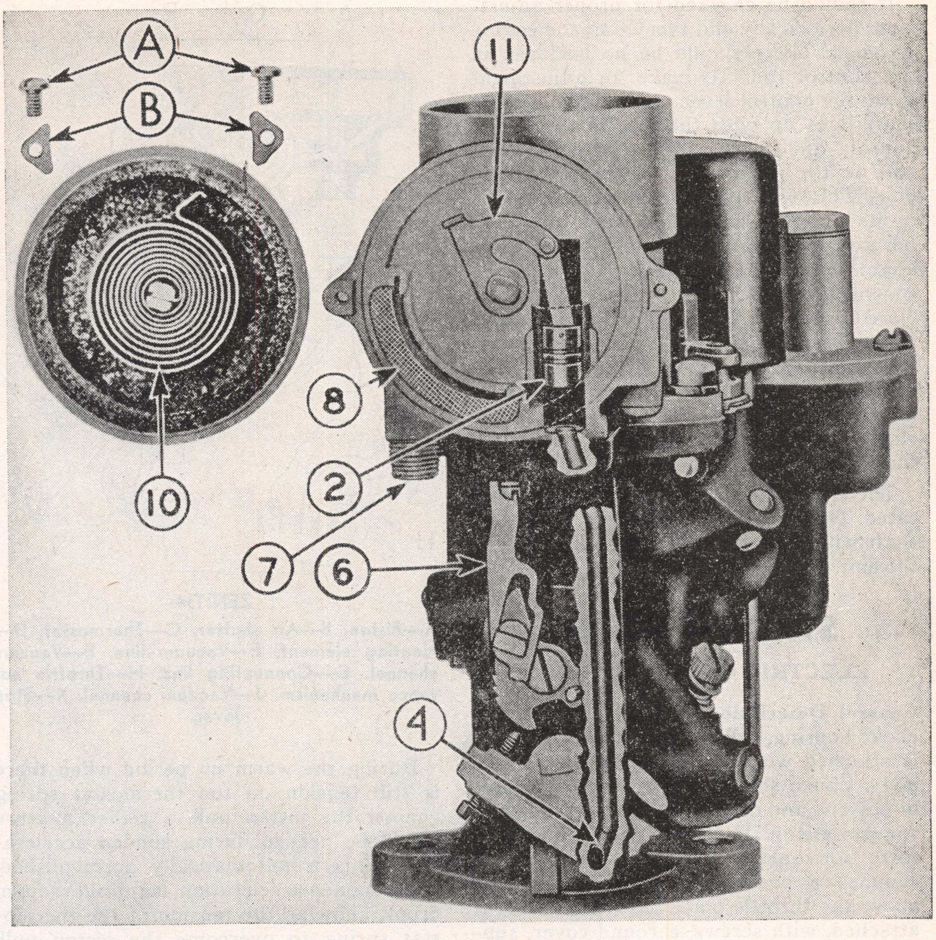
On initial starting, as the engine fires, the vacuum created in the manifold pulls the choke piston down, exerting tension on the thermostat attached to the piston lever and opening the carburetor choke valve enough for initial running. Hot air is drawn from the stove on the exhaust manifold through the flexible tube and screen to the automatic choke housing. As the heat increases around the thermostat it loses its tension, allowing the choke to open gradually. After the choke reaches its full open position it remains open by its own weight. When the engine is stopped, the thermostat cools off, revolving the choke shaft and allowing the choke to close. The automatic choke is provided with a screen in the hot air line to keep dirt and soot from entering the thermostat housing. If the screen clogs, it will restrict the flow of hot air to the thermostat housing and cause loading.

Except for a check of the moving parts to see that they operate freely and an occasional cleaning of the hot air line screen, adjustment of the unit is seldom necessary.

To clean the screen on single carburetors it is not necessary to remove the carburetor from the engine. Remove the thermostat housing which will allow removal of the screen. On dual carburetors it is necessary to remove the carburetor from the manifold by removing the fuel line, vacuum spark line, throttle rod and flange bolts before the thermostat housing and thermostat assembly can be removed. With these parts removed, loosen the screws in the piston plate and lift out the screen.

The choke valve should close tightly on its seat at a temperature of 79 degrees for single carburetors and 74 degrees for the dual carburetors. If the choke valve does not close at the proper temperature, install a new thermostat housing and thermostat assembly.

If a cold engine shows a tendency to run lean during the warm-up period, turn the housing counterclockwise one mark at a time to richen it until the desired results are obtained. If a cold engine has a tendency to load or run rich during the warm-up period, revolve the housing clockwise one mark at a time until the desired results are secured. The direction in which the housing must be turned for an adjustment is indicated. Under normal conditions it should not be necessary to change the setting more than one or two graduations. The chokes are calibrated for average gasoline and of course, any special or high test gasoline will affect its calibration. Adjustments should be made with care and with the engine cold. Between adjustments the engine must be thoroughly cooled off. At least four hours should be used to cool the engine.



CARTER CLIMATIC CONTROL

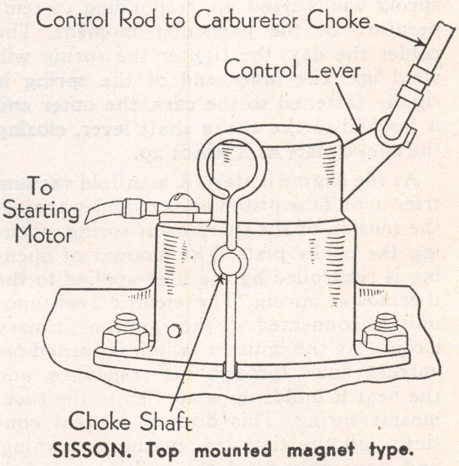
A—Thermostat housing screw. B—Housing retainer. 2—Piston. 4—Heat tube. 6—Fast idle connector link. 8—Piston housing strainer. 10—Thermostat housing coil. 11—Choker shaft and lever assembly.

Disassemble: No attempt should be made to service the unit on the carburetor. Remove attaching screws and housing retainers and remove thermostat coil and housing assembly. Remove the choker valve. Loosen clamp screw on fast idle link and lever assembly and bend the lip under screw, so it will pass over the portion of the choke shaft which is not milled flat, and remove the fast idle link and lever assembly. Remove the choker piston lever, link and shaft assembly. Remove the suction passage gasket from air horn. Do NOT remove rivet holding air horn and piston housing together, as these parts are line-reamed at the factory. However, if it is necessary to disconnect these parts, line them up with the shaft and valve, so that the valve, shaft and piston work freely.

Assemble: Wash all parts except cork pieces, and coil and housing assembly, with clean gasoline. Blow through all passages with compressed air to remove all foreign substances and to allow all parts to work freely. Use all new gaskets and replace all worn or damaged parts.

When installing the choker valve, use new screws. With the valve loose, tap it lightly to centralize it in the air horn and tighten screws securely. Be sure the valve moves freely in the air horn.

If the cork insulating strip in the thermostat housing is shrunk or damaged, it should be replaced. Replace the entire coil and housing assembly if any of the parts are damaged.



SISSON. Top mounted magnet type.

SISSON

TOP-MOUNTED MAGNET TYPE

This type automatic choke is connected to the starting motor and operates the carburetor choke when the starter button is pressed. It then controls the opening of the choke according to manifold temperature.

It should be checked for proper adjustment periodically and every time the engine is tuned. There should be no backlash in the control rod. To make an adjustment move the control lever until the hole in its shaft lines up with the slot in the choke housing and then insert a straight 3/32" wire or the shank of a No. 42 drill in the hole. This will lock the automatic choke in its closed position. Remove the carburetor air cleaner. Loosen the control lever clamp screw and push upward on the control lever until the carburetor choke is closed tight. Hold the choke in this position and tighten the control lever clamp screw. Remove the wire or drill. After this adjustment there should be no evidence of backlash in the control rod. Replace the air cleaner and do not tighten so that it causes the choke or shaft to bind.

The automatic choke should not be lubricated. The presence of oil around the choke shaft will seriously impair the efficiency of the unit.

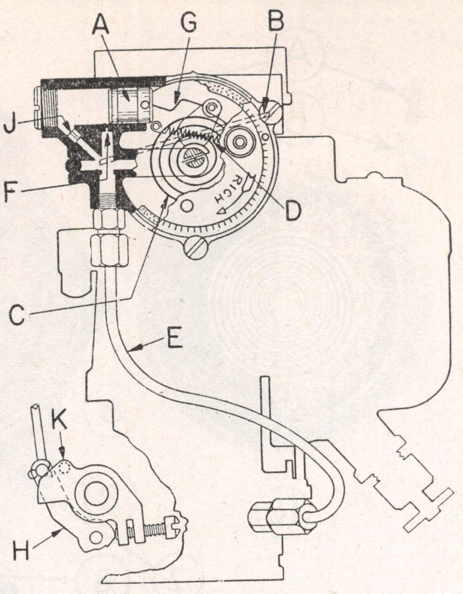
STROMBERG SF

ELECTRIC CHOKE CONTROL

General Description: A special automatic choke housing, called a thermostat housing, is attached with screws to the lower fuel body. Choke shaft extends through center of housing and connects to a lever, link, and vacuum piston. The piston moves back and forth horizontally in a cylinder. A tubing supplies a passage to manifold vacuum above the throttle plate. To the housing, is attached, with screws, a round cover, supporting a thermostat spring and an electric resistance unit. This is called the Thermostat electric unit.

Operation: On a cold engine, the thermostat spring winds itself up, responding to temperature of the particular moment. The colder the day, the tighter the spring will wind up. The inner end of the spring is rigidly fastened to the case, the outer end is hooked to the choke shaft lever, closing the choke plate as it winds up.

As the engine is started, manifold vacuum tries to pull the piston in its cylinder against the tension of the thermostat spring, opening the choke plate. The amount of opening is controlled by the heat applied to the thermostat spring. The electric resistance unit is connected in the ignition primary circuit. As the ignition switch is turned on, current flows through the resistance, and the heat it builds up is applied to the thermostat spring. This flow of current continues all the time the engine is running, and stops only when the ignition switch is turned off. The current draw is one ampere at 6 volts. As the thermostat spring is warmed up, its action is to unwind in the direction of the vacuum piston pull, allowing the choke plate to open gradually, always admitting the correct amount of air to the engine during the warm up period. As engine operating temperature is reached, the thermostat spring offers no resistance to the choke plate, being held wide open by the pull of the piston.



ZENITH

A—Piston. B—Air shutter. C—Thermostat. D—Heating element. E—Vacuum line. F—Vacuum channel. G—Connecting link. H—Throttle advance mechanism. J—Vacuum channel. K—Stop lever.

During the warm up period when there is still tension on the thermostat spring against the piston pull, a richer mixture would be needed during sudden acceleration. This is automatically accomplished. Upon sudden acceleration, manifold vacuum drops, allowing the tension of the thermostat spring to overcome the piston pull, thereby allowing the choke plate to close momentarily.

Service: There are three complaints that can be connected with the choke assembly: hard starting, engine back-firing during warm up period, and engine lopes or loads up during warm up.

Hard starting can be caused by sticking piston or choke shaft, caused by formations of carbon and dirt after long periods of use. Should either one of these two parts stick the choke plate will no doubt be forced open by air velocity during the engine running period, but, as the engine is shut off and allowed to cool, the thermostat spring tension is the only pressure applied to rotate the choke shaft and move the vacuum piston to a closed choke position, and if sticking exists, the choke plate may only close ¾ or ⅞ of the way. The choke plate must be fully closed at temperatures below 65 degrees. For easy starting as on the SF series carburetor, the accelerating pump is vacuum operated and you cannot get the assistance of fuel pumped into the air passage with the accelerator pedal, as you can on a mechanically-operated accelerating pump system. A disassembly and cleaning will usually clear up this trouble. Do not use abrasives or wire wheel on the piston. A chemical cleaner that removes carbon does a thorough job. Do not use any form of lubricant when installing piston.

Back firing during warm up period can be caused by choke plate opening too far, too soon. Check for bent or distorted thermostat spring. This spring can in no way be bent, without changing its calibrated value.

Loading up, or too rich during warm up: The electric resistance unit can burn out after much use, therefore, only engine heat would be applied to the thermostat spring, which would stay cool too long, not allowing the choke plate to open far enough for proper mixture.

Thermostat Setting: There is no winter or summer setting, as the thermostat spring is controlled by temperatures; it merely does not close the choke plate as tightly in the summer as it does in the winter. There can be a change made for extremely high volatile fuel, but it should never exceed two graduations lean. The setting of the thermostat cover is 12 notches rich from the ▲ mark.

Deflooder setting: With throttle plate held in wide open position, choke plate should be open to fit a 19/64 drill. Measure on the offset side of the choke plate. To adjust, bend choke stem pin to obtain correct setting. This feature is used after an engine has been cranked a long while without starting up. The engine is flooded with fuel and unless air is admitted it never will start. By depressing the accelerator pedal all the way, the choke plate is opened to admit air when next cranked.

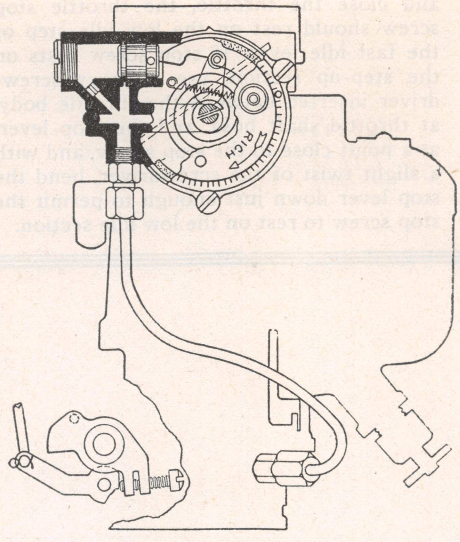
ZENITH—20 SERIES

ELECTRIC CHOKE CONTROL

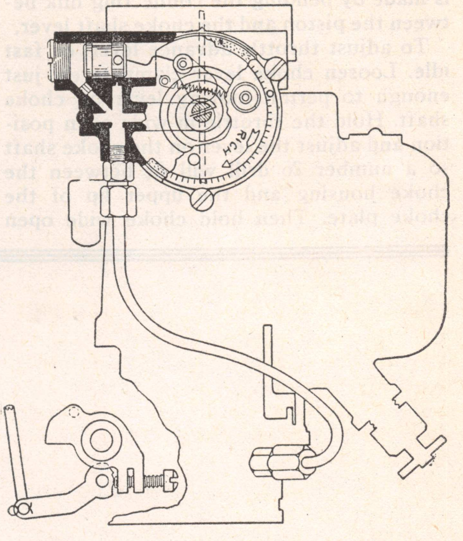
General Description: The automatic choke control, as adapted to the 23 and 28 Series, is made as part of the carburetor assembly. It controls the opening and closing of the choke plate during the entire range of engine operation. It is directly connected to the choke shaft, which assures positive action, and accurate control, under various warm up operating temperatures.

Manifold vacuum is used to open the choke shaft partially after the initial firing of the engine, and heat is used on the thermostat spring to control the amount of opening during the warming up period. Heat for the thermostat is provided by an electric element in the thermostat chamber. A throttle advance mechanism provides fast idling during the warming up period, and a pin, located on the stop lever, provides a positive means to open the air shutter if the engine fails to start due to over choking. This is accomplished by opening the throttle to a wide open position. This choke control is available for either 6 or 12 volt ignition systems.

The electrical connection from the automatic choke should be on the ignition switch so that current will flow only when the ignition switch is turned on. This furnishes heat to control the tension of the thermostat. The current draw is 1.0 to 1.1 amperes at 6 volts.



ZENITH. Showing air shutter open against thermostat spring tension, admitting sufficient air to give satisfactory running mixture.



ZENITH. As engine warms up, the heating element warms thermostat, causing air shutter to open, moving throttle advance lever to warm idle position

Operation: A throttle advance lever on the throttle body is actuated by a rod and lever on the choke shaft so that, while the choke is partially closed, the engine speed is automatically increased to prevent stalling during the warming up period. With a cold engine the choke will not close until the throttle has been opened slightly.

As the engine begins to fire, the manifold vacuum pulls the vacuum piston to open the choke against the tension of the thermostat spring. Sufficient air is thereby admitted to give a satisfactory running mixture.

A heating element gradually warms the thermostat, decreasing its resistance to the pull of the piston, which gradually causes the choke to open as the engine warms up. This action also moves the throttle advance lever to the warm idle position.

While the thermostat is only partially warmed up, its tension against the pull of the vacuum piston is sufficient to hold the choke partially closed during acceleration at which time the manifold vacuum is too low to exert much pull on the piston.

When the thermostat becomes completely warmed up, its tension is reversed and holds the choke open regardless of manifold vacuum.

Thermostat Setting: All units are initially set with the thermostat 15 notches rich. To examine and check thermostat proceed as follows:

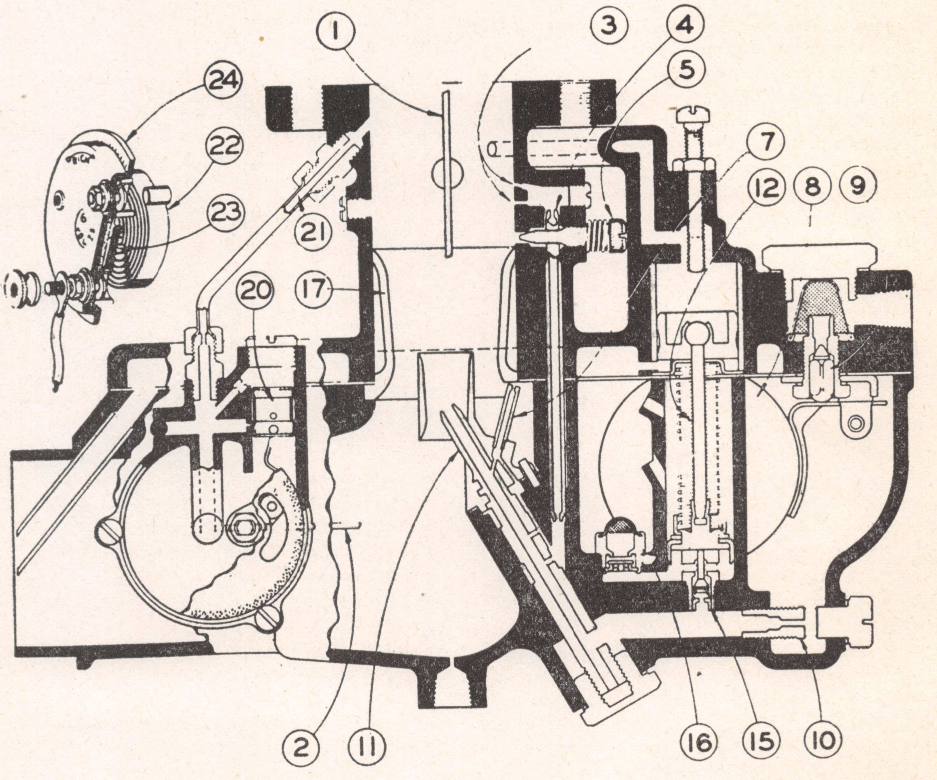
Remove the three cover plate screws and the cover plate and allow the thermostat to cool or warm until it has reached the temperature of 70 degrees F. This is very important and should be done in a room having a temperature of 70 degrees. When the thermostat reaches 70 degrees, the inside of the eye at the end of the thermostat should coincide with the "Zero" marking on the outside of the cover, which is the original setting made at the factory. When installing a new thermostat, or other parts, check the "Zero" location very carefully at 70 degrees temperature and change the location if necessary.

NOTE—If it is impossible to maintain a room temperature of 70 degrees you can provide for the difference by allowing one notch on the cover for each 5 degrees variation in temperature. For example, if temperature is 60 degrees, the eye on the thermostat will coincide with the second graduation to the right of the zero marking, or, if the temperature is 80 degrees, the eye will coincide with the second graduation to the left of the zero.

To adjust the thermostat, re-assemble cover onto the case so the eye is in position on the pin on the lever, with no tension on the thermostat and with the choke in wide open position. The zero mark on the cover will be 3 or 4 graduations to the left of the indicator line on the case. Move cover to bring the zero mark up to the indicator line, then, rotate cover 15 notches rich, as indicated by the arrow on the cover, and fasten screws securely.

The cover assembly is sold as a unit only. The resistance unit should not touch the thermostat at any place otherwise a short will occur and destroy the resistance unit.

To check for proper vacuum piston kick, insert a number 66 drill into the opening where the vacuum line from the throttle body enters the choke housing, close the choke and allow the 66 drill just to protrude into the cylinder to contact the piston when the choke is partially opened. Contact should occur when a number 70 drill can be inserted between the choke housing and the upper lip of the choke plate. Adjustment



STROMBERG. Used with SF Series carburetors.

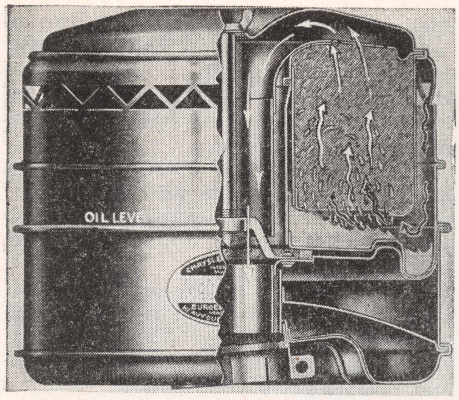
1—Throttle valve. 2—Choke valve. 3—Idle discharge holes. 4—Idle tube. 5—Idle needle valve. 7—High speed air bleed. 8—Float. 9—Float needle valve and seat. 10—Main metering jet. 11—Main discharge jet. 12—Accelerating pump. 15—Economizer valve (power jet). 16—Check valve. 17—Large venturi. 20—Automatic choke vacuum piston. 21—Vacuum passage (automatic choke). 22—Thermostat. 23—Electric element (heat unit). 24—Thermostat cover and adjusting plate.

is made by bending the connecting link between the piston and the choke shaft lever.

To adjust throttle advance lever, or fast idle. Loosen choke lever clamp screw just enough to permit moving lever on choke shaft. Hold the throttle in wide open position and adjust the lever on the choke shaft so a number 26 drill will fit between the choke housing and the upper lip of the choke plate. Then hold choke wide open and close the throttle, the throttle stop screw should rest on the low idle step of the fast idle lever. If stop screw rests on the step-up section, use a heavy screwdriver inserted between the throttle body, at throttle shaft boss, and the stop lever, at a point close to the stop screw, and with a slight twist of the screwdriver, bend the stop lever down just enough to permit the stop screw to rest on the low idle section.

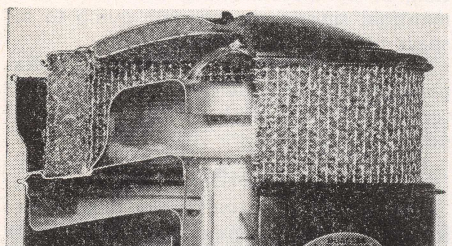
NOTE—If, after the engine has been thoroughly warmed up, it is stopped for several minutes, and then restarted, it may be necessary to hold the throttle wide open momentarily to prevent overchoking. The cause of this is that under certain conditions the automatic choke unit may cool faster than the engine, and will close the choke even though the engine is not cold enough to require choking.

AIR CLEANERS



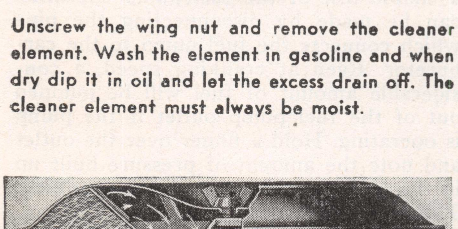
BURGESS OIL BATH TYPE

Unscrew the wing nut and remove the top and the cleaner element from silencer. Wash the cleaner element in kerosene but do not oil it. Empty the oil from the sump and wash it with kerosene. Refill the reservoir with one pint of SAE 50 oil in summer and SAE 20 oil in winter.



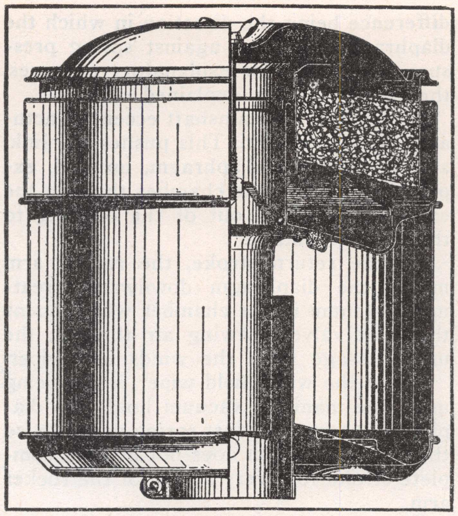
BURGESS

Unscrew the wing nut and remove the cleaner element. Wash the element in gasoline and when dry dip it in oil and let the excess drain off. The cleaner element must always be moist.



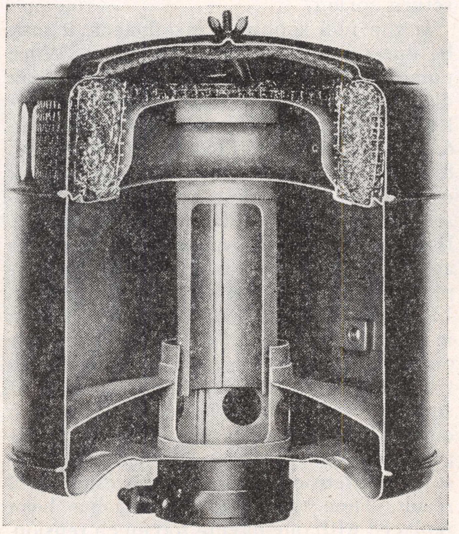
HANDY

Remove complete unit from carburetor and detach the upper half of cleaner from the sump. Remove oil from sump and refill with clean oil. Type 800 holds one pint and type 200 holds one quart of oil.



AC OIL BATH TYPE

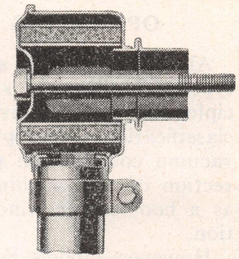
Remove the wing nut from the top and remove the cover. Then remove the filter element by hand. Do not pry this part if it sticks for it may damage the filter element flange which must lie flat to insure a tight seat against the body to prevent air leaks when the cover is assembled. Empty the oil from the cleaner and remove all accumulated dirt. Wash the body with clean gasoline and wipe it dry. Wash the filter element thoroughly by slushing it up and down in clean gasoline and then let it stand until thoroughly dry. Pour one pint of engine oil, SAE 50 in summer and SAE 20 in winter, into the reservoir. Do not oil the filter element as this is done automatically when the car is driven. Reassemble the filter element to the cleaner and then replace the cover and tighten it in place with the wing nut.



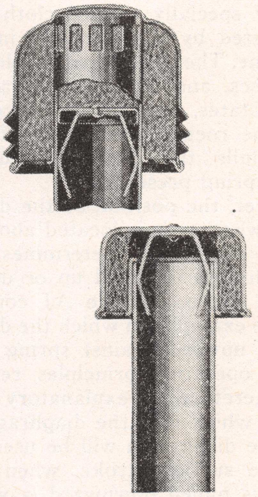
AC STANDARD TYPE

Unscrew wing nut and remove cover and felt pad. Remove cleaner element and wash it in clean gasoline or kerosene. Dip cleaner element in SAE 50 oil and let excess drain off. The felt pad must be free of oil and have its hard side down. The cleaner element must always be moist.

CRANKCASE BREATHER AIR CLEANER

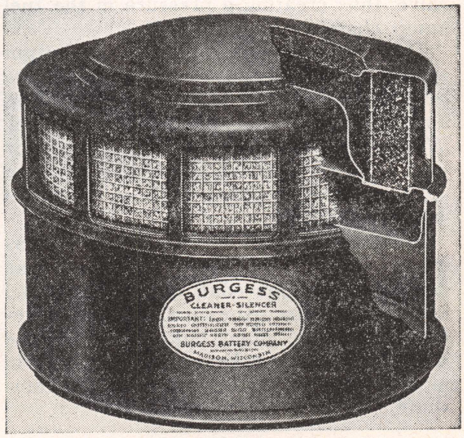


When an air cleaner is fitted to the crankcase ventilator outlet pipe it should be serviced when the carburetor air cleaner is serviced. To do this, remove the filter, wash it in kerosene and dry it thoroughly. Then dip it in SAE 50 engine oil and replace it.



OIL FILLER AIR CLEANER

The air filter in the oil filler pipe cap should be cleaned whenever the carburetor air cleaner is serviced. To clean the unit, remove it from the cap and wash the filter in kerosene. Dry it thoroughly and then dip it in clean SAE 50 engine oil



BURGESS

Remove complete unit from the car. Invert the assembly and dip it in clean gasoline just the depth of the cleaner element. Shake it until clean. When dry dip the complete unit in oil the depth of the cleaner element.

FUEL PUMPS AC

OPERATING PRINCIPLE

All AC fuel pumps are of the diaphragm type and utilize the same operating principle. They may be divided chiefly into two classifications: fuel pumps, and fuel and vacuum combination pumps. The vacuum section of the combination pump is used as a booster for windshield wiper operation.

However, models K and AN are separate vacuum pumps; the K being the same as the vacuum section of the AB combination pump, while the AN is identical with the vacuum section of the AA combination pump.

The diaphragm is composed of several layers of specially treated cloth which is not affected by the chemical ingredients of gasoline. The diaphragm is held between metal discs, and, as the camshaft of the engine rotates, the camshaft eccentric actuates the rocker arm of the fuel pump, which pulls the diaphragm downward against spring pressure.

However, the position of the diaphragm spring—whether it is located above or below the diaphragm—determines whether the diaphragm is pulled up or down. The AH fuel pump and the AJ combination pump are examples in which the diaphragm is pulled upward against spring pressure, but the operating principles remain the same. Therefore, for explanatory purposes, the type which uses the diaphragm spring below the diaphragm will be used.

On the suction stroke, when the diaphragm is pulled downward, a vacuum is created in the pump chamber above the diaphragm, which causes fuel from the supply tank to enter the sediment bowl, passing through the strainer, and then through the inlet valve into the pump chamber.

On the return stroke, spring pressure in the diaphragm pushes it upward, forcing fuel from the pump chamber through the outlet valve to the carburetor.

When the carburetor bowl is filled, the float in the carburetor will close the needle valve, thus creating a pressure in the fuel pump chamber.

This pressure will hold the diaphragm against spring pressure where it will remain inoperative in its downward position until the carburetor requires further fuel. When this need occurs, the carburetor float will fall, allowing the needle valve to open, and the operating cycle of the pump will be repeated.

The movement of the diaphragm is controlled by linkage, because, when in the depressed position—due to sufficient fuel in the carburetor—the up and down movement of the fuel pump link ceases, and the rocker arm spring keeps the rocker arm in contact with the eccentric on the camshaft.

VACUUM PUMP OPERATION

Some combination pumps have the vacuum section below the fuel section—such as the AB—while others have the vacuum section above the fuel section as illustrated by the AJ pump. However, the operating principles remain the same, the difference being the direction in which the diaphragm is moved against spring pressure. Therefore, for explanatory purposes, the AJ unit will be explained.

Rotation of the camshaft eccentric actuates the rocker arm. This pushes the link, and in turn, the diaphragm, upward, expelling the air in the chamber through the exhaust valve and out of the opening to the intake manifold.

On the return stroke, the rocker arm moves the diaphragm downward, creating a vacuum in the chamber which opens the inlet valve, drawing air through the inlet passage from the windshield wiper.

When the windshield wiper is not being used, the manifold vacuum holds the diaphragm upward against spring pressure, so that the diaphragm does not make a complete stroke for every stroke of the rocker arm.

When manifold vacuum is greater than the vacuum created by the pump, the air will flow from the windshield wiper through both valves of the pump, and the operation of the wiper will be the same as if the pump were not installed.

However, when the intake manifold vacuum is low, that is, when the engine is accelerating or operating at high speed, the vacuum created by the pump will be greater and will operate the windshield wiper.

To check the operation of the vacuum pump, open the windshield wiper valve, and alternately idle and accelerate the engine. The operation of the windshield wiper should be reasonably constant, regardless of engine speed.

FUEL PUMP COMPLAINTS

If the pump fails to deliver fuel, this will indicate a broken rocker arm, a broken rocker arm spring or a broken diaphragm return spring.

If the fuel supply is insufficient, it may be due to any of the following: 1. Worn pump links. 2. Leaking diaphragm. 3. Weak diaphragm spring. 4. Leak at inlet or outlet valves. 5. Sticking or gummed valves. 6. Clogged filter. 7. Leak at cover gasket. 8. Leak in the fuel line to the supply tank or fittings. 9. Fuel line to supply tank restricted. 10. Leak at filter bowl or gasket. 11. Housing or cover warped, allowing leakage between screws which retain the diaphragm between the cover and housing. 12. Water in filter bowl or water freezing in the pump. 13. The gasket between the pump flange and the crankcase may be too thick due to a makeshift installation at some previous time—if so, replace with one of standard thickness. 14. If the diaphragm return spring is broken or has insufficient tension, a weak fuel pressure will result. Then too, if the spring has been replaced with one having too much tension, a strong pressure will result, resulting in a flooded condition in the carburetor, causing a rich mixture. 15. If fuel leaks at the vent hole in the pump body, it indicates a punctured or worn diaphragm.

VACUUM PUMP COMPLAINTS

If the windshield wiper is slow-acting at high speed or full throttle, it indicates an inoperative vacuum pump unit. Check the lines to the wiper. If the trouble is not in the lines, disassemble the vacuum pump unit and examine the valves and diaphragm.

If the vacuum pump operation is noisy, it generally indicates a worn or improperly installed oil seal, a worn vacuum pump link and rocker arm pin or a broken rocker arm spring.

High gasoline pressure and noise indicates that the fuel pump is striking the vacuum pump diaphragm. This can be corrected by replacing the rocker arm pin and vacuum pump link.

If the vacuum pump diaphragm is punctured, oil is drawn from the crankcase, causing high oil consumption and ignition miss due to fouled plugs. A small hole in the diaphragm, when first encountered, may be indicated by a partial miss on the two cylinders adjacent to the spot where the vacuum line taps into the manifold. This condition may be checked by the action of the windshield wiper upon acceleration, or by disconnecting the line on the manifold side of the vacuum pump to inspect for oil leakage.

Noisy operation or failure of the diaphragm may also indicate that it is either too taut, or too slack, which will be evident if the diaphragm is wrinkled.

FUEL PUMP SERVICE

The service operations which can be performed on fuel pumps and vacuum pumps without special tools are the cleaning of the filter and its component parts; the vapor dome (if used), and the inlet and outlet valves. Any other operations which necessitate the disassembly of the housings, should not be attempted unless special tools, which are expressly made for such work, are available.

If a fuel pump analyzer is not available, a simple test of the fuel pump operation can be made by disconnecting the pipe which connects the fuel pump to the carburetor. Even at cranking speed, a considerable amount of fuel will be pumped out of the fuel pump outlet if the pump is operating. Hold a finger over the outlet and note the amount of pressure built up in the pump while the engine is cranking. This will give a rough check as to the condition of the valves and diaphragm.

Due to the strength of the diaphragm spring in the vacuum pump unit, it is not practical to attempt a bench test of the completed pump after assembly, except where special equipment is available. The only practical test for the complete fuel and vacuum pump is on the engine. When testing, never operate the pump with the outlet passage of the vacuum pump unit closed with a plug of any sort, for the exhaust stroke of the pump is positive, and the mechanism may be damaged as a result of this stoppage.

Fuel pump repairs may be divided into two classifications: Repairs made without disturbing the pump installation, and repairs which necessitate the removal and disassembly of the pump.

Should trouble occur in supplying the correct amount of fuel to the carburetor, an inspection should be made before removing the pump from the engine for repairs.

The first step is to check the fuel pump on the engine with an analyzer, which should show a pump pressure of about 3 to 4 pounds. If the pump pressure is too low, it may starve the engine, while if the pressure is too high, flooding of the carburetor may be the result.

Check the carburetor float and float needle valve for proper operation. If a lack of fuel is evidenced, check also, the fuel lines for leaks, split seams, loose connections, kinks, or other obstructions.

A leak in the line on the fuel tank side of the pump may not show up as fuel leakage, but air leakage at that point will prevent the vacuum from drawing fuel from the pump.

Tighten all pipe connections, for leaks at pipe fittings sometimes allow fuel to run down to the pump flange so that the leaks appear to originate at that point.

If the pump shows high pressure, a quick remedy may be made by adding another gasket between the pump mounting flange and the crankcase.

The fuel pump bowl should be removed and cleaned at least twice a year. Loosen the nut which holds the filter bowl to the pump body, and remove the filter bowl, gasket and filter. Clean the bowl and wipe it dry. When a screen is the filter, clean it in kerosene and dry it with compressed air. Do not use a cloth for drying purposes because of the possibility of lint clinging to the screen and later causing an obstruction of fuel in the carburetor.

For pumps where the bowl cannot be removed—such as the model R—it will be necessary to remove the screw plug and flush out the bowl.

When a built-up filter is used, loosen the nuts on the filter assembly, but do not remove them. Shake the filter assembly in clean kerosene to remove any dirt from between the thin flat plates of the filter. Blow the filter dry with compressed air, and then, tighten the nuts with finger force only.

If the pump leaks at the diaphragm flange, tighten the cover screws alternately and securely; do not use shellac or other adhesive on the diaphragm.

If the operation of the pump is impaired by gum collecting on the valves, it will be necessary to clean and polish the valves, valve seats and filter parts.

The vent hole in the pump body must be kept open at all times. A leaking oil seal at the diaphragm stem is evidenced by oil passing out of the vent hole. A leaking diaphragm will also cause a leak at the vent hole.

ASSEMBLY PROCEDURE

Before disassembling any pump, it is important to mark the cover and body of the pump so that when assembling, they may be replaced in the same relative position.

MODEL AA

Fuel Section: Assemble links, rocker arm, link spacer washers, rocker arm spring and rocker arm pin in position in body. Assemble steel washer over counterbored end of pin, and swedge the end of the pin against the washer.

Fuel Diaphragm: The diaphragm and pull rod assembly with the protector washers are serviced as a unit. To assemble, place the diaphragm spring over the pull rod boss in the pump body, and install the spring retainer, with cupped side downward, on top of the diaphragm spring, and insert the diaphragm and pull rod assembly in the body.

Invert the body to allow the fuel pump link to fall toward the top of the body, and push downward against the diaphragm spring pressure and engage the flattened end of the pull rod into the slot in the end of the link. Turn the diaphragm assembly 90 degrees so that the pull rod is locked to the operating link.

Fuel Valve & Cover Assembly: To install the valve and cover assembly, place gaskets in position in the outlet and inlet valve cage seats in the top cover. Install the valve and cage assemblies in position in the cage seats, making sure that the large diameter is placed downward against the gasket on the inlet side, and the small diameter is assembled into the outlet hole in cover, permitting the shoulder of the cage to fit properly against the gasket.

Place the valve cage retainer in position with the curved end of the two legs fitting snugly against each valve cage, and insert two screws and tighten them securely, making sure that the retainer legs are in the proper position when finally tightened.

Seat the cork bowl gasket in the cover and assemble the filter bowl, bowl seat, thumb nut and bail in position, then tighten the thumb nut securely.

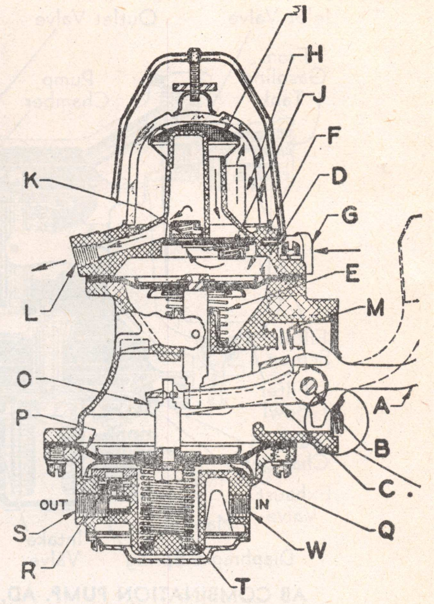
Fuel Cover Assembly: Push the rocker arm upward until the diaphragm is level with the body flange and place the cover assembly in the proper position designated by the marks made before the unit was disassembled.

Install the screws and washers, tightening only enough so that the screws barely engage the washers. Release the rocker arm, which will allow the diaphragm to flex to its highest position, then tighten the cover screws alternately and securely.

Vacuum Section Diaphragm: Fasten the pull rod in a bench vise by its flatted end, and place the pull rod gasket, diaphragm alignment washer, cloth gasket and lower diaphragm protector on the threaded end of the pull rod, with the cupped side of the protector downward.

Place five layers of the diaphragm material on the pull rod, lining up the tabs on the diaphragm exactly with the center line of the flats on the pull rod.

Assemble the upper diaphragm protector—with the cupped side upward—the alignment washer, lockwasher and nut in position. Hold the alignment washer in position with a special wrench, tighten the pull rod nut, taking care not to disturb the layers of the diaphragm cloth. Engage the flatted end of the pull rod into the vacuum pump link slot, and turn the diaphragm assembly 90 degrees to lock the pull rod to the link.



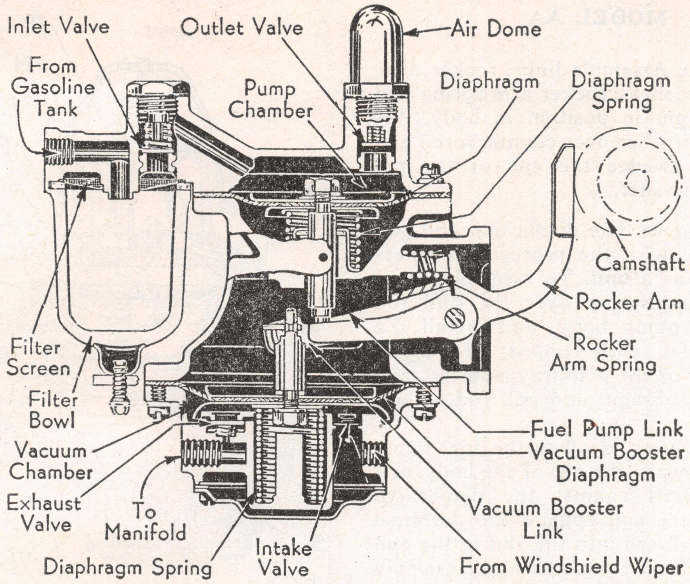
MODEL AA

A—Rocker arm. B—Rocker arm pivot. C—Rocker arm link. D—Fuel section diaphragm. E—Diaphragm spring. F—Pump chamber. G—Gasoline inlet. H—Sediment chamber. I—Strainer. J—Inlet valve. K—Outlet valve. L—Gasoline outlet. M—Rocker arm return spring. N—Sediment chamber drain screw. O—Link. P—Vacuum section diaphragm. Q—Air chamber. R—Exhaust valve. S—Air opening to manifold. T—Diaphragm spring. W—Air inlet passage.

Vacuum Valves & Cover: Position the fibre inlet valve on top of the brass inlet valve seat in the body and place the inlet valve spring on top of the inlet valve. Place the spider-shaped valve stop plate on top of the valve spring, with the top coil of the spring seating in the recess in the bottom of the valve stop plate.

Position the outlet valve spring, centering the coils of the spring in the recess. Press the spider-shaped inlet valve stop downward with the finger against inlet valve spring pressure, being sure that the valve spring is properly centered in the inlet valve stop, and that the legs of this valve stop fit down in the recess in the body.

Place the fiber outlet valve in position on top of the outlet valve spring, and, with the inlet valve stop held down, slide the valve retainer gasket into its position. While still holding the inlet valve stop down, place the valve retainer in position on top of the gasket, with the countersunk holes in the retainer facing upward. Secure the valve retainer in position by tightening the center screws first and the end screw last.



AB COMBINATION PUMP. AD, AL, F, I and J pumps are similar.

Turn the vacuum pump body over and place the screen in position, being sure that the screen lies flat and fits properly around the shoulders of the screw holes in the body. Position the bottom cover gasket on top of the screen and line up the screw holes, and then assemble the bottom cover.

Vacuum Pump to Fuel Pump Assembly: Secure the fuel pump section in an inverted position in a bench vise. See that the flatted end of the pull rod is in the proper 90-degree engagement with the link, and position the diaphragm spring on the diaphragm. The pull rod nut fits inside of the spring and the coil rests against the alignment washer.

Lay the vacuum pump assembly in position on the fuel pump assembly, centering the heavy spring around the boss of the vacuum pump body. Push in on the rocker arm so that the diaphragm is flat on the flange, and place the blade of a small screwdriver between the body and the shoulder on the rocker arm to retain the arm in this position until the assembly is completed.

Line up the marks on the body flanges, which were made before disassembly, press down on the vacuum unit, and install the screws carefully through the diaphragm cloth, tightening the screws evenly until the cover is barely tight. Remove the screwdriver and then, tighten the cover screws securely.

Place the oil baffle assembly and mounting gasket in position, and install the pump assembly on the engine, being careful to place the cam surface of the rocker arm against the eccentric, and not under it.

MODELS AB, AD, AL, F, I, J, K

Fuel Section (Except K): Assemble rocker arm, fuel link, link spacer, and vacuum links on the rocker arm pin bushing in the same relative position as when removed from the pump. Place the hooked end of one of the vacuum links on top of the other vacuum link, and install this entire assembly in the pump body, being sure that the rocker arm spring seats properly on the ear of the link spacer. Assemble the rocker arm pin washer in position and swedge the pin over securely against the washer.

Fuel Diaphragm: Invert the assembly so that the link will fall against the body stop, and check to see that the hooked end of one vacuum link is on top of the other vacuum link. Use a screwdriver to hold the link in this dropped position. Place the diaphragm spring in the lower diaphragm protector washer, and insert the pull rod and diaphragm assembly into the body. Depress the diaphragm spring and connect the pull rod to the hooked end of the link, making sure that the spring is still seated properly in the body and in the lower protector washer.

Fuel Valve & Cover Assembly: Blow out the valve chamber to remove any foreign particles which may prevent the valve from seating properly. Insert the fibre valve in the chamber so that the valve lies flat against the valve seat, and place the valve spring on top of the valve.

Place the fibre gasket on the valve plug, and the stem of the valve plug into the coil spring and tighten the plug securely. Be certain that the stem of the valve plug does not distort the valve spring, but fits inside of the spring properly.

Fuel Pump Cover Assembly: Line up the screw holes in the cover with those of the diaphragm and body, and, when installing the screws, tighten them until the cover is drawn up to within ⅛" of the body, then push upward on the pull rod, forcing the diaphragm to its highest position, and while in this position, tighten the cover screws alternately and securely.

Strainer Assembly: Assemble the screen in the cover, fitting it snugly around the gasoline inlet and the edges of the casting. Place the strainer next to the screen, then assemble the glass bowl and bail.

Vacuum Section (All): The inlet valve seat is furnished with the vacuum pump body as an assembly. Position the fibre inlet valve on top of the brass inlet valve seat in the body, and the inlet valve spring on top of the inlet valve. Install the spider-shaped valve stop plate on top of the valve spring with the top coil of the spring seating in the recess in the bottom of the spider.

Position the outlet valve spring with its coils in the recess, and press the inlet valve stop downward with the finger against inlet valve spring pressure. Make sure that the valve spring is properly centered in the inlet valve stop, and that the valve stop legs fit down into the recess.

Place the fibre outlet valve in position on top of its valve spring and, with the inlet valve stop held down, slide the valve retainer gasket into its proper position, continuing to hold down the inlet valve stop. Place the valve retainer in position on top of the gasket, being certain that the countersunk holes in the retainer are facing upward, and secure it in this position, tightening the center screws first, and the end screw last.

Invert the vacuum pump body and place the screen in position so that it lies flat, and fits properly around the shoulders of the screw holes. Place the cover gasket in position on top of the screen and install the cover.

Fuel Pump to Vacuum Pump Assembly: Secure the fuel pump section in a bench vise in an inverted position. Place the diaphragm assembly in position, making sure that the slot in the pull rod engages the hooks on both vacuum links properly; and that the screw holes in the diaphragm match those of the body.

Install the diaphragm spring, and lay the assembled vacuum pump unit in position on the body, centering the diaphragm spring around the boss in the vacuum pump body, and see that the marks, which were made before disassembly, are matched properly.

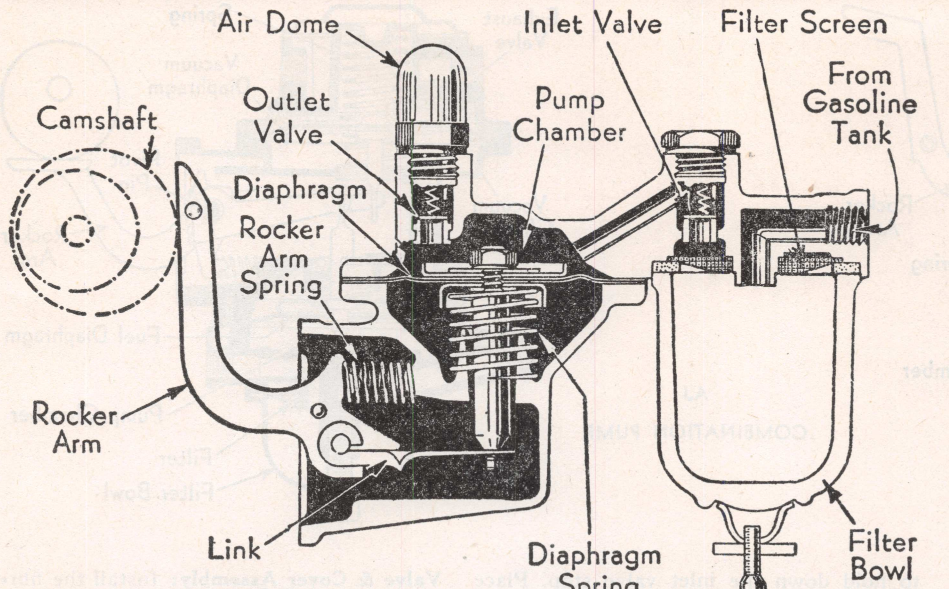
Press in on the rocker arm, holding the diaphragm even with the flat surface of the body flange, and, while in this position, insert and tighten the body screws until the vacuum unit is drawn to within ⅛" from the pump body. Release the rocker arm, which permits the diaphragm to flex to its highest position, then tighten the screws alternately and securely.

MODELS AE, E, P, W

Assemble: To install the oil seal to the diaphragm push rod, assemble the oil seal spring, upper retainer, two leather seals, and the lower retainer with the convex side out.

Raise the fuel pump link with a screwdriver, install the diaphragm spring, and hook the diaphragm pull rod over the end of the link.

Assemble the top cover to the fuel pump body, and tighten the cover screws alternately and securely. Assemble the glass


Air Dome
Inlet Valve
Filter Screen
From Gasoline Tank
Outlet Valve
Pump Chamber
Camshaft
Diaphragm
Rocker Arm Spring
Rocker Arm
Link
Diaphragm Spring
Filter Bowl

MODELS E, P

bowl to the cover, making sure that the cork gasket is in good condition, and that the bowl nut is tight. Install the pump to the engine.

MODEL AF

Assemble: To install the oil seal to the diaphragm push rod, assemble the oil seal spring, upper retainer, two leather seals, and the lower retainer with the convex side out. This is important in order to seal the fuel pump from any oil that might come up from the crankcase.

Raise the fuel pump link with a screwdriver, install the diaphragm spring, and hook the diaphragm pull rod over the end of the link.

Install the valve assemblies and paper gaskets making sure to install the inlet valve with the spring down, and the outlet valve with the spring up. The inlet valve is assembled in the cover assembly next to the tapped passage marked "INT".

Install the valve retainer with the convex side up, and then install the retainer screws.

Assemble the top cover assembly to the fuel pump body and tighten the cover screws alternately and securely.

Assemble the screen on the cover, and the filter bowl, making sure that the cork gasket is in good condition, and tighten the bowl nut.

MODELS AH & AW

Fuel Section: Assemble link, rocker arm bushing and spring in position in the body. In place of the rocker arm pin, insert the small end of the special rocker arm assembling pin through the rocker arm pin hole in the body, holding the rocker arm, spring and link in position.

Position the diaphragm spring in the body and hook the diaphragm and pull rod assembly over the hooked end of the link.

Force the small end of the special assembling pin out through the holes in the body, link and rocker arm, until the large end of the pin is holding the assembly together. Using the regular rocker arm pin, drive out the special assembling pin, which will leave the rocker arm pin properly assembled. Assemble the steel washer over the counterbored end of the rocker arm pin and swedge it against the washer.

Valve & Cover Assembly: Place the gasket in position in the valve cage seats in the cover. Install the valve and cage assemblies in position in the cage seats, making sure that the large diameter is placed against the gaskets on the inlet side and that the small diameter is assembled into the outlet hole in the cover, permitting the shoulder of the cage to fit properly against the gasket.

Place the valve cage retainer in position with the curved end of two lugs fitting snugly against each valve cage. Insert two screws and tighten securely, making sure that the retainer lugs are in the proper position when finally tightened.

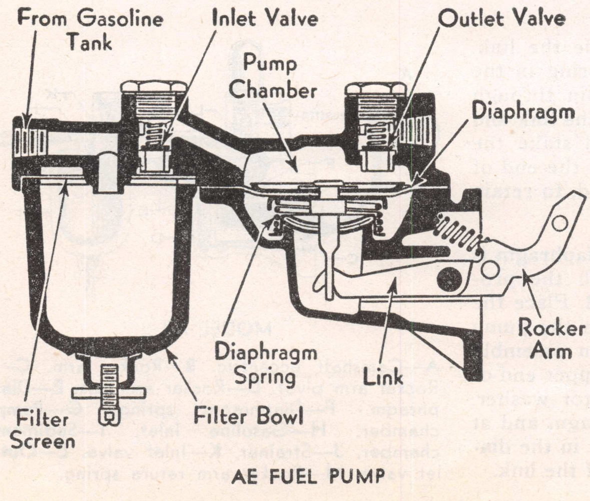
Cover Assembly: Push upward on the rocker arm until the diaphragm is level with the body flange. Position the cover properly as designated by the marks which were made when disassembled, and install the cover screws, tightening only until the screws barely engage the washers. Release the rocker arm, and tighten the screws alternately and securely.

MODEL AJ

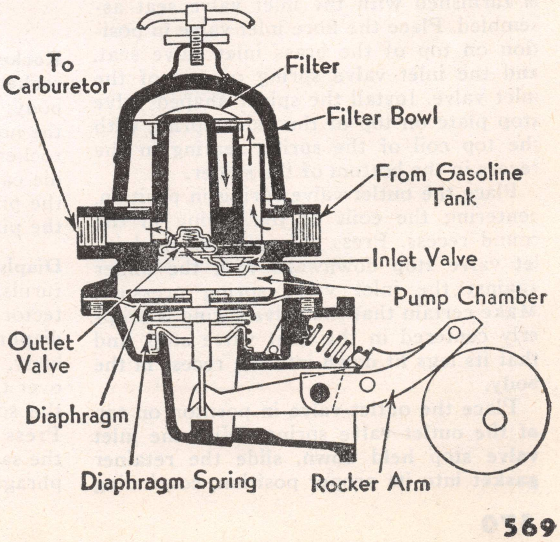
Fuel Section: Assemble link, rocker arm bushing, link spacer washers, and rocker arm spring in position in the body. Insert the small end of the special rocker arm assembling pin through the rocker arm pin hole in the body, holding these parts in position.

Position the diaphragm spring and assemble the pull rod and diaphragm through the boss in the body, hooking the pull rod over the end of the link.

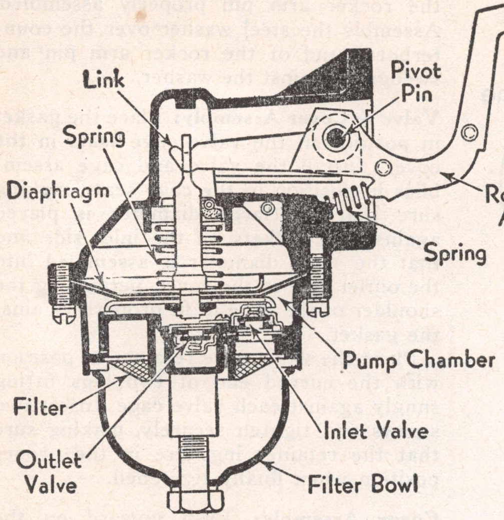
Force the small end of the special assembling pin through the holes in the body, links and rocker arm, until the large end of the pin is holding the assembly together. Using the regular pin, drive the special pin on through the assembly, leaving the rocker arm pin properly assembled. Assemble the steel washer over the coun-


From Gasoline Tank
Inlet Valve
Outlet Valve
Pump Chamber
Diaphragm
Diaphragm Spring
Rocker Arm
Link
Filter Screen
Filter Bowl

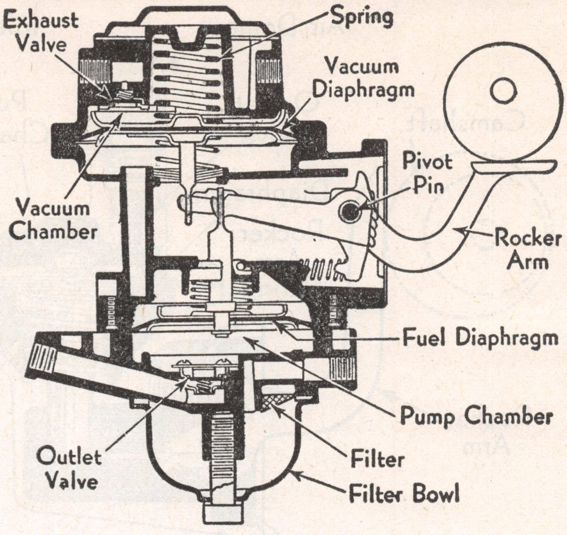
AE FUEL PUMP


To Carburetor
Filter
Filter Bowl
From Gasoline Tank
Inlet Valve
Pump Chamber
Outlet Valve
Diaphragm
Diaphragm Spring
Rocker Arm

AF FUEL PUMP



MODEL AH—AW IS SIMILAR



AJ
COMBINATION PUMP

counterbored end of the pin and swedge the pin against the washer.

Valve & Cover Assembly: Position the gasket in the inlet and outlet cage seats in the fuel cover. Place the valve and cage assemblies in position in the cage seats, making sure that the large diameter is placed against the gasket on the inlet side, and that the small diameter is assembled into the outlet hole in the cover, permitting the shoulder of the cage to fit properly against the gasket.

Install the valve cage retainer in position with the curved end of the two lugs fitting snugly against each valve cage. Insert two screws and tighten securely, making sure that the retainer lugs are in the proper position when finally tightened, and then, assemble the bowl.

Cover Assembly: Push the rocker arm upward until the diaphragm is level with the top surface of the body flange, and place the cover assembly in the proper position designated by the marks made before disassembly, and install the cover screws, tightening only until the flanges are ⅛" apart. Release the rocker arm and tighten the screws alternately and securely.

Vacuum Section: The vacuum pump body is furnished with the inlet valve seat assembled. Place the fibre inlet valve in position on top of the brass inlet valve seat, and the inlet valve spring on top of the inlet valve. Install the spider-shaped valve stop plate on top of the valve spring with the top coil of the spring seating in the recess in the bottom of the spider.

Place the outlet valve spring in position, centering the coils of the spring in the round recess. Press the spider-shaped inlet valve stop downward with the finger against the inlet valve spring pressure. Make certain that the valve spring is properly centered in the inlet valve stop, and that its legs fit down into the recess in the body.

Place the outlet valve in position on top of the outlet valve spring. With the inlet valve stop held down, slide the retainer gasket into its proper position, continuing to hold down the inlet valve stop. Place the valve retainer in position on top of the gasket, with the countersunk holes in the valve retainer facing upward.

Secure the valve retainer in position, tightening the center screws first and the end screw last.

Turn the vacuum pump body over and place the screen in position, with the screen lying flat and fitted properly around the shoulders of the screw holes in the body, and assemble the cover.

Vacuum Pump to Fuel Pump Assembly: With the pump inverted and the diaphragm assembly connected to the linkage, operate the rocker arm until the diaphragm is exactly level with the surface of the body flange. Insert a tool between the rocker arm and the die-cast body so that the diaphragm cannot move from this level position when the vacuum spring is assembled.

Place the vacuum diaphragm spring and cover assembly in position, compressing the spring sufficiently to permit engagement of the cover screws. Install all the cover screws, but tighten only enough to place a slight tension on the lockwashers. Remove the tool and tighten the cover screws alternately and securely.

MODEL AK

Rocker Arm & Link: Assemble the link, rocker arm and rocker arm spring in the body. Insert the rocker arm pin through the hole in the body, engaging the link and rocker arm. Use a punch, and stake the die-cast metal of the body over the end of the pin in one place at each end, to retain the pin in place.

Diaphragm & Pull Rod: The diaphragm is furnished as an assembly with the protector washers and the pull rod. Place the diaphragm spring in position in the pump body, and then, the diaphragm assembly over the spring, centering the upper end of the spring in the lower protector washer. Press downward on the diaphragm and at the same time assemble the slot in the diaphragm pull rod over the end of the link.

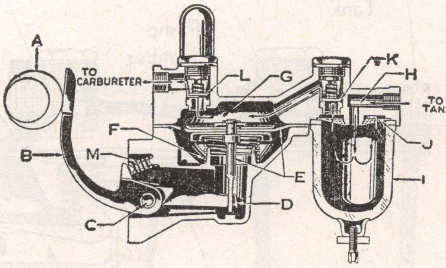
Valve & Cover Assembly: Install the fibre inlet valve in the valve chamber, making sure that the valve lies flat against the valve seat. Install the valve spring on top of the valve. Place the fibre gasket on the valve plug and then, place the stem of the valve plug into the coil spring and tighten securely. Be certain that the stem of the valve plug does not distort the valve spring.

Cover Assembly: Push upward on the rocker arm until the diaphragm is level with the body flange. Install the cover in the proper position as designated by the marks which were made before disassembly. Install the cover screws and tighten only enough so that the screws barely engage the lockwashers. Release the rocker arm and tighten the cover screws alternately and securely.

MODEL AN

Diaphragm: Place the pull rod gasket, diaphragm alignment washer, cloth gasket, and the lower diaphragm protector on the threaded end of the pull rod, with the cupped side of the protector downward

Place the diaphragm cloth on the pull rod, lining up the tabs on the diaphragm exactly with the center line of the flats on the pull rod



MODEL AK

A—Camshaft eccentric. B—Rocker arm. C—Rocker arm pivot. D—Rocker arm link. E—Diaphragm. F—Diaphragm spring. G—Pump chamber. H—Gasoline inlet. I—Sediment chamber. J—Strainer. K—Inlet valve. L—Outlet valve. M—Rocker arm return spring.

Assemble the upper diaphragm protector—with the cupped side upward—the alignment washer, lockwasher and nut in position. Hold the alignment washer in position with a special wrench, tighten the pull rod nut, taking care not to disturb the layers of the diaphragm cloth. Engage the flatted end of the pull rod into the vacuum pump link slot, and turn the diaphragm assembly to lock the pull rod to the link.

Valves & Cover: Position the fibre inlet valve on top of the brass inlet valve seat in the body, and place the inlet valve spring on top of the inlet valve. Place the spider-shaped valve stop plate on top of the valve spring, with the top coil of the spring seating in the recess in the bottom of the valve stop plate.

Position the outlet valve spring, centering the coils of the spring in the recess. Press the spider-shaped inlet valve stop downward with the finger against spring pressure, being sure that the valve spring is properly centered in the inlet valve stop, and that the legs of this valve stop fit down in the recess in the body.

Place the fibre outlet valve in position on top of the outlet valve spring, and, with the inlet valve stop held down, slide the valve retainer gasket in its position. While still holding the valve stop down, place the valve retainer in position on top of the gasket, with the countersunk holes in the retainer facing upward. Secure the valve retainer in position by tightening the center screws first and the end screw last.

Turn the vacuum body over and place the screen in position, being sure that the screen lies flat and fits properly around the shoulders of the screw holes in the body. Position the bottom cover gasket on top of the screen and line up the screw holes, and then assemble the bottom cover.

MODELS AS & AT

Fuel Section (Both): After removing the filter bowl and screen, remove the screws which hold the two halves of the fuel pump body together and separate the halves. Remove the inlet and outlet retainer screw and lift off the retainer and valves. Compress and remove the rocker arm return spring.

Drive out the rocker arm pivot pin and unhook the diaphragm operating lever, and then, lift out the diaphragm and rocker arm parts.

Remove the oil seal by chipping off pieces of the pump body which clinch the oil seal in place. It is only necessary to replace the oil seal when an excessive amount of oil leaks out of the vent hole in the body. Pull out the oil seal with a suitable hook.

When installing a new seal, be certain that the leather is in good condition—soft and pliable. The leather should be soaked in thin oil for about 30 minutes, and worked by rolling a small rod on the inside of the seal.

The shaft of the diaphragm assembly should be smooth before installing to avoid rapid wear on the leather, which in turn results in excessive oil leakage.

To assemble the pump, reverse the foregoing operations, using care to hold the rocker arm to the end of its stroke, tight against spring pressure when tightening the screws which connect the two halves of the pump.

When assembling the inlet and outlet valves in the filter body, make sure that they are assembled properly. These valves are identical, and should be assembled with the spring side up on one valve and down on the other, so that the retainer plate lies flat when holding the valves in place.

Vacuum Section (AS): Service procedure for vacuum section of the AS pump is similar to that which is described for the AN vacuum pump.

MODEL AU

Rocker Arm & Link: Assemble the link, rocker arm and rocker arm spring in the body. Insert the rocker arm pin through the hole in the body, engaging the link and rocker arm. Use a punch, and stake the die-cast metal of the body over the end of the pin in one place at each end, to retain the pin in place.

Diaphragm & Pull Rod: The diaphragm is furnished as an assembly with the protector washers and the pull rod. Place the diaphragm spring in position in the pump body, and then, the diaphragm assembly over the spring, centering the upper end of the spring in the lower protector washer. Press downward on the diaphragm and at the same time, assemble the slot in the diaphragm pull rod over the end of the link.

Valve & Cover Assembly: Place the gaskets in position in the valve cage seats in the cover. Install the valve and cage assemblies in position in the cage seats, making sure that the large diameter is placed downward against the gasket on the inlet side, and the small diameter is assembled into the outlet hole in the cover, permitting the shoulder of the cage to fit properly against the gasket.

Place the valve cage retainer in position with the curved end of the two legs fitting snugly against each valve cage, and insert two screws and tighten securely, making sure that the retainer legs are in the proper position when finally tightened.

Seat the cork bowl gasket in the cover and assemble the filter bowl, bowl seat, thumb nut and bail in position, then tighten the thumb nut securely.

Cover Assembly: Push the rocker arm upward until the diaphragm is level with the body flange, and place the cover assembly in the proper position designated by the marks which were made before the pump was disassembled.

Install the cover screws and washers, tightening only enough so that the screws barely engage the washers. Release the rocker arm and tighten the cover screws alternately and securely.

MODEL AX

Fuel Section: Assemble the rocker arm, fuel link, link spacer, and vacuum links on the rocker arm pin bushing in the same relative position as when removed from the pump. Place the hooked end of one of the vacuum links on top of the other vacuum link, and install the entire assembly in the pump body, being sure that the rocker arm spring seats properly on the ear of the link spacer. Assemble the rocker arm pin in position and swedge the pin over securely against the washer.

Fuel Diaphragm: Invert the assembly so that the link will fall against the body stop, and check to see that the hooked end of one vacuum link is on top of the other vacuum link. Use a screwdriver to hold the link in this dropped position. Place the diaphragm spring in the lower diaphragm protector washer, and insert the pull rod and diaphragm assembly into the body. Depress the diaphragm spring and connect the pull rod to the hooked end of the link, making sure that the spring is still seated properly in the body and in the lower protector washer.

Fuel Valve & Cover Assembly: To install the valve and cover assembly, place the gaskets in position in the valve cage seats in the top cover. Install the valve and cage assemblies in position in the cage seats, making sure that the large diameter is placed downward against the gasket on the inlet side, and the small diameter is assembled into the outlet hole in the cover permitting the shoulder of the cage to fit properly against the gasket.

Place the valve cage retainer in position with the curved end of the two legs fitting snugly against each valve cage, and insert two screws and tighten them securely making sure that the retainer legs are in the proper position when finally tightened

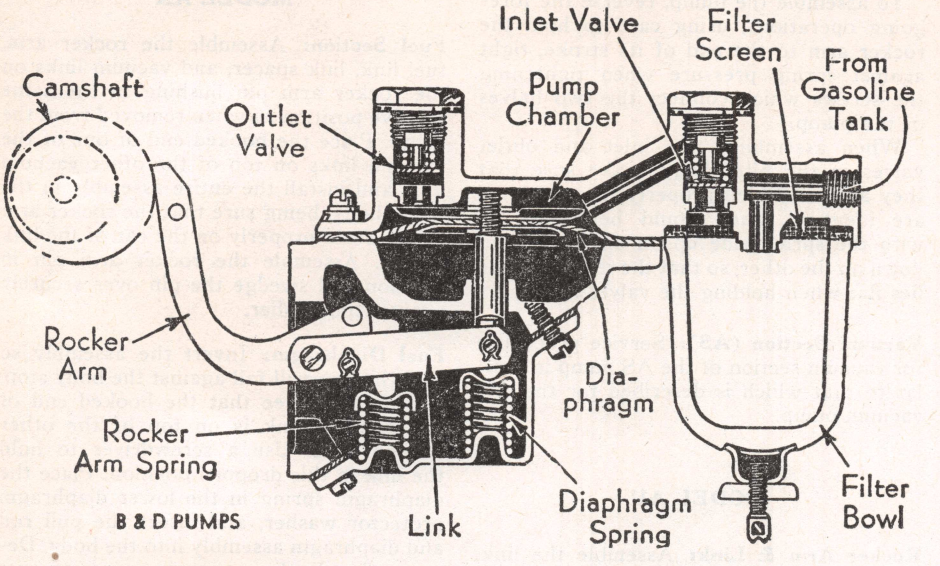
Seat the cork bowl gasket in the cover and assemble the filter parts.

Cover Assembly: Push the rocker arm upward until the diaphragm is level with the body flange and place the cover assembly in the proper position designated by the marks made before the unit was disassembled.

Install the screws and washers, tightening only enough so that the screws barely engage the washers. Release the rocker arm and then tighten the cover screws alternately and securely.

Vacuum Section: The inlet valve seat is furnished with the vacuum pump body as an assembly. Position the fibre inlet valve on top of the brass inlet valve seat in the body, and the inlet valve spring on top of the inlet valve. Install the spider-shaped valve stop plate on top of the valve spring with the top coil of the spring seating in the recess in the bottom of the spider.

Position the outlet valve spring with its coils in the recess, and press the inlet valve stop downward with the finger against inlet valve spring pressure. Make sure that the valve spring is properly centered in the



B & D PUMPS

inlet valve stop, and that the valve stop legs fit down into the recess.

Place the outlet valve in position on top of its valve spring, and, with the inlet valve stop held down, slide the valve retainer gasket into its proper position, continuing to hold down the inlet valve stop. Place the valve retainer in position on top of the gasket, being certain that the countersunk holes in the retainer are facing upward, and secure it in this position, tightening the center screws first, and the end screw last.

Invert the vacuum pump body and place the screen in position so that it lies flat, and fits properly around the shoulders of the screw holes. Place the cover gasket in position on top of the screen and install the cover.

Fuel Pump to Vacuum Pump Assembly: Secure the fuel pump section in a bench vise in an inverted position. Place the diaphragm assembly in position, making sure that the slot in the pull rod engages the hooks on both vacuum links properly; see that the screw holes in the diaphragm match those of the body.

Install the diaphragm spring, and lay the assembled vacuum pump unit in position on the body, centering the diaphragm spring around the boss in the vacuum pump body, and see that the marks, which were made before disassembly, are matched properly.

Press in on the rocker arm, holding the diaphragm level with the flat surface of the body flange, and, while in this position, insert and tighten the body screws until the vacuum unit is drawn to within 1/8" from the pump body. Release the rocker arm and then tighten the screws alternately and securely.

MODELS B & D

Rocker Arm & Links: Assemble the two side pieces which make up the linkage and attach them to the rocker arm with the sheared corners of the side pieces connected to the pull rod. Insert the rocker arm pin through the holes in the pump body, linkage and rocker arm, and place a retaining ring at each end. Check the assembly to see that the rocker arm and linkage move freely on the rocker arm pin.

Diaphragm: Place the pull rod gasket over the threaded end of the pull rod, seating the gasket against the shoulder of the pull rod. Place the cup-shaped lower diaphragm protector washer over the end of the pull rod, and then, install the diaphragm cloth over the threaded end of the pull rod, and line up the holes of the cloth, holding the cloth in alignment with a special locating ring.

Install the upper diaphragm protector over the threaded end of the pull rod, making certain that the cupped end is placed away from the diaphragm. Install the alignment washer over the pull rod, then, the lockwasher and pull rod nut, using a special wrench to hold the diaphragm alignment washer stationary to prevent the diaphragm from twisting or tearing, and tighten the nut securely.

Cover Assembly: Lay the cover on the pump in the proper position, as designated by the marks which were made before disassembly, and insert the cover screws, tightening only enough so that the screws barely engage the washers. **Insert a tool through the opening in the pump body and exert pressure on the linkage to force the diaphragm to its extreme high position. While the diaphragm is held in this position, tighten the cover screws alternately and securely.**

Valve Assembly: Place a drop of light oil on the fibre valve, and install it in the proper position in the valve chamber. Be sure that the valve lies flat against the valve seat. Insert the valve spring on top of the valve, and install the valve plug with its gasket, being sure that the stem of the valve plug does not distort the valve spring.

Bottom Cover: Invert the pump and place the rocker arm spring cap over the projection on the rocker arm and the diaphragm spring cap over the end of the pull rod. Place the gasket in position and locate the springs for the diaphragm and the rocker arm in their respective caps, and then assemble the cover to the body, making sure that the bosses fit into the bottom of the springs, and that the caps and springs remain in their proper positions. Tighten the cover screws securely and install the filter parts.

MODEL R

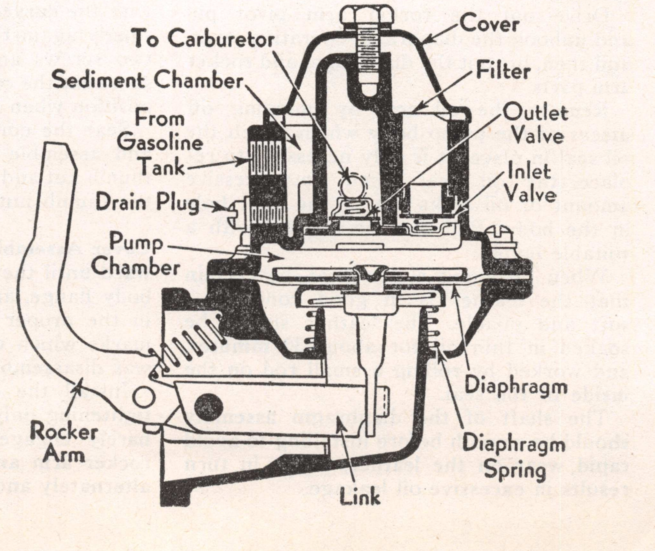
Rocker Arm & Link: Assemble link, rocker arm and its spring in the body. Insert the rocker arm pin through the hole in the body, engaging the link and rocker arm. Use a punch to stake the die-cast metal of the body over the end of the pin at each end, to retain the pin in place.

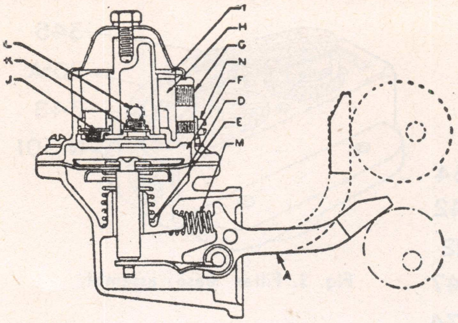
Diaphragm & Pull Rod: The diaphragm is an assembly including the protector washers and pull rod. Place the diaphragm spring in position in the body, and the diaphragm assembly over the spring, centering the upper end of the spring in the lower protector washer. Press downward on the diaphragm, and at the same time, assemble the slot in the diaphragm pull rod over the end of the link.

Valve & Cover Assembly: Place the outlet valve spring retainer in the cover, taking

R

FUEL PUMP





MODEL T

A—Rocker arm. **D**—Diaphragm. **E**—Diaphragm spring. **F**—Pump chamber. **G**—Gasoline inlet. **H**—Sediment chamber. **I**—Strainer. **J**—Inlet valve. **K**—Outlet valve. **L**—Gasoline outlet. **M**—Rocker arm return spring. **N**—Sediment chamber drain screw.

care not to distort the legs of the retainer. Install the valve plate gasket in position, and place the outlet valve spring in the spring retainer, and, the outlet valve on the spring.

Install the inlet valve on the valve seat, and the valve spring on the center of the inlet valve. Assemble the inlet valve retainer in the valve plate, taking care that the shoulder of the retainer fits down flush in the depression in the plate. Position the valve plate and secure it with three screws, being certain that the valve parts are positioned properly.

Install the screen in position on top of the cover and complete the assembly of the filter.

Cover Assembly: Push upward on the rocker arm until the diaphragm is level with the body flange, and install the cover assembly in the proper position as designated by the marks which were made before the unit was disassembled. Install the cover screws, tightening only enough so that the screws barely engage the lockwashers. Release the rocker arm and tighten the screws alternately and securely.

MODEL T

Rocker Arm & Link: Assemble link, rocker arm and rocker arm spring in the pump body, with the loop of the link assembled upward. Insert the rocker arm pin through the hole in the body, engaging the link and pull rod.

Place the diaphragm spring over the boss in the pump body, and install the diaphragm and pull rod assembly in the body.

Invert the body and push the diaphragm against its spring, and engage the flatted end of the pull rod into the slot in the end of the link, turning the diaphragm assembly 90 degrees, which locks the assembly in position.

Valve & Cover Assembly: Place the outlet valve spring retainer in the pump cover, taking care not to bend or distort the legs of the retainer. Install the valve plate gasket in position, the outlet valve spring in the spring retainer, and the outlet valve on the spring.

Install the inlet valve on its seat, the inlet valve spring on the center of the inlet valve, and assemble the inlet valve retainer in the valve plate, making sure that the shoulder of the retainer fits down flush in the depression in the plate.

Place the valve plate in position and secure it with three screws. The inlet valve spring must be centered properly in the spring seat in the valve plate, and the outlet valve must be seated properly against the valve seat in the valve plate. Place the strainer screen on top of the cover, making sure that it fits snugly around the gasoline inlet and the edges of the cover, and complete the assembly of the filter.

Cover Assembly: Push upward on the rocker arm until the diaphragm is level with the top surface of the body flange. Place the cover assembly in the proper position as designated by the marks made before the pump was disassembled, and install the cover screws, tightening only until the flanges are 1/8" apart. Now release the rocker arm and tighten the cover screws alternately and securely.

MODEL X

Fuel Section: Assemble rocker arm, fuel link, link spacer, and vacuum links on the rocker arm pin bushing in the same relative position as when removed from the pump. Place the hooked end of one of the vacuum links on top of the other vacuum link, and install this entire assembly in the pump body, being sure that the rocker arm spring seats properly on the ear of the link spacer. Assemble the rocker arm pin washer in position, and swedge it over securely against the washer.

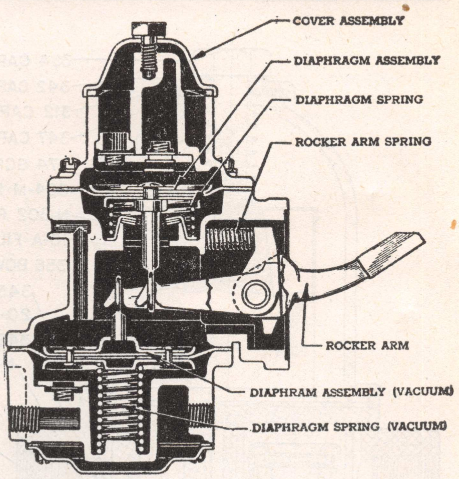
Fuel Diaphragm: Invert the assembly so that the link will fall against the body stop, and check to see that the vacuum links are still positioned properly. Use a screwdriver to hold the link in this dropped position. Install the diaphragm spring in the lower protector washer, and insert the diaphragm and pull rod assembly into the body. Depress the diaphragm spring and connect the pull rod to the hooked end of the link, making sure that the spring is in the proper position.

Fuel Valve & Cover Assembly: Place the outlet valve spring retainer in the cover. Install the valve plate gasket in position, place the outlet valve spring in the retainer, and, the outlet valve on the spring.

Install the inlet valve on its seat, and the valve spring on the center of the inlet valve. Assemble the inlet valve retainer in the valve plate so that the shoulder of the retainer fits down flush in the depression in the plate. Position the valve plate and secure it with three screws, making sure that the valve parts are positioned properly.

Install the screen in position on top of the cover and complete the assembly of the filter parts.

Cover Assembly: Push upward on the rocker arm until the diaphragm is level with the body flange, and install the cover assembly in the proper position as designated by the marks made before the unit was disassembled. Install the cover screws, tightening only enough to engage the lockwashers. Release the rocker arm and then, tighten the cover screws alternately and securely.



MODEL X. Combination Pump.

Vacuum Section: The vacuum section of the unit is the same as described for the AB pump.

AUTOPULSE

ELECTRIC FUEL PUMP

METHOD OF OPERATION

The autopulse electric fuel pump, Fig. 1. consists of a bellows coupled to the armature of an electro-magnet. The terminal of the electro-magnet is connected to the coil side of the ignition switch. When the ignition is turned on, current flows through the winding of the electro-magnet and the pump begins operating immediately. It continues to operate whenever the carburetor needs fuel and it is autmatically controlled by the back pressure in the fuel line, when the float valve in the carburetor closes.

When current flows through the winding of the electro-magnet, the armature is drawn down, expanding the bellows. This action draws gasoline from the supply tank, through the inlet valve, into the bellows chamber. At the end of this suction stroke the armature hits the contact spring, the contacts open and the circuit is broken. The driving spring then pushes the armature upward. This up-stroke collapses the bellows and forces the gasoline through the outlet valve into the carburetor bowl. At the end of the delivery stroke the contacts close and the cycle of the pump is repeated.

There are two models: Model 300 has a capacity of 15 to 18 gallons per hour and uses 1 ampere at 6 volts. Model 400 has a capacity of 22 to 28 gallons per hour and uses 1¾ amperes at 6 volts.

Where greater capacities are required, one, two, three or more pumps can be installed in the same supply line.

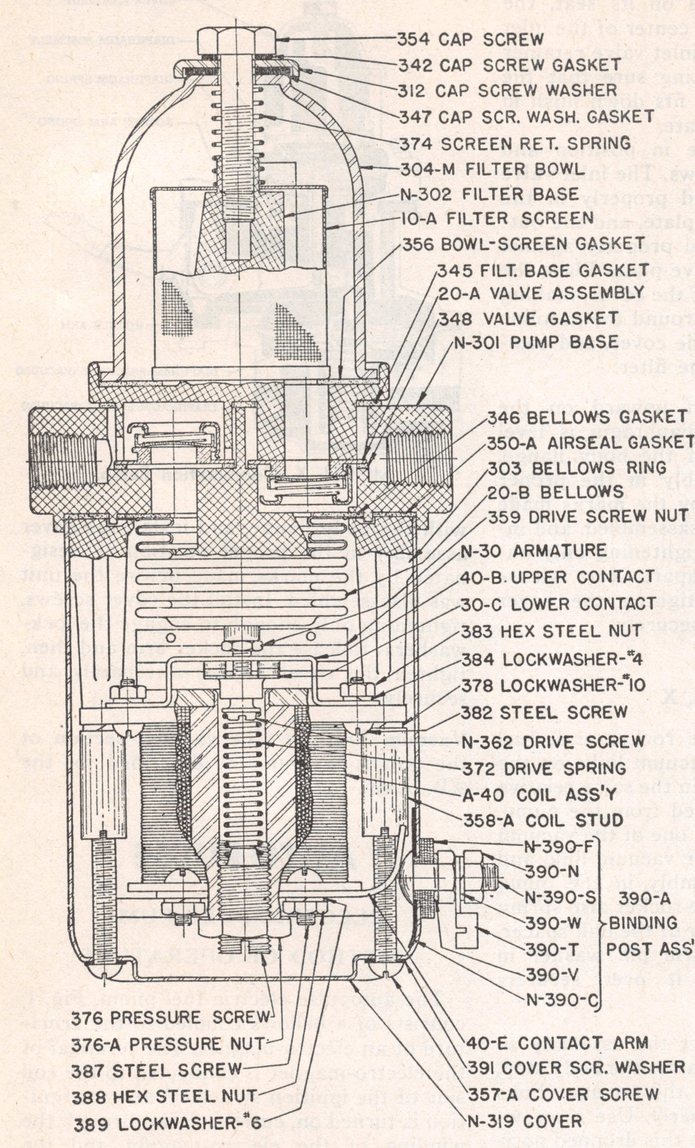
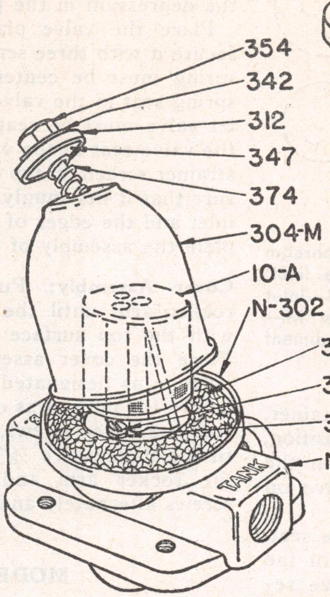

354 CAP SCREW
342 CAP SCREW GASKET
312 CAP SCREW WASHER
347 CAP SCR. WASH. GASKET
374 SCREEN RET. SPRING
304-M FILTER BOWL
N-302 FILTER BASE
10-A FILTER SCREEN
356 BOWL-SCREEN GASKET
345 FILT. BASE GASKET
20-A VALVE ASSEMBLY
348 VALVE GASKET
N-301 PUMP BASE
346 BELLOWS GASKET
350-A AIRSEAL GASKET
303 BELLOWS RING
20-B BELLOWS
359 DRIVE SCREW NUT
N-30 ARMATURE
40-B UPPER CONTACT
30-C LOWER CONTACT
383 HEX STEEL NUT
384 LOCKWASHER-#4
378 LOCKWASHER-#10
382 STEEL SCREW
N-362 DRIVE SCREW
372 DRIVE SPRING
A-40 COIL ASS'Y
358-A COIL STUD
N-390-F
390-N
N-390-S
390-W
390-T
390-V
N-390-C
390-A BINDING POST ASS'Y
376 PRESSURE SCREW
376-A PRESSURE NUT
387 STEEL SCREW
388 HEX STEEL NUT
389 LOCKWASHER-#6
40-E CONTACT ARM
391 COVER SCR. WASHER
357-A COVER SCREW
N-319 COVER

Fig. 1. Section through Autopulse fuel pump


354
342
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347
374
304-M
10-A
N-302
356
357
377
N-301
TANK

Fig. 2. How filter is disassembled.

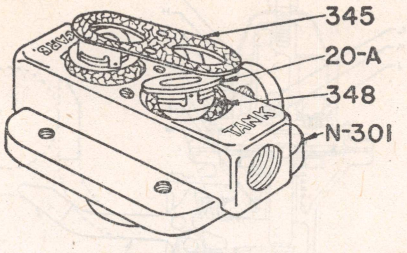

345
20-A
348
N-301
TANK

Fig. 3. Filter base assembly

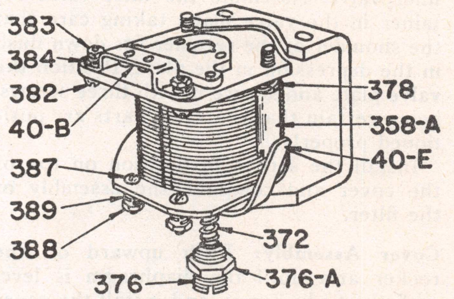

383
384
382
40-B
387
389
388
376
378
358-A
40-E
372
376-A

Fig. 4. Autopulse electro-magnetic drive

Duplex installation output is 30-36 gallons per hour. Triplex output 45-54 gallons per hour.

Model 300 or Model 400 are obtainable with 12 volt windings for use on trucks with 12-volt equipment.

OPERATION No. 1

Service and Clean Filter

1. Disassemble by removing cap screw 354, Fig. 2, and cap screw washer and gaskets.
2. Clean all parts, clear away gasket particles.
3. Replace screen if damaged.
4. To insure air tight filter use new gaskets, 342, 347, 356, Fig. 2.

OPERATION No. 2

Service and Clean Valves

1. Remove two filter base screws 357, Fig. 2.
2. Remove filter base N-302, Fig. 2.
3. Remove valve assemblies 20-A and valve gaskets 345 and 348, Fig. 3.
4. Clean all parts; replace valves if warped or excessively worn. Valve seats may be re-surfaced with crocus cloth. Insure tightness of valve chambers by use of new gaskets, 345 and 348, Fig. 3.

OPERATION No. 3

Replace Upper Contacts
Disassemble Coil and Armature

1. Remove cover screws and cover 357-A and N-319, Fig. 1.
2. Remove upper contact screws and nuts 382 and 384, Fig. 4.
3. Remove upper contact assembly 40-B, Fig. 4.
4. Replace with new contact assembly.

OPERATION No. 4

Replace Lower Contacts

1. Remove lower contacts 30-C, punch out two rivets 381-A, Fig. 5.
2. Replace with new contacts and rivets 9/32 long.
3. Check armature hinge spring; if it is weak or rusted, replace armature assembly N-30 instead of contacts, Fig. 1.

OPERATION No. 5

Re-Assemble Magnet and Armature

It is essential to proper magnetic action that armature and magnet be precisely lined up. The use of **special armature centering tool** is necessary, Fig. 7.

Insert centering tool in magnet core hole. Place armature 30 flat on top of magnet 40 so that steel collar on 30-CL is free inside centering tool, and tool is free in core hole.

Hold units in position so as to re-assemble armature and coil in correct relation.

Fasten with armature screws, nuts and washers 358, 365 and 378, Fig. 5. **Once this relation is established, do not disturb in any way.**

OPERATION No. 6

Service and Replacement of Bellows

1. Remove four bellows ring screws and washers 357 and 377, Fig. 7.
2. Remove bellows ring 303, Fig. 7.
3. Remove bellows 20-B with gaskets 346 and 350-A, Fig. 7.
4. Re-assemble with new bellows.
5. If replacing old style soldered bellows with new type one-piece bellows, use new long drive screw N-362, Fig. 1 (25/32 long); also new type armature N-30, Fig 1, to provide sufficient power to operate one-piece bellows.
6. In re-assembly, clean faces of bellows ring 303 and pump base N-301, Fig. 7.
7. Use new gaskets 346 and 350-A, Fig. 7 Replace four screws and washers and

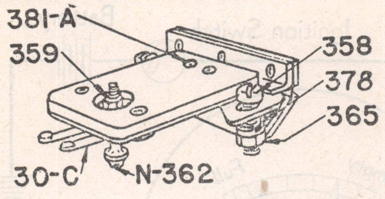


Fig. 5. Lower contact assembly

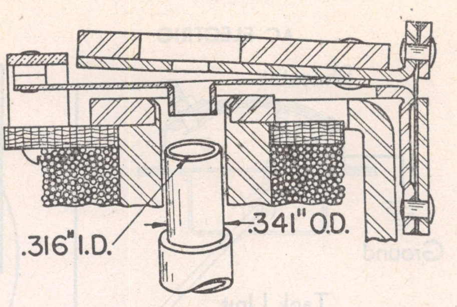


Fig. 6. How Armature is centered

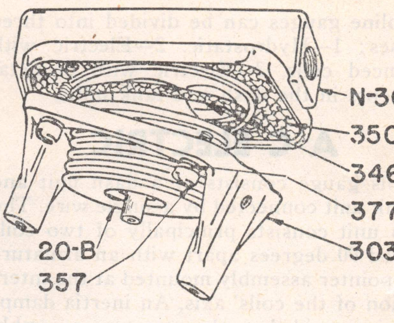


Fig. 7. Servicing bellows

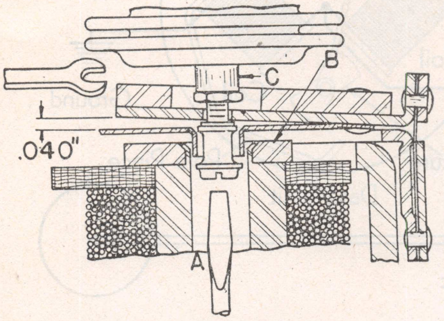


Fig. 8. Breaker adjustment

draw down bellows ring and bellows into place.

OPERATION No. 7
Bench Assembly of Pump Units

First, check that space between breaker spring, Fig. 8, and main armature body is 040" at point shown. Second, align and assemble armature and coil as in Operation 5.

Now assemble coil and armature to the bellows ring 303, using studs 2-358-A or the corresponding screws and lockwashers, Fig. 1.

Press armature plate flat against coil head B, Fig. 8. Assemble drive screw 362 into bellows stud C until bellows can just be seen to start downward movement. After releasing armature, tighten lock nut 359, using ¼" magneto wrench.

Insert drive spring 372, adjusting screw 376 and lock nut 376-A. This completes the bench assembly of pump, and the remaining adjustments should be made with pump in test rack.

OPERATION No. 8
Final Adjustment on Test Rack

If your shop has test rack for mechanical pumps, this can be adapted satisfactorily. **Otherwise, order an Autopulse test rack through your distributor or direct from factory.** Test with fuel, not air.

Remove cover 319. Place pump in rack, connect to battery at C, Fig. 9. Turn on current. Pump will race noisily until it picks up fuel from container D. Align upper and lower contact points by bending the flexible bridge 40-B at point F; never move **lower** contact points laterally, always the **upper.** Lower contacts may be adjusted vertically from armature by special **contact point adjusting tool** until best performance is reached. Shut cock B; and if pressure on Gauge A is below 2 to 2½ pounds or other desired cut-off pressure, tighten pressure adjusting screw (use longer spring in older pumps); if pressure is above that desired, ease off at point E to reach the action desired. Put on cover 319 and re-test for electrical connections. This completes the work.

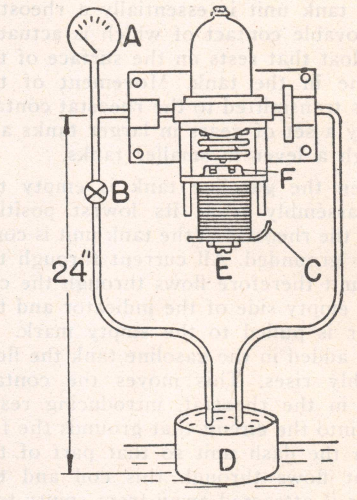


Fig. 9. Autopulse test rack

GASOLINE GAUGES AC, AUTO-LITE

Gasoline gauges can be divided into three classes: 1—Hydrostatic. 2—Electric with balanced coils. 3—Electric with bi-metal elements in the dash and tank units.

A C ELECTRIC

This gauge consists of a dash unit and a tank unit connected by a single wire. The dash unit consists principally of two coils spaced 90 degrees apart with an armature and pointer assembly mounted at the intersection of the coils' axis. An inertia dampener is provided on the armature assembly to prevent vibration of the pointer on rough roads.

The tank unit is essentially a rheostat, the movable contact of which is actuated by a float that rests on the surface of the gasoline in the tank. Movement of the float is transmitted to the rheostat contact arm by a set of gears in larger tanks and through a lever in smaller tanks.

When the gasoline tank is empty the float assembly is at its lowest position where the rheostat in the tank unit is completely grounded. All current through the dash unit therefore flows through the coil at the empty side of the indicator and the pointer is pulled to the empty mark. As fuel is added in the gasoline tank the float assembly rises. This moves the contact brush in the rheostat, introducing resistance into the circuit that grounds the full coil in the dash unit so that part of the current flows through this coil and the pointer is attracted away from empty to a position of balance between the two coils, its point of rest depending upon the amount of resistance which in turn is governed by the amount of gasoline in the tank.

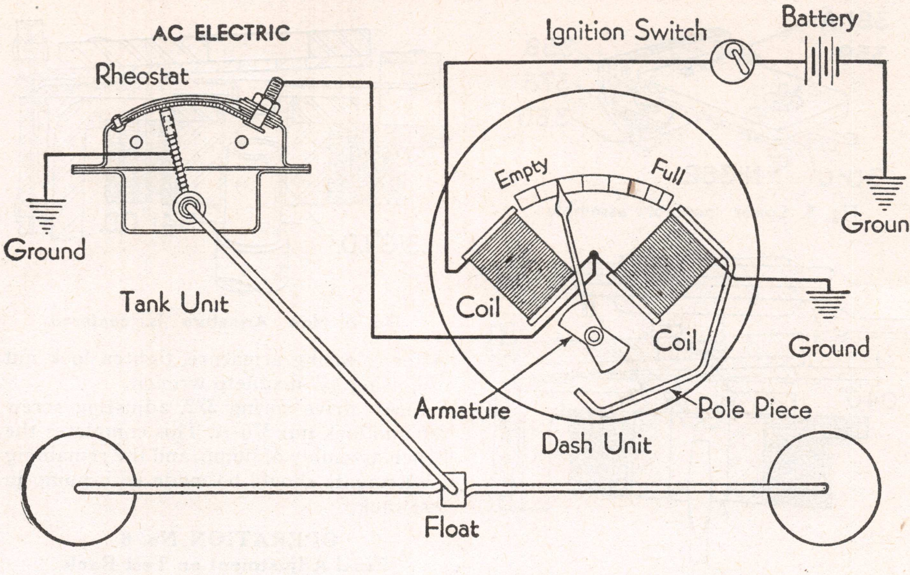
Variations in battery voltage do not affect the reading of the gauge as its operation depends upon the proportion of current flowing through the two coils rather than the strength of the magnetic field of the two coils.

Service: If the gauge does not register properly, first check all wire connections to be sure that they are tight and also make sure that wires are not pinched between any metal parts such as between fender arms and frame, etc. Then make sure that the dash unit case is grounded to the metal dash and that the tank unit is also grounded.

If trouble is experienced with either the dash unit or the tank unit, replacement of the inoperative unit is the only remedy.

Work in locating trouble will be considerably simplified if an extra tank unit is available as it can be connected temporarily with the dash unit by a short piece of wire and grounding the body of the unit to the chassis. The float can then be moved to full and empty positions. If the dash unit indicates the correct position of the float, the trouble is confined to the tank unit and wiring.

If the gauge shows full under all conditions check the wire and all connections between the dash unit and the tank unit. The tank unit may be burned out and should be replaced or the tank unit may be improperly grounded due to loose mounting screws or paint under the screw heads. If this is the case tighten the screws holding the tank unit and ground the tank to the chassis. If this does not locate the trouble, remove the wire from the tank unit terminal and ground it to the frame of the vehicle. Turn on the ignition switch. If the gauge shows full the wire from the dash unit to the tank unit is open circuited and must be replaced. If the gauge shows empty the wire is okeh but the tank unit is open circuited and must be replaced.



When the gauge shows empty under all conditions it may be caused by the wires being reversed on the dash unit. This can be corrected by simply attaching the wires to the proper terminals. The trouble may also be due to the fact that the dash unit is not grounded and should therefore be replaced. Remove the wire from the dash unit terminal leading to the tank unit and turn on the ignition switch. If the gauge now shows full the dash unit is okeh. If the gauge still shows empty the dash unit is at fault and must be replaced. Replace the wire at the dash unit and disconnect the wire at the tank unit. Turn on the ignition switch. If the gauge now shows full the wire from the dash unit to the tank unit is okeh but the tank unit is shorted and must be replaced. If the gauge shows empty the wire from the dash unit to the tank unit is shorted and must be replaced.

If it becomes necessary to remove the gauge from the dash, disconnect the battery terminal to prevent possible short circuits which may damage the tank unit or other electrical equipment. When connecting the battery wire to the dash unit, make certain that the wire which leads to the tank unit does not come in contact with the ammeter connection or the upper terminal on the dash unit marked "ignition" as this may result in damage to the tank unit rheostat.

Do not install or remove the tank unit without making sure that the ignition switch is off to prevent danger of sparks near the fuel supply.

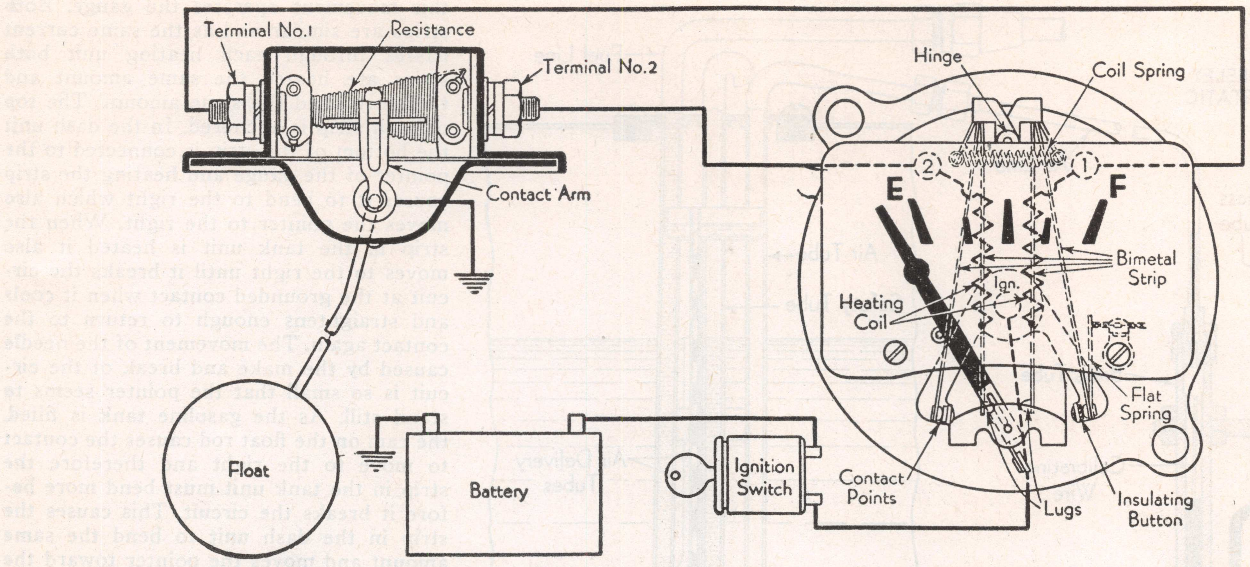
AUTO-LITE ELECTRIC

MOTO METER

The Auto-Lite gauge includes a dash unit and a tank unit connected by two wires. It operates only when the ignition switch is turned on. The dash unit has two bimetal strips that are wound with heating coils, and two bimetal strips without coils that compensate for external temperatures, and also protect the coils from overheating. The heating coils are wound around the strips that actuate the pointer and are welded to the strip at the lower end. The other end of each coil is connected to terminals at the rear of the gauge. At the lower end of one unheated strip is a set of contact points held together by a coil spring. There are no contact points at the lower end of the other unheated strip but there are two stops. One is an insulating button and the other is a flat spring which is insulated from the frame.

The tank unit consists of a resistance and a contact arm which are grounded to the case. The position of the float in the gasoline tank controls the movement of the arm on the resistance which in turn controls the current in the heating circuits of the dash unit. The amount which the heated strips in dash unit bend, depends upon current in the heating coils. As the strips bend, the lugs at the lower end of the strips grip the pointer and move it into position on the dial to indicate the amount of fuel in the tank.

The unheated strips are assembled so that any external temperature change causes the hinge to rotate slightly and thus move the strips that actuate the pointer so that the gripping lugs remain stationary. If the coils should become overheated, the excessive bending of the heated strips rotates the hinge and opens the contact points. Cooling begins immediately and the points swing together before the position of the pointer is affected.



AUTO-LITE MOTO METER

There are three types of dash units. With the first type some difficulty was experienced due to the Ign. Sw. terminal becoming loosened when the nut was turned to tighten the cable terminal. On the second type the Ign. Sw. terminal is staked to prevent turning and provision was made for the installation of a radio resistor. On the third type all three terminals are staked to prevent turning. This unit can be identified from the second type by the addition of an insulating strip between No. 1 and No. 2 terminals instead of an insulating washer at each terminal.

The simplest way of checking for a defective gauge is through the use of a tank unit known to be in good condition. It is only necessary to disconnect the wires from terminals No. 1 and No. 2 on the back of the dash unit, and connect the spare tank unit, being sure to run a ground wire from the tank unit to a good ground on the frame of the car. Then turn on the ignition and move the tank unit float arm by hand to check the action of the pointer. Allow approximately one minute for the gauge to come to its true reading.

If the gauge does not record properly it indicates that the fault is in the dash unit. If the gauge operates okeh it indicates that the trouble is either in the tank unit or in the wiring. To check the wiring, insert a six-volt test light between the tank unit and a wire to the dash unit. With the ignition on, the lamp should go on and off at regular intervals. If the lamp does not light, it indicates either a ground or an open circuit in the wire. This test should be made on both wires to tank unit.

Should the wires between the dash unit and the tank unit be reversed, the gauge readings will also be reversed. The following table shows the effect on the reading if either of the wires is open circuited or grounded.

Tank Condition	Gauge Reading			
	No. 1 Wire		No. 2 Wire	
	Grounded	Open	Grounded	Open
Empty	E	½	½	E
½	¼	F+	¾	E
Full	½	F+	F	E

Open circuits usually occur at the connectors in the rear. This can be remedied by thoroughly cleaning the contact surface to remove grease, soldering flux, insulating varnish or other foreign matter. Grounds may occur at the left windshield post where the wires pass up the post.

On the first two types of dash units described above, inaccurate gauges may be caused by drawing up the nuts too tight on the back of the dash unit when attaching terminals. This loosens the stud and destroys the accuracy of the gauge. A replacement is the only remedy.

Sticking pointers may be caused by insufficient clearance between the lower end of the pointer and the panel. It can be remedied by making a gasket to fit the mounting face of the dash unit and inserting it between the mounting face and the back of the panel, thus moving the gauge back in the panel enough for the pointer to be free. If sticking is caused by conditions other than interference with the panel, it will be necessary to replace the unit.

A fluctuating pointer is caused by dirty contact points. This can be remedied by drawing a clean piece of bond paper between the points to clean them.

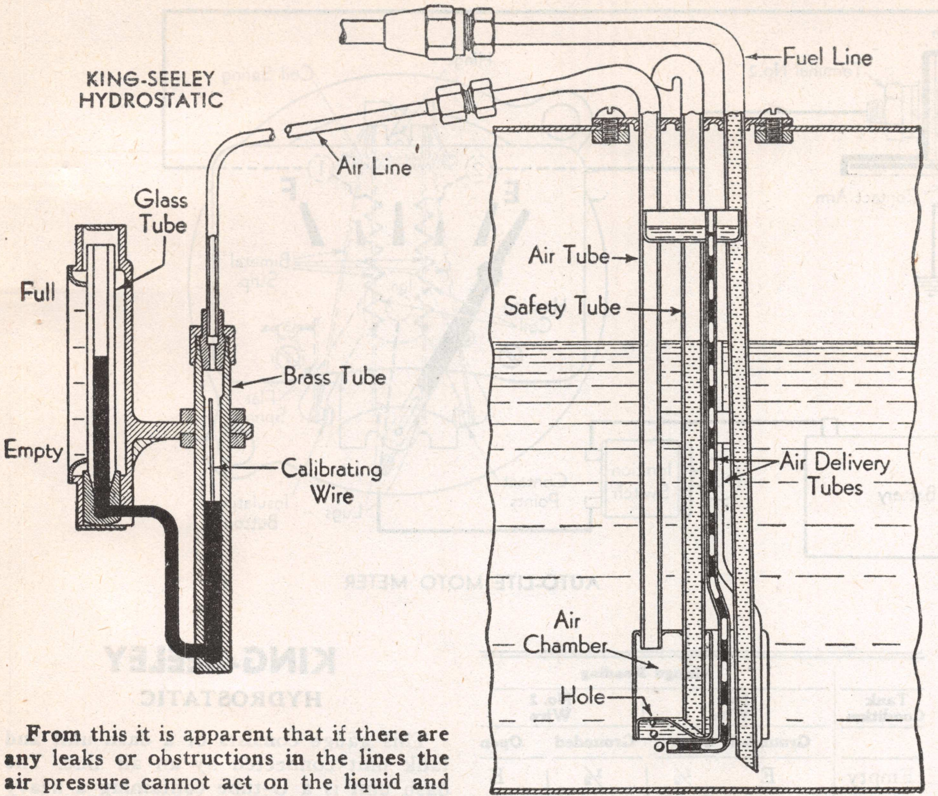
When checking the dash unit off the vehicle in the open air, be sure to shield the unit from air currents which might cause uneven cooling of the bimetal strips.

KING-SEELEY

HYDROSTATIC

This gauge consists of a dash unit and tank unit connected by an air line. The dash unit is a U-tube containing a heavy red liquid. The front half of the U-tube is glass and gives the tank reading while the back half is brass and is connected to the air line. With the air line disconnected, liquid in both sides of the U-tube balance, and the liquid in the glass side registers with the lowest line on the dash unit scale. The tank unit consists in general of five tubes. One supplies fuel to the engine, one is connected to the air line leading to the dash unit, one is a safety tube or air vent to protect the gauge from excessive air pressure and the other two are air tubes which supply air to the air chamber and keep it filled with air. When the cup on an air supply tube is above the level of the gasoline it is constantly being filled as the gasoline splashes around while the car is in motion. The gasoline runs down the air supply tube and in so doing, draws with it a few bubbles of air. At the bottom of the tube this air bubbles out and rises under the air chamber. The air, being lighter than gasoline, rises and enters the air chamber through the hole at the bottom and pushes out any gasoline which may be there. When the air chamber is filled with air, these bubbles pass off and are not used.

In operating condition, the air line, air tube and air chamber are filled with air. Gasoline tries to rise to the same level in the air tube as it is in the tank. This is not possible because of the air trapped between the air chamber and the liquid in the U-tube. However, the effort of the gasoline to get into the air chamber presses on the trapped air and this pressure transmitted to the liquid in the U-tube forces the liquid down in the brass tube and up in the glass tube, where it registers on the scale.



From this it is apparent that if there are any leaks or obstructions in the lines the air pressure cannot act on the liquid and the reading of the gauge will remain stationary. It is also important that the correct liquid is used for if it is too light the reading will be too high and if it is too heavy the reading will be too low. Incorrect liquid may also evaporate or freeze.

Service: To inspect the dash unit, disconnect the air line. The liquid in the glass part of the U-tube should register with zero on the gauge. Inspect the glass tube, brass tube and small connecting tube for damage and if broken, the complete dash unit must be replaced. If it is too high, remove excess liquid from the top of the brass tube with a pipe cleaner, toothpick or match. Do not remove any wires that may be in the brass tube as it will destroy the accuracy of the gauge. If the liquid level in the glass tube is too low, add the correct liquid at the top of the brass tube with a medicine dropper. To test the dash unit, move the thumb or finger rapidly up and down against the top of the brass tube. This action will supply air pressure to the liquid causing it to rise in the glass tube. Entrap the air by holding the thumb tightly over the top of the brass tube. If the liquid holds its reading the unit is okeh.

When inspecting the air line, make sure that it is dry first. To do this remove the gasoline tank filler cap. Attach a hand tire pump to the end of the air line at the dash unit end and give at least 50 continuous, full strokes. When pumping, make sure that air is going through the line and that it is not clogged. Now disconnect the air line at the tank unit and inspect the connections for roughness, dirt and flaws. If necessary smooth up the cones with fine emery cloth. Plug one end of the air line and suck with the mouth on the other end. If the suction created will hold the tongue for one minute the line does not leak. If the air line now leaks or is plugged, it should be replaced.

Before checking the tank unit, inspect the air vent and if it is plugged in any way, clear it. It is necessary to remove the tank unit from the gasoline tank to check it any further. Inspect the hole at the bottom of the air chamber and if it is clogged, open it up. If the tank unit is broken or leaks, replace it.

To determine whether or not the gauge is now working properly, connect the air line to the dash and tank units, making sure that the joints are tight. Disconnect the fuel line at the fuel pump. With the gasoline tank filler cap in place, blow back into the gasoline tank with the mouth. This will supply air to the tank unit and bring the liquid in the dash unit up to its proper reading. If the reading obtained holds for half an hour the trouble has been corrected. If the reading does not hold, the trouble is in the tank unit or the inspection of dash unit or air line was not thorough.

KING-SEELEY ELECTRIC

This gauge consists of a tank unit and dash unit connected by a single wire. The controlling element in both units is a bimetal strip. An electric heating unit is wound around each strip and connected in series so that current flows from the battery, to the dash unit, and to the grounded contact in the tank unit to complete the circuit. When the strip is heated it bends and this movement operates the gauge. Both strips are similar and as the same current passes through each heating unit both strips are heated the same amount and therefore bend the same amount. The top of each strip is anchored. In the dash unit the bottom of the strip is connected to the pointer of the gauge and heating the strip causes it to bend to the right which also moves the pointer to the right. When the strip in the tank unit is heated it also moves to the right until it breaks the circuit at the grounded contact when it cools and straightens enough to return to the contact again. The movement of the needle caused by the make and break of the circuit is so small that the pointer seems to stand still. As the gasoline tank is filled, the cam on the float rod causes the contact to move to the right and therefore the strip in the tank unit must bend more before it breaks the circuit. This causes the strip in the dash unit to bend the same amount and moves the pointer toward the full mark on the dial. In this way the position of the float determines the position of the pointer in the dash unit.

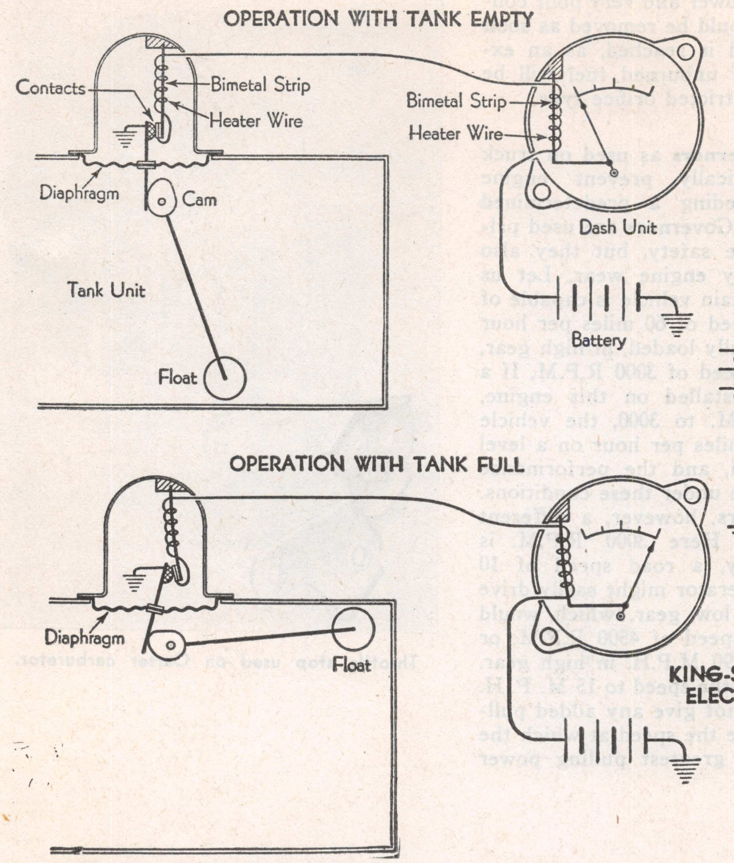
Since the gauge depends entirely on temperature for its operation, a change in voltage in the system will not affect the reading. A higher voltage will show a change in fuel level faster, but the final reading will be the same. Because the strips heat and cool slowly, any sudden change in gasoline level caused by rough roads, etc., are dampened out and a steady reading of the average level in the tank is given.

Service: The following equipment is necessary for checking the operation of the gasoline gauge: a tank unit, a dash unit and two 4" lengths of insulated wire with clip terminals on each end.

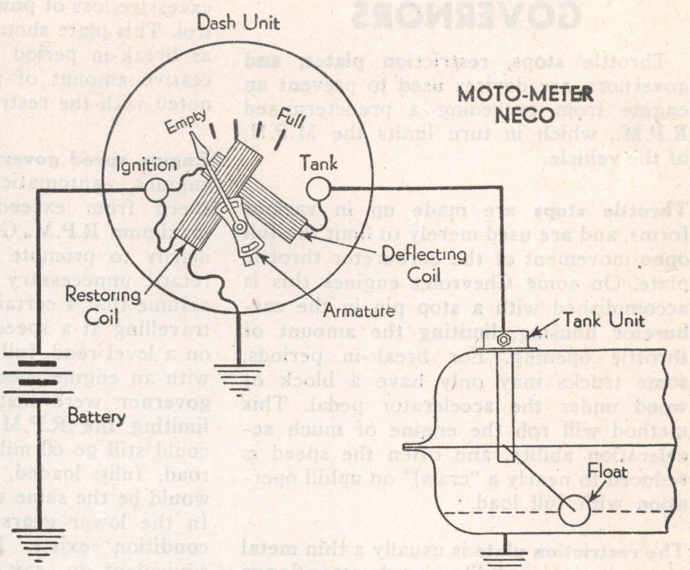
To check the tank unit, disconnect the wire at the tank unit and connect it to the extra tank unit. Ground the tank unit to the car frame and turn on the ignition switch. Move the float from empty to full position and watch the action of the dash unit. Allow 10 to 15 seconds for the dash unit to read full. If the dash unit registers correctly, the tank unit has a poor ground connection because of paint or grease or, if the vehicle is equipped wtih a radio, the condenser attached to the tank unit may be shorted. This will cause overreading when the ignition switch is on. The condenser can be checked by disconnecting the wire from the condenser to the tank unit. If the gauge operates correctly with the condenser disconnected replace the condenser. The original tank unit may be damaged and should be replaced. If the reading is the same with the extra tank unit the wiring should be checked. If the wire connecting the tank and dash units is broken or grounded it must be repaired or replaced. If the tank unit and the wiring are okeh then check the dash unit.

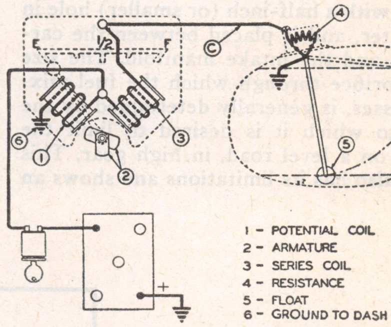
To check the dash unit disconnect the wires from the dash unit and attach them to the extra dash unit. If the extra dash unit reads correctly, then replace the dash unit. If the reading is the same as originally,

GASOLINE GAUGES


OPERATION WITH TANK EMPTY
Contacts
Bimetal Strip
Heater Wire
Diaphragm
Cam
Tank Unit
Float
Bimetal Strip
Heater Wire
Dash Unit
Battery
OPERATION WITH TANK FULL
Diaphragm
Float

KING-SEELEY ELECTRIC


Dash Unit
MOTO-METER NECO
Empty
Full
Ignition
Tank
Deflecting Coil
Armature
Restoring Coil
Battery
Tank Unit
Float


1 - POTENTIAL COIL
2 - ARMATURE
3 - SERIES COIL
4 - RESISTANCE
5 - FLOAT
6 - GROUND TO DASH

STEWART-WARNER

the previous checks were not correctly made or the installation was correct all the time.

MOTO METER NECO

This gauge is similar to the AC electric except for the arrangement of two coils in the dash unit. When the gasoline tank is filled the float assembly is at its highest position where the rheostat in the tank unit is completely grounded. All current through the dash unit is therefore equally divided between the two coils and the pointer is pulled to the full mark. As fuel is used from the tank the float sinks, moving the contact brush on the rheostat. This introduces resistance into the circuit that passes through the deflecting coil so that a greater portion of the current flows through the restoring coil and the pointer is attracted away from the full mark in accordance with the amount of gasoline in the tank.

STEWART-WARNER

This gauge is similar to the AC electric in that magnetic coils in the dash unit control the position of the indicator. The current flowing through each of these coils is determined by the position of the contact arm on the rheostat in the tank unit.

A float in the gasoline tank moves the contact arm, dividing the current in the dash unit coils according to the amount of gasoline in the tank. When the gasoline tank is filled, the rheostat in the tank unit is completely grounded out and all current through the dash unit is equally divided between the two coils so that the pointer is pulled to the full mark. As fuel is used, and the contact arm moves on the rheostat, resistance is introduced into the circuit which passes through the deflecting coil so that a greater portion of the current flows through the restoring coil, and the pointer is attracted away from the full mark.

Service: If the gauge does not register properly, check all connections to be sure they are tight. Also, make sure that the wires are not pinched between any metal parts which may cause a ground. Make sure that the tank unit and the dash unit are properly grounded. If, after all the wires and connections are in good condition, the gauge still does not register properly, check the dash and tank units. To do this, remove the wire from the tank unit terminal and ground it to the frame of the car while the ignition is on. The gauge should then read full. Remove the wire from the frame, and with the ignition still on, the gauge should read empty. If this is not the case, replace the dash unit. If the gauge indicates as described, replace the tank unit.

GOVERNORS

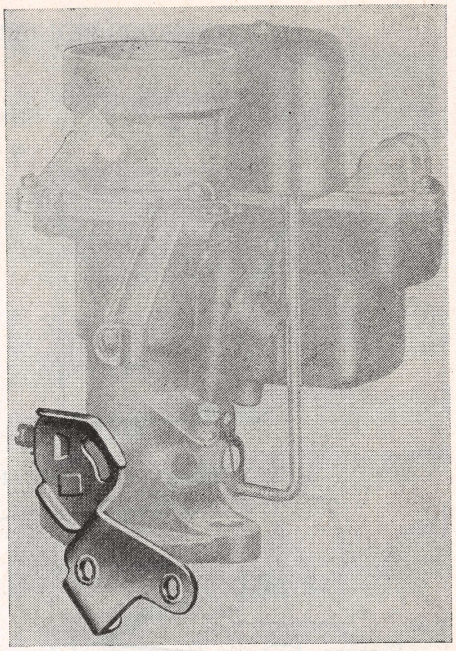
GOVERNORS

Throttle stops, restriction plates, and governors, are devices used to prevent an engine from exceeding a predetermined R.P.M., which in turn limits the M.P.H. of the vehicle.

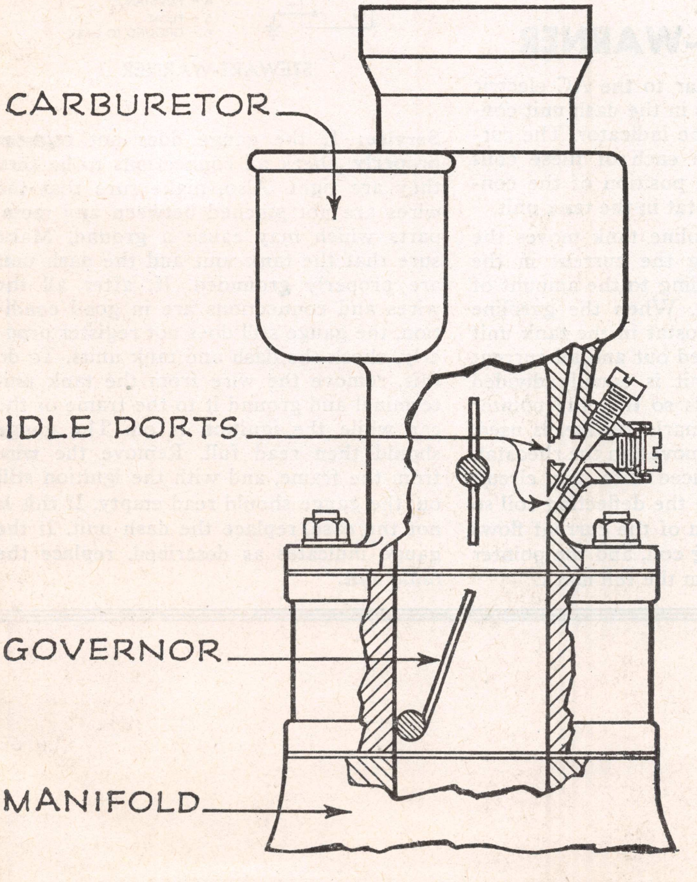
Throttle stops are made up in various forms, and are used merely to limit the full open movement of the carburetor throttle plate. On some Chevrolet engines this is accomplished with a stop pin in the carburetor housing, limiting the amount of throttle opening. For break-in periods, some trucks may only have a block of wood under the accelerator pedal. This method will rob the engine of much acceleration ability, and often the speed is reduced to nearly a "crawl" on uphill operation with full load.

The restriction plate is usually a thin metal plate, shaped much like a carburetor flange gasket, with a half-inch (or smaller) hole in the center, and is placed between the carburetor and the intake manifold. The size of the orifice through which the fuel mixture passes, is generally determined by the speed to which it is desired to limit the vehicle on a level road, in high gear. This device also has its limitations and shows an excessive loss of power and very poor control. This plate should be removed as soon as break-in period is reached, as an excessive amount of unburned fuel will be noted with the restricted orifice type.

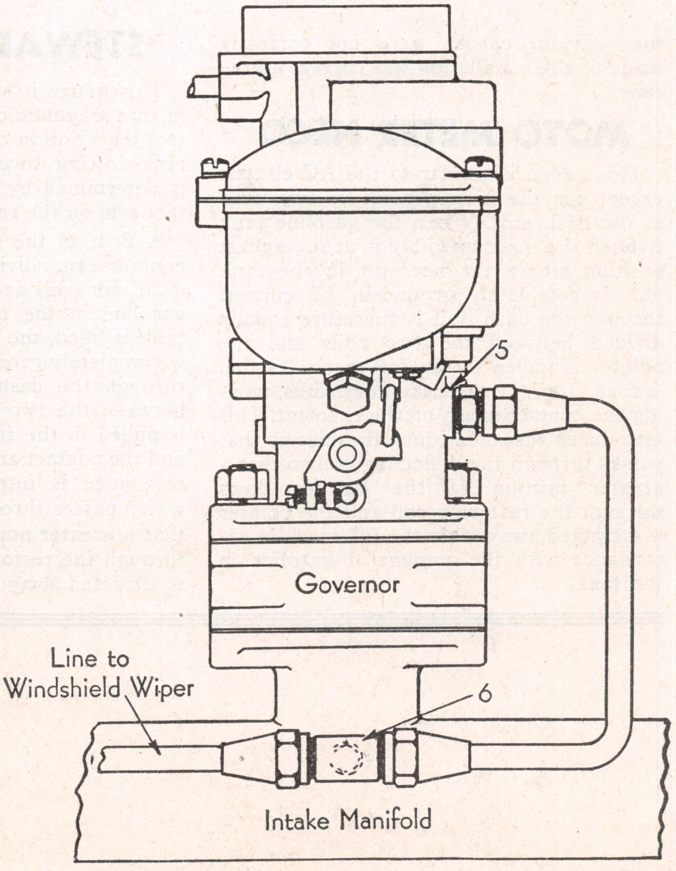
Engine speed governors as used on truck engines, automatically prevent engine speed from exceeding a predetermined maximum R.P.M. Governors are used primarily to promote safety, but they also retard unnecessary engine wear. Let us assume that a certain vehicle is capable of travelling at a speed of 60 miles per hour on a level road, fully loaded, in high gear, with an engine speed of 3000 R.P.M. If a governor were installed on this engine, limiting the R.P.M. to 3000, the vehicle could still go 60 miles per hour on a level road, fully loaded, and the performance would be the same under these conditions. In the lower gears, however, a different condition exists. Here 3000 R.P.M. is equivalent to, say, a road speed of 10 M.P.H. but an operator might easily drive at 15 M.P.H. in low gear, which would mean an engine speed of 4500 R.P.M. or the equivalent of 90 M.P.H. in high gear. This increasing of the speed to 15 M. P. H. in low gear does not give any added pulling power, because the speed at which the engine exerts its greatest pulling power



Throttle stop used on Carter carburetor.



Showing correct governor installation. Governor throttle plate must always be on the side opposite the carburetor idle port.



Showing external vacuum line hook-up with vacuum-operated carburetor when governor has no vacuum by-pass channel.

has long since been exceeded. The speeding up of the engine in this case, therefore, serves no useful purpose and the over-speeding of the engine causes its premature destruction. This, of course, would not be possible if the engine is equipped with a proper governor.

There are **two classes of governors** commonly usely on truck engines today, one known as the mechanical type, and the other as the automatic type. The operation of mechanical governors is dependent upon the centrifugal force developed from flying balls or weights. A belt, gear or some other driving means must be provided, also automatic oiling, for the internal mechanism of the governor.

Automatic governors now used are of the velocity or flow type, and vacuum type. Velocity type is so called, because the main operating force is the velocity of the fuel mixture, after passing the carburetor throttle plate, strikes the governor plate and tends to carry it to a closed position, thereby restricting the amount of fuel mixture that can pass to the cylinders. The vacuum type is operated by intake manifold vacuum applied to a piston. Opposing this force that is trying to close the governor throttle plate, is a force trying to keep it open, usually a spring, of either the coil or flat type. This spring must be calibrated to a proper strength, to create a balance between these two forces at all engine speeds. Under actual operating conditions, the governor throttle plate does not close all the way, but assumes a position, sufficiently open, to give the required amount of mixture to maintain the engine at whatever speed the governor has been set for.

GENERAL GOVERNOR SERVICE

Usually, governor settings are made to meet the truck manufacturers' requirements, who are interested in a speed which will provide the maximum horsepower, and which will not in any way affect the ability of the truck to perform in high gear, with full load, on a level road. This is a high speed range governor, and is supplied as standard equipment. In some cases, however, when such a truck goes into service, the operator may, for purposes of his own, desire a setting very much lower than he now has. If an attempt is made to adjust the high speed factory calibrated governor for lower speeds than specified, simply by loosening the speed adjustment, thereby weakening the pull of the spring against the throttle plate, surging and erratic operation will result. The governor will need internal changes and recalibration to a so-called low speed range unit.

Speed setting on all standard equipment governors, regardless of make, is really a simple operation. We are only concerned here with speed setting, assuming the governor is in good working order, which is about all the service a mechanic can apply to the governor when it is on the vehicle. All that is necessary is to locate the adjustment, which is usually sealed by the manufacturer in some fashion, to prevent tampering by an unauthorized person. Usually the seal consists of a wire inserted either through a small clevis pin or through a small plug; some governors are sealed by a metal cap.

To set the governor, there is only one thing to remember: Tighten the adjustment, or screw it clockwise, to increase the governed speed (from 35 to 40 M.P.H. for example) and loosen the adjustment, or screw it anti-clockwise to lower the governed speed. If an R.P.M. meter (tachometer) is on the vehicle, use that for a guide; if not, you may have to jack up a rear wheel. Of course all floor settings will be too low; the ideal setting is only obtained on a level road, full load, going in high gear. If a change in governed speed causes erratic action of the governor, then it will no doubt have to be removed, thoroughly cleaned and internal calibrations changed.

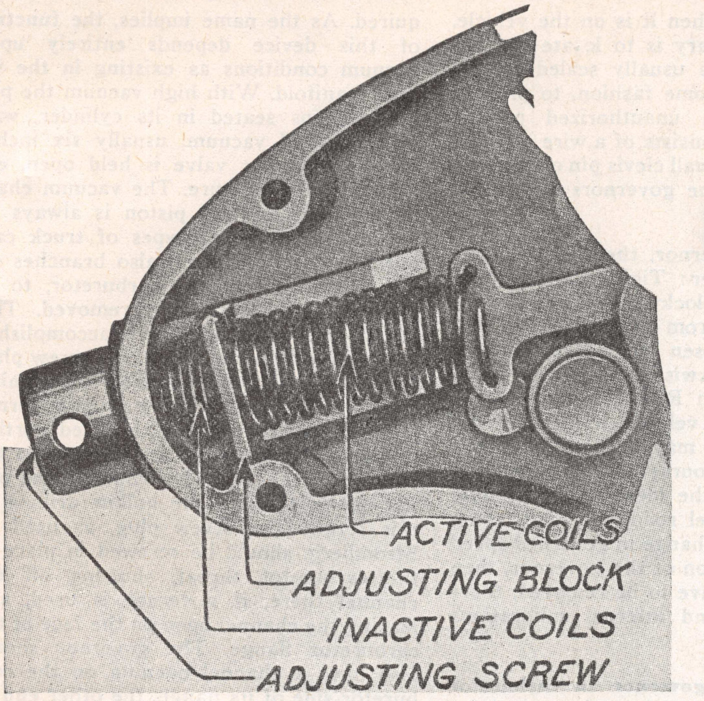
The relation of governor to carburetor must be carefully noted, as the same governor could be used on either a downdraft or an updraft carburetor by turning the governor upside down—if changed from one to the other. Remembering that the rush of air passing through the carburetor is the force that tries to close the governor plate, place the governor on the intake manifold, allowing the free end of the plate to face the carburetor. If properly placed, a slight, steady pressure of the finger will close the governor plate, the same as the inrushing air, or velocity, will do when the carburetor is in place. Most governor housings are properly marked—carburetor side and engine side. Another installation feature that has caused a slight flat spot in engine performance around 15 to 18 M.P.H. is the relation of the **idle discharge ports** of the carburetor, to the open side of the throttle plate of the governor. Most governors have a larger open space area at the carburetor end of the governor throttle plate than they have at the manifold end. These discharge ports should be directly above the larger spacing between governor plate and housing, as engine performance depends entirely on fuel fed from these ports up to about 20 M.P.H., therefore, there should be no restriction in the path of this fuel mixture entering the manifold. If these carburetor ports are above the narrow, or almost closed edge of the governor throttle plate, there is a "crowding" of the fuel at this point, due to the angle of the governor throttle plate, and also, usually rods or linkage, that operate from an anticheat device, are on this side of the governor plate.

GASKETS

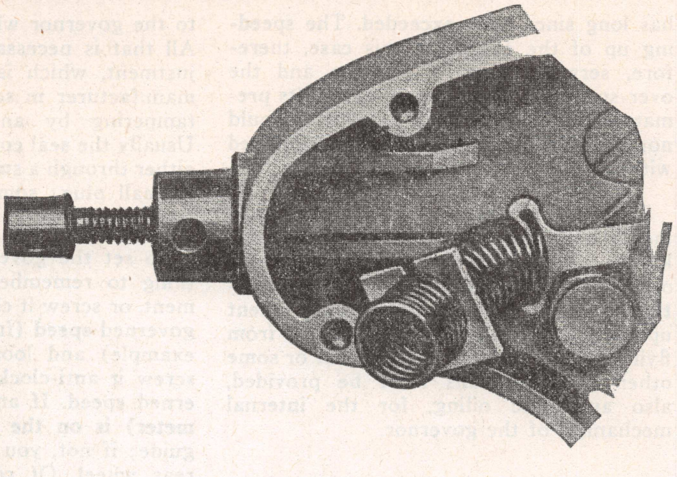
Vacuum economizer pistons are used in most carburetors to supply a richer mixture for full power operation, when so required. As the name implies, the function of this device depends entirely upon vacuum conditions as existing in the intake manifold. With high vacuum the piston remains seated in its cylinder, with low manifold vacuum, usually six inches or less, a power valve is held open, enrichening the mixture. The vacuum channel opening for this piston is always on the flange of recent types of truck carburetors, but a channel also branches off into the throat of the carburetor, to be used if the governor is removed. This switch in channel opening is accomplished with either a hollow screw or a screw plug. The hollow screw, as used on Zenith, should be screwed in place when governor is in use, as the outside threaded portion of the screw shuts off the channel to the carburetor throat, and vacuum to the piston passes through the hollow drilling of this screw. The screw plug, as used on Stromberg, should be screwed in place in the carburetor throat, shutting off the channel there, if governor is used, and leaving the channel open on the face of the carburetor flange. The governor should also have a channel opening on the carburetor side of its flange, the other end of the channel opening is in the governor throat, near the manifold side. A moments study of these channel openings will clear up much confusion about how to apply "special governor gaskets," whereas, the only function of this gasket is to allow a direct passage between these two channels, from governor to carburetor, with a suitable hole or slot, but at the same time admitting no outside air. Just a plain flange gasket is used between governor and manifold. Should you have a governor without this vacuum passage (used on carburetors without a vacuum economizer), and a carburetor with a vacuum economizer, then an outside tubing should be installed between intake manifold and vacuum channel of carburetor.

VACUUM ADVANCE DISTRIBUTOR

Automatic Vacuum Spark Control is used on many trucks. This device produces a retarded spark for idling and heavy load operation, and an advance spark for intermediate and high speed operation. Its regulation is determined by the position of an orifice in the carburetor throat to the position of the carburetor throttle plate. This orifice is connected to the distributor, and which, in turn, retards or advances the spark, dependent upon the manifold vacuum existing at the orifice. Some governors have no provision for automatic spark advance, with the result that when the governor is controlling the speed of the engine, the spark is retarded instead of advanced; therefore, a vehicle with a vacuum advance distributor, must have a governor with a spark transfer valve, which is also vacuum operated. When the governor throttle plate is open, the carburetor throttle plate controls the action of the distributor diaphragm, and when the governor throttle plate is nearly



HANDY. Internal governor adjustment.



HANDY. Showing spring removed to turn adjusting block.

closed, manifold vacuum controls the action of the diaphragm.

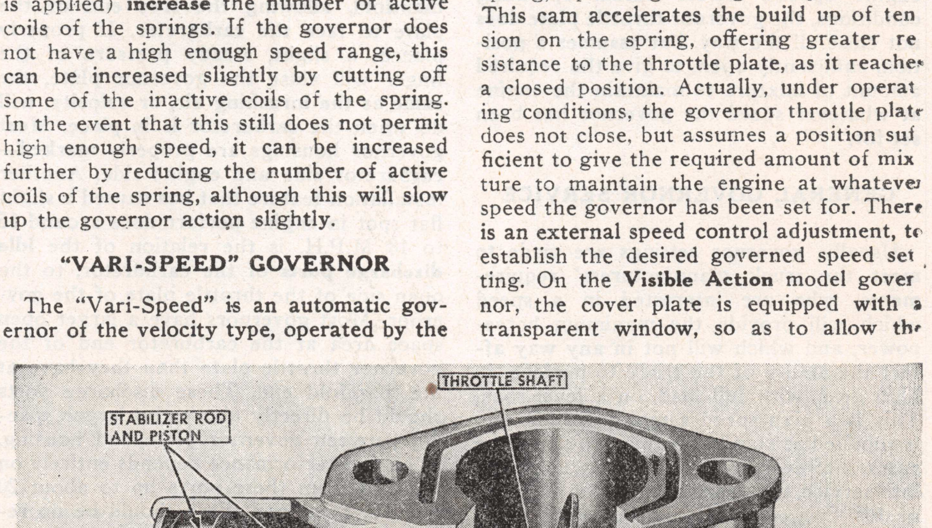
HANDY

STANDARD GOVERNORS

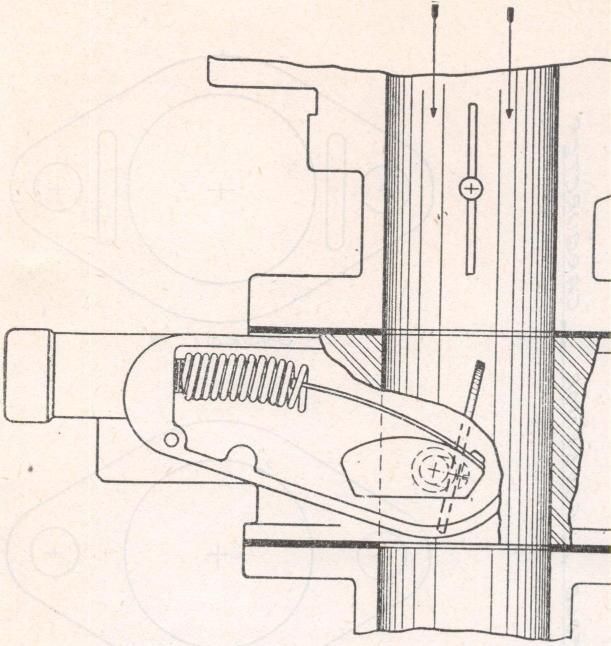
This is an automatic, velocity type engine speed governor. All models are equipped with a stabilizer piston, which is vacuum operated, pushing the governor throttle plate to a closing position, when a high vacuum exists above the throttle plate, which action, in turn, prevents overrun of engine speed. There is only one **external adjustment**, a speed setting, locked with a small clevis pin and a wire seal. Tightening the screw adjustment, or turning clockwise, allows a higher governed speed, loosening the screw adjustment, or turning anti-clockwise, lowers the governed speed. **Internal adjustment** is accomplished by changing the number of active spring coils. Remove the governor housing cover and study the assembly of the coil spring. You will note a square adjusting block on the spring, the speed adjustment screws into this block, and the block can be screwed along the spring, much like a nut. Looking at the adjusting block, the few turns of the spring, toward the adjusting screw head, are the **inactive coils.** The many turns of the spring, on the other side of the block, are the **active coils.** To make spring adjustments, remove the adjusting screw all the way, raise the spring away from the governor housing enough to turn the adjusting block on the spring—as you would turn a nut to the left or anti-clockwise—to decrease the number of active coils, and to the right, or clockwise, to increase the number of active coils. To slow up governor action, or to correct a hunt or surge, or to stabilize the governor action, **decrease** the number of active coils. To speed up the rate of opening of the governor, (in order to reduce the drop of engine speed when load is applied) **increase** the number of active coils of the springs. If the governor does not have a high enough speed range, this can be increased slightly by cutting off some of the inactive coils of the spring. In the event that this still does not permit high enough speed, it can be increased further by reducing the number of active coils of the spring, although this will slow up the governor action slightly.

"VARI-SPEED" GOVERNOR

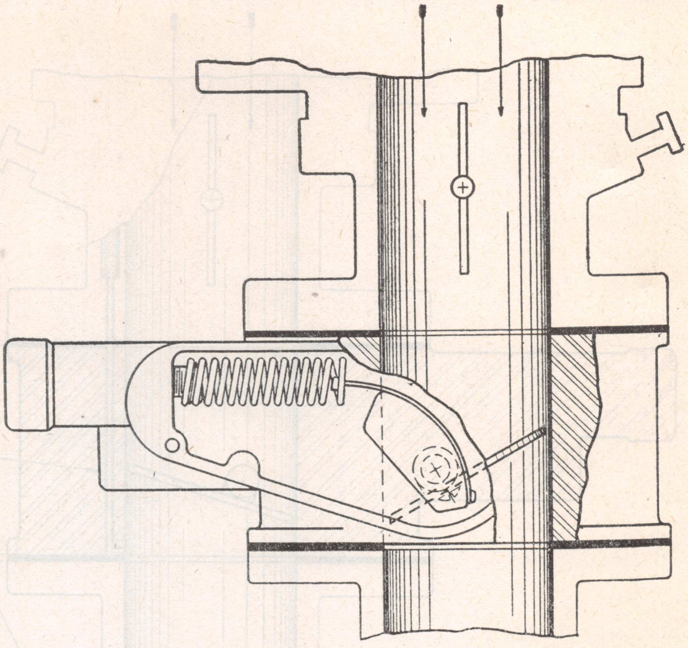
The "Vari-Speed" is an automatic governor of the velocity type, operated by the force generated by the flow of the intake mixture. As the intake air and fuel mixture passes through the governor, it impinges on approximately seventy-five per cent of the governor throttle plate area in such a manner as to push the throttle plate to a closing position, thereby shutting off the flow of the intake mixture. This condition is obtained by installing the throttle shaft off center from the governor throat. A proper opposing, or braking force, is accomplished by means of a coil spring, operating through a special cam. This cam accelerates the build up of tension on the spring, offering greater resistance to the throttle plate, as it reaches a closed position. Actually, under operating conditions, the governor throttle plate does not close, but assumes a position sufficient to give the required amount of mixture to maintain the engine at whatever speed the governor has been set for. There is an external speed control adjustment, to establish the desired governed speed setting. On the **Visible Action** model governor, the cover plate is equipped with a transparent window, so as to allow the



HANDY VARI-SPEED GOVERNOR.



HANDY VARI-SPEED. Showing governor throttle plate in wide-open position—governor not operating.



HANDY VARI-SPEED. Showing relative position of cam and spring with governor in operation.

movement of the cam to be seen when operating on the vehicle.

Vacuum pistons are used in most type carburetors to operate a power valve, responding to vacuum changes in the intake manifold. A proper passage is incorporated in the construction, permitting the vacuum channel opening to be transferred to a position below the governor throttle plate. By doing this the vacuum piston functions properly, regardless of whether the carburetor or the governor is controlling engine speed. In order to have this function properly, it is extremely important that the proper gaskets be used in their proper positions. To use the wrong gasket would destroy the functioning of the by-pass passage, and along with it the functioning of the vacuum economizer.

An automatic spark transfer valve is incorporated in the governor for use on engines with vacuum advance distributors. As long as the carburetor throttle plate controls engine speed, it also controls the spark advance, and the engine functions the same as if it were not governor equipped. However, when the governor controls engine speed, the vacuum produced below the governor throttle plate pulls the spark transfer valve downward, permitting an opening from below the governor throttle plate to operate the distributor vacuum unit. At the same time, the upper part of the valve closes off the opening from the carburetor orifice.

A non-cheating stabilizer piston is used in all these units. It consists of a cylinder and piston, open on one side to the vacuum existent above the governor throttle plate and open at the other end to atmospheric pressure. By manipulation of the carburetor throttle, a high vacuum can be created above the governor throttle plate. The result would be an opening up of the governor throttle plate, thus permitting the engine to exceed its governed speed. This high vacuum draws the piston toward the throat of the governor, and the stem attached to this piston acts to close the governor throttle plate.

SERVICE

It may be noticed after a period of operation that the governor becomes sluggish and not as responsive as when it was new. Such sluggishness is generally caused by deposits of carbon and gum on the valve shaft and bearing, or on the stabilizer piston, rod and cylinder. The remedy for this is to remove the governor and submit it to a thorough cleaning. Several highly efficient cleaners are available, that provide satisfactory results by the cold immersion cleansing process. The factory does not recommend the disassembling of governors for service repair work, unless the shop is equipped with a special **Handy Calibrating Machine.** On this machine governor settings are made from readings on a dial indicator, and finished settings are quite accurate, even to a speed setting.

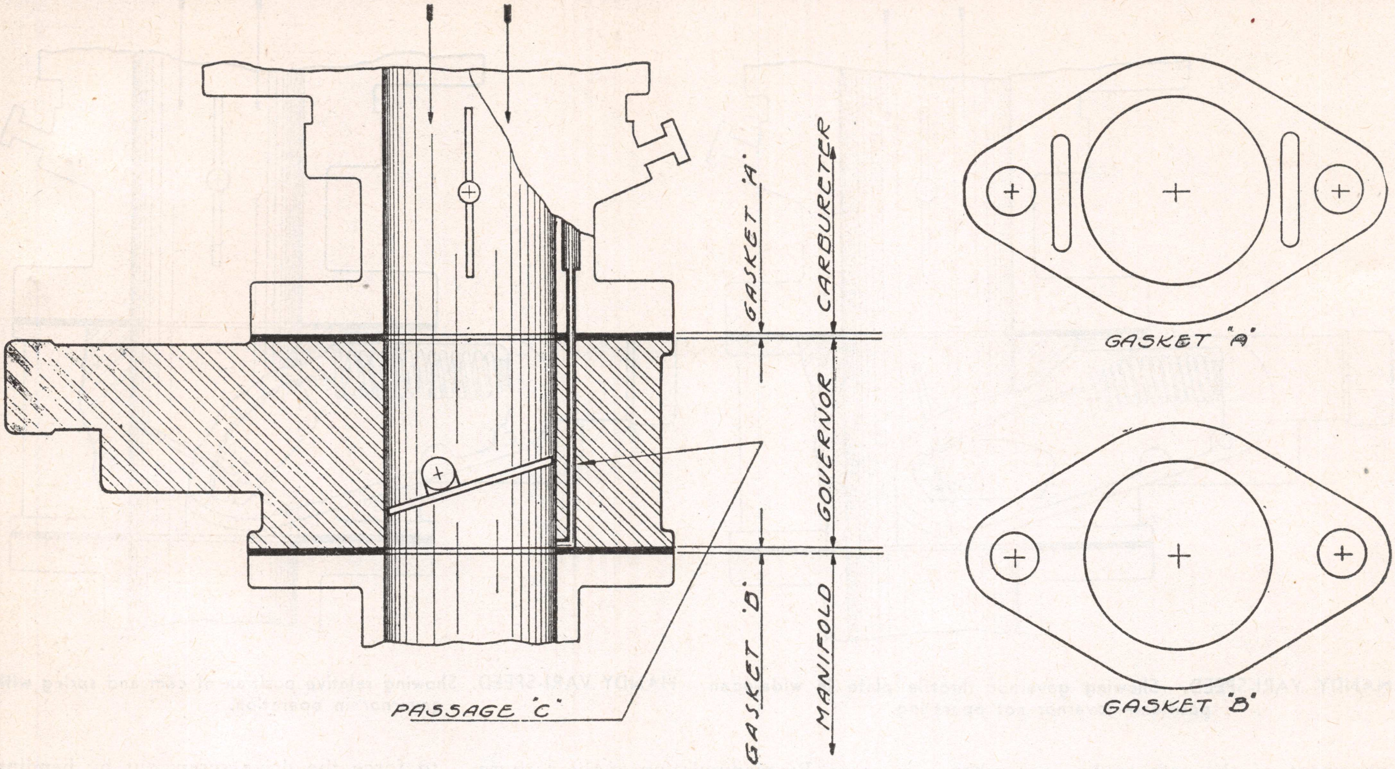
If a part is stuck or frozen, making it necessary to disassemble the unit, remove the operating spring **housing cover.** In removing the cover drive screw, hold the governor with the cover plate down, apply a blunt tool against the bottom edge of the cover at a point directly over the cover drive screw. Tap the end of the tool lightly to start the drive screw out. Do not use a screw driver or similar sharp tool that will cut the casting or cover. Do not try to force the drive screw out by bending upon the free end of the cover, as the cover must fit the housing tightly after it is replaced and must be air-tight. A piece of ¼" steel rod, five inches long is a good tool for this. After the drive screw has moved out far enough to get a pair of side cutting pliers under the head, turn the drive screw counter-clockwise as you would remove an ordinary screw. To replace, locate the "thread" with the fingers, and drive in with a hammer.

The operating spring and cam ribbon (flat spring steel) assembly can be removed by taking off the hair pin spring clip on the cam ribbon end, and unscrewing the adjustment, anti-clockwise, till it leaves the coil spring. With the same tool as used to remove the cover drive screw placed against the adjusting screw, inside the housing, tap lightly, and the **adjusting screw assembly** will fall out of place. Be careful not to damage the pilot threads that screw into the coil spring.

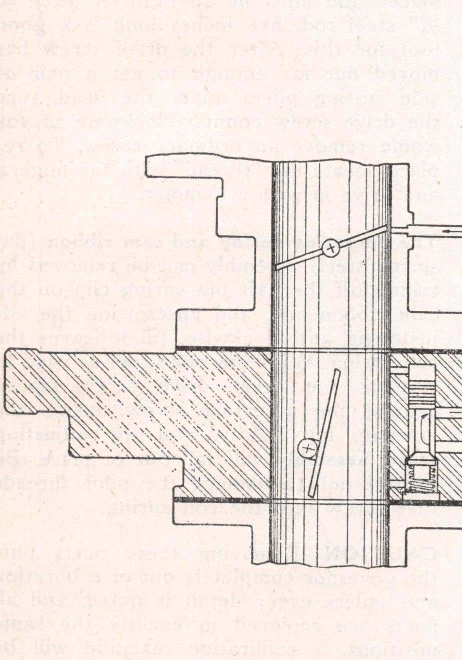
CAUTION—Removing these parts puts the governor completely out of calibration and unless every detail is noted, and all parts are replaced in exactly the same positions, a calibration machine will be needed for a resetting.

If all calibrations have been upset, turn adjusting screw bushing on the adjusting screw about two-thirds of the way and insert into the governor housing. Hold the extended end of the coil spring, in the guide channel of the governor housing, and turn the adjusting screw into the spring three spring coils.

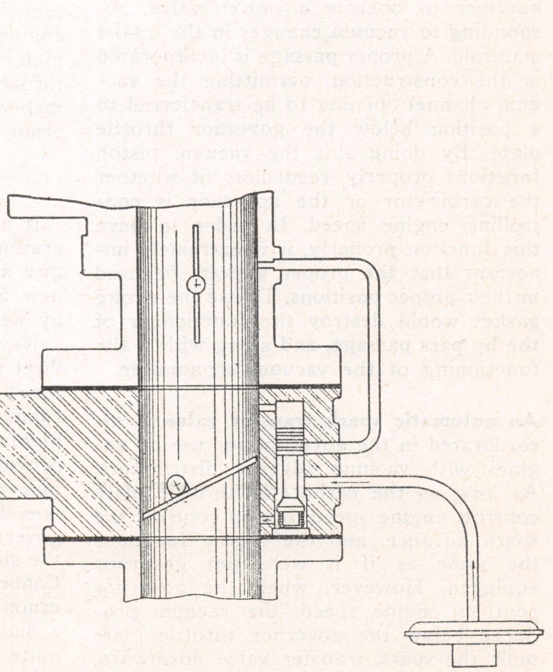
The cam and throttle shaft must be removed as an assembly. Do not remove the



HANDY VARI-SPEED. Showing vacuum by-pass channel for vacuum power jet operated carburetor.

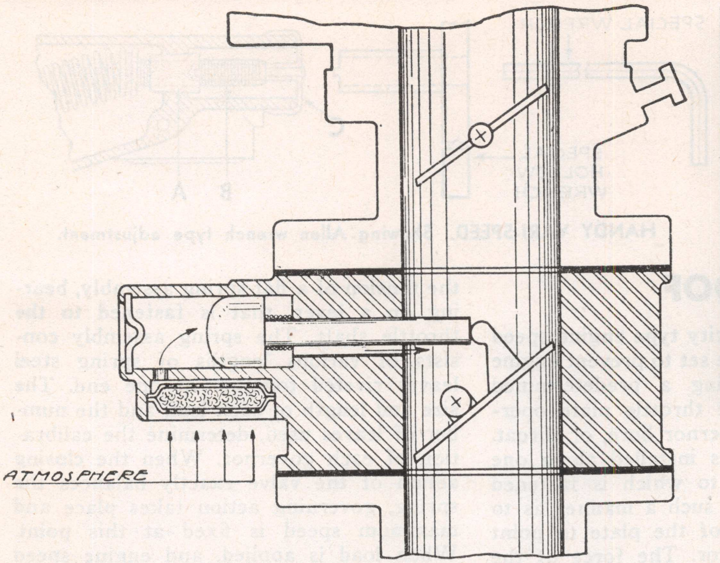


HANDY VARI-SPEED. Showing the carburetor throttle plate operating the distributor vacuum advance unit through the transfer valve.

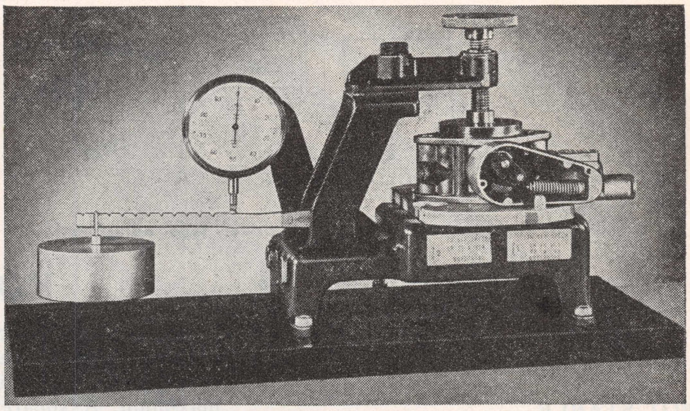


HANDY VARI-SPEED. Showing manifold vacuum operating the distributor vacuum advance unit through the transfer valve.

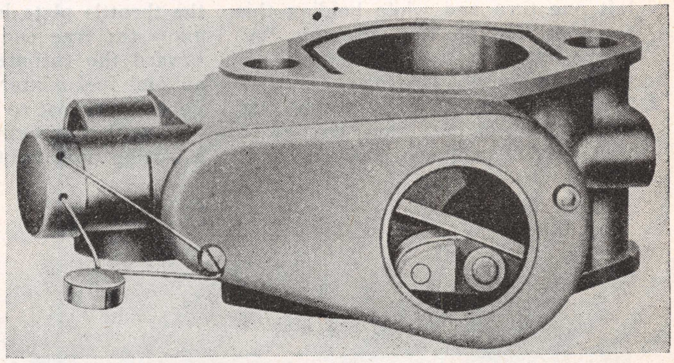
cam from the shaft, and do not try to remove the complete assembly by pulling on the cam. The cam is on the shaft in a definite position to insure proper opening and closing of the throttle plate. The complete assembly must be pried or jarred out as a unit (after the removal of the throttle plate). Holding the adjusting screw end of the governor with the cover housing opening down, rap the end of the governor flange briskly against the surface of a block of wood. (A hard surface such as iron or steel will damage the casting.) Repeat until the shaft and cam assembly can be pulled out by hand. If it does not come out, insert the rear throttle plate screw only. Placing a large screw driver against this screw, pry gently against the throat



HANDY VARI-SPEED. Showing anti-cheat device.



HANDY CALIBRATING MACHINE.



HANDY VISIBLE ACTION GOVERNOR.

of the governor, forcing the cam and shaft assembly out through the cover housing. Removing a clip allows the removal of needle type roller bearing from shaft. To remove and clean the **air-filter**, insert a small pointed punch into one of the perforated holes of the cover, and pry out. Replace with convex side up (the one under the air filter felt should be convex side down), and it may be necessary to bend or distort the perforated cover to get it under the several projections. However, after it is in place, it may be tapped down and spread out so that the sides are forced against the casting.

Do not attempt to remove the plug that keeps the **stabilizer piston** in place. The casting is rolled over the plug to seal it permanently in place, to discourage tampering with when on the vehicle. There will be practically no wear on these parts, but they will become dirty and gummy, and need a soaking in a cleaning solution. Occasionally, these plugs will blow out due to an engine backfire.

ADJUSTMENTS

These are what could be termed, set calibration governors. The parts affecting the calibration are, cam and shaft assembly, spring assembly, adjusting screw assembly and throttle plate assembly. These calibrated parts cannot be changed from one governor to another at random, as a group of these parts are synchronized to operate on a particular kind of engine.

Speed control screw adjustment raises the governed speed by turning clockwise, and lowers the governed speed by turning anticlockwise. All screw driver type adjusting screws should be replaced with an adjusting screw assembly, consisting of a cap and a piece of hexagon stock (like an Allen wrench). The speed control screw turns in or out of the spring, allowing more or less active coils to operate. To change the spring tension (with the same amount of active coils), insert a hollow type screw driver (or carburetor tool) and while holding the adjusting screw rigid, turn the adjusting screw bushing anti-clockwise to weaken the spring tension, and clockwise to tighten the spring tension. This bushing may be stuck in the housing too tight for the tool to turn, and if so, tap the adjusting screw, from the spring side, lightly, to unseat the bushing. Tap it back into place after each change of setting.

Screw Driver Type: To adjust governor for a HIGHER speed, remove cap "C" and with a screw driver, turn adjusting screw "B" anti-clockwise or to the left; for LOWER speeds, turn adjusting screw "B" clockwise or to the right. One turn on adjusting screw will change speed approximately 4 to 5 miles.

When a more sensitive regulation is desired or if the governor is too sensitive and inclined to surge, correct as follows by means of the calibrating nut shown at "A" in illustration.

TOO SENSITIVE

1. If a governor is TOO SENSITIVE or on the point of surging, place special hollow wrench No. 24283 in position on nut "A." Insert special screw driver No. 24286 through this wrench and turn main adjusting screw "B" to the right one turn.
2. With hollow wrench in slot of nut "A" turn this nut to the right about ¼ turn. Using the special screw driver the main adjusting screw "B" must be kept from turning while nut "A" is adjusted.

NOT STABLE

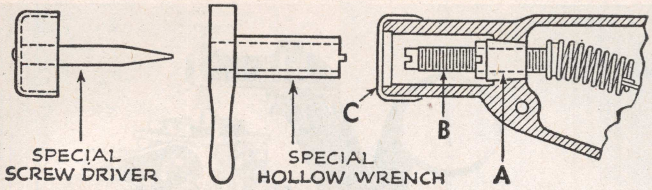
1. If a MORE SENSITIVE governor is desired, adjust main screw "B" to the left one turn and while holding this screw in new position, turn nut "A" to the left ¼ turn at a time until desired regulation is obtained.
2. When adjustment is completed, tap lightly on end of hollow wrench so that nut "A" will seat properly.

Allen Wrench Type: To adjust governor for a HIGHER speed, turn adjusting cap "C" anti-clockwise or to the left; for LOWER speeds, turn adjusting cap "C" clockwise or to the right. One turn on adjusting screw will change speed approximately 4 to 5 miles.

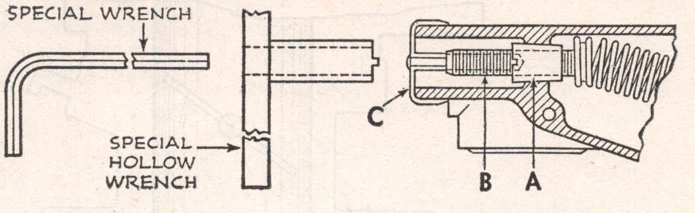
When a more sensitive regulation is desired or if the governor is too sensitive and inclined to surge, correct as follows by means of the calibrating nut shown at "A" in illustration.

TOO SENSITIVE

1. If a governor is TOO SENSITIVE or on the point of surging, place special hollow wrench No. A24283 in position on nut "A." Insert special adjusting wrench No. A25264 through this wrench and turn main adjusting screw "B" to the right one turn.
2. With hollow wrench in slot of nut "A" turn this nut to the right about ¼


SPECIAL SCREW DRIVER
SPECIAL HOLLOW WRENCH
C
B
A

HANDY VARI-SPEED. Showing screw driver type adjustment.


SPECIAL WRENCH
SPECIAL HOLLOW WRENCH
C
B
A

HANDY VARI-SPEED. Showing Allen wrench type adjustment.

turn. Using the special wrench No. A25264 the main adjusting screw "B" must be kept from turning while nut "A" is adjusted.

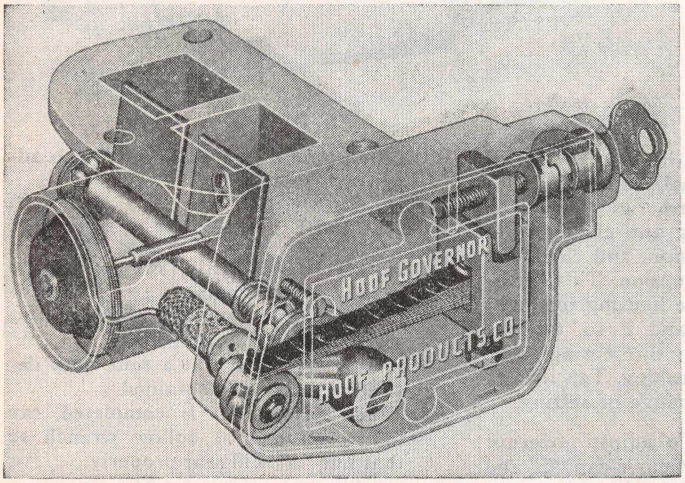
NOT STABLE

1. If a MORE SENSITIVE governor is desired, adjust main screw "B" to the left one turn and while holding this screw in new position, turn nut "A" to the left ¼ turn at a time until desired regulation is obtained.
2. When adjustment is completed, tap lightly on end of hollow wrench so that nut "A" will seat properly.

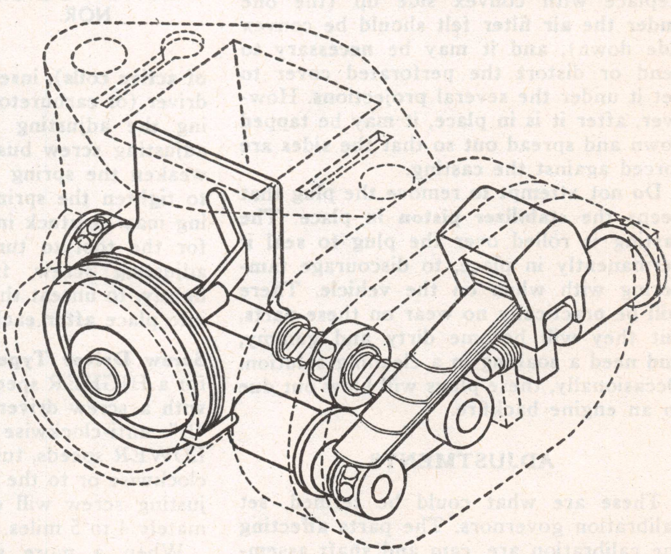
HOOF

This is also a velocity type engine speed governor, that can be set to prevent engine speed from exceeding a predetermined maximum. A square throttle plate operates in a square governor bore, or throat. The throttle shaft is installed along one side of the throat, to which is fastened the throttle plate in such a manner as to allow the free end of the plate to point toward the carburetor. The force of the air and fuel mixture, rushing through the governor throat to enter the intake manifold, pushes the governor throttle plate to a closing position. Opposing this action is the tension of a flat spring assembly, bearing on a lever, that is fastened to the throttle shaft. The spring assembly consists of various lengths of spring steel leaves riveted together at one end. The size and length of each leaf, and the number of leaves used, determine the calibration of each governor. When the closing action of the valve exactly balances the spring, governing action takes place and maximum speed is fixed at this point. When load is applied, and engine speed tends to drop, the velocity of the air and fuel mixture through the manifold and the pressure against the governor plate is reduced, and the spring opens the governor plate to feed more gasoline to the engine to meet the increased load demand. The governor housing is marked "carburetor side" on the face of the flange.

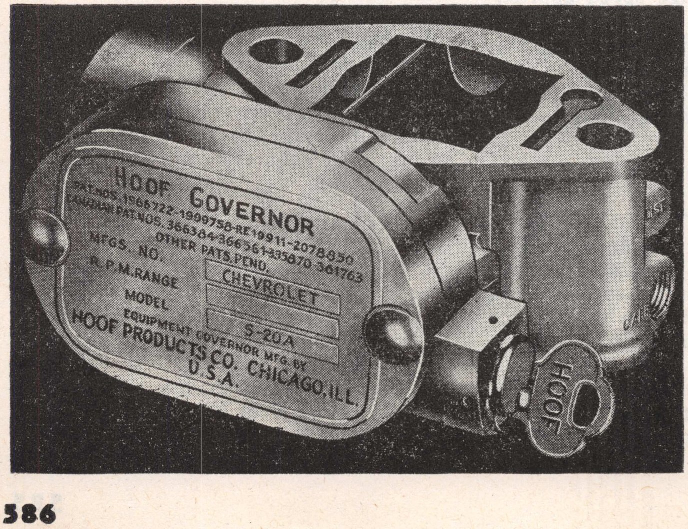
Vacuum by-pass channels: Provision is made for extending the vacuum passag-


HOOF GOVERNOR
HOOF PRODUCTS CO.

HOOF. Phantom view of calibrated key type governor used with dual carburetors.

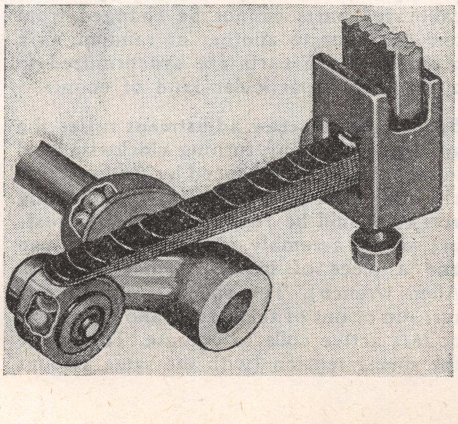


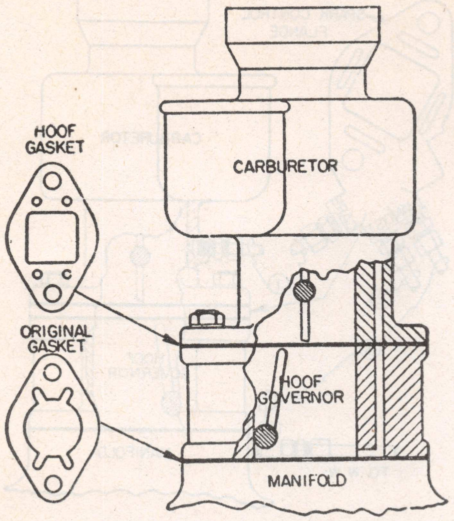
HOOF. Phantom view of governor used with single barrel carburetors.


HOOF GOVERNOR
PAT.NOS. 1968722-1999758-RE19911-2078830
CANADIAN PAT.NOS. 363384-366361-335870-361763
OTHER PATS.PEND.
MFGS. NO.
R.P.M.RANGE
CHEVROLET
MODEL
S-20A
EQUIPMENT GOVERNOR MFG. BY
HOOF PRODUCTS CO. CHICAGO, ILL.
U.S.A.
HOOF

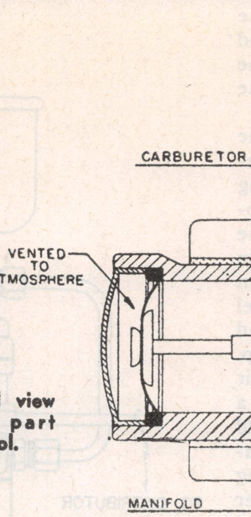
HOOF. External view of governor used with single barrel carburetors.

HOOF. Showing cantilever spring assembly in position.





HOOF. Showing by-pass channel for vacuum-operated power jet in carburetor. Be sure to install gaskets in positions indicated.



HOOF. Sectional view of diaphragm part throttle control.

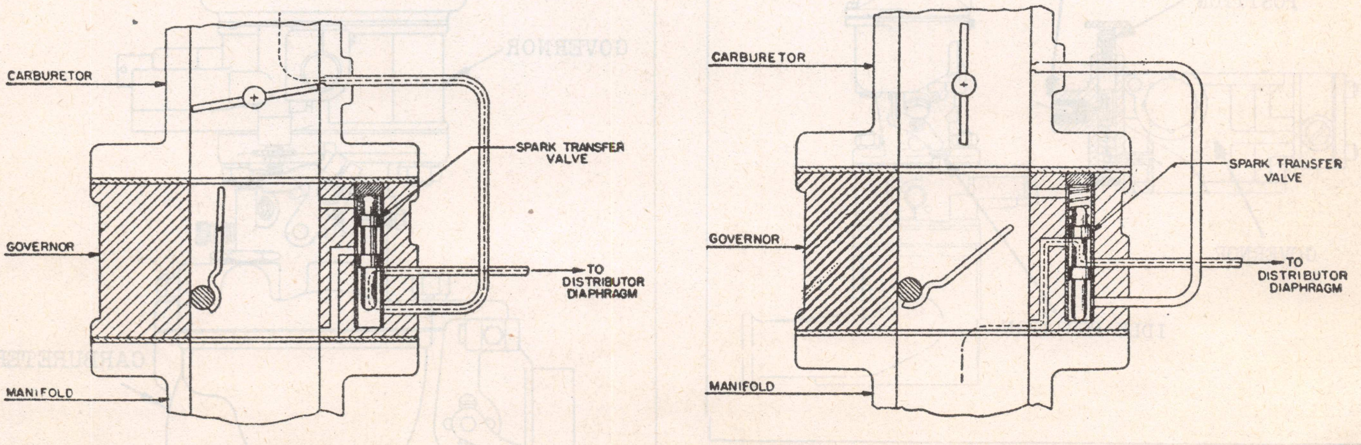
from the carburetor piston to a point below the governor throttle plate, with two channels, one on each end of the housing, in center-line with the stud mounting holes. A special gasket is supplied by the governor manufacturer for installation between governor and carburetor, when vacuum piston operated, power jet carburetor is used.

Anti-cheat Assembly: Consists of a diaphragm and shaft assembly fastened to throttle plate. The diaphragm is covered and sealed with a heavy gauge steel cup, and should not be removed as the cup is swaged in place after assembly. There is a passage from one side of the diaphragm to an air filter in the adjustment housing. The other side of the diaphragm is open to manifold vacuum. This assembly automatically maintains the governed speed, regardless of throttle manipulation. If the carburetor butterfly is wide open, and the governor plate in a partly closed position, the vacuum below the governor plate is higher than above it—so the tendency is to close the governor plate further. The governor spring compensates for this and controls the plate, but, manipulation of the carburetor throttles creates, or transfers, high vacuum above the governor plate, which would normally permit the engine to exceed its governed speed and create what is commonly called "cheat." Under part throttle manipulation, however, the high vacuum created above the governor plate pulls out the diaphragm toward the governor valve. The diaphragm stem pushes against the valve, closing it—in this way off-setting the tendency of the governor plate to open.

Vacuum spark control transfer valve consists of a piston and spring, built into the governor housing, in such a manner as to cover or uncover passage holes, in its up or down position. It is operated by intake manifold vacuum. When the governor throttle plate is in a closed, or governed speed position, the transfer valve allows the amount of vacuum present, at the manifold side of the governor throttle plate, to operate the distributor vacuum unit. When the carburetor throttle is closed, the transfer valve shifts, and allows the carburetor throttle plate to control the vacuum applied to the distributor unit. The Hoof Products Company also supply a separate **spark control flange** with a transfer valve, that is installed much like a gasket.

SERVICE

The adjustment housing covers are either recessed into the casting, or are the slip-over type, neither of which can be pried open without mutilation or breakage. This cover is a casting and removing the tubular rivet, or rivets, (one used on early model, two on late model) does not free the cover, as an inside piece of this casting surrounds the adjusting screw (or key) assembly. This speed adjusting assembly is held in place by a horseshoe shaped washer, and is kept raised above the shaft surface by the tension of a small coil spring. (Very much like a piston ring on a piston, if you pressed on one side of the ring, it would protrude enough on the other side to act



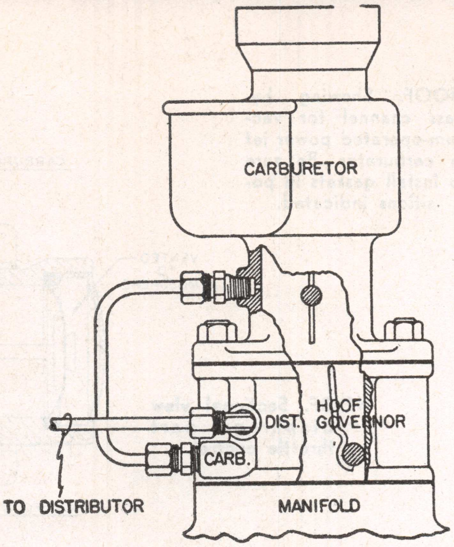
HOOF. Left: Showing position of spark transfer mechanism, governor, and carburetor valve when engine is at complete idle; distributor at full retard. Dotted line shows atmosphere vent to distributor. Right: Showing carburetor valve wide open and governor valve controlling the speed. The spark transfer mechanism opens the ports so that the manifold vacuum operates directly on the distributor diaphragm, as indicated by the dotted lines.

as a stop.) A slot is cut in the head of the adjustment, through which can be inserted a strong, thin piece of rod, to depress the washer and spring. With the key type, the lock nut must be open.

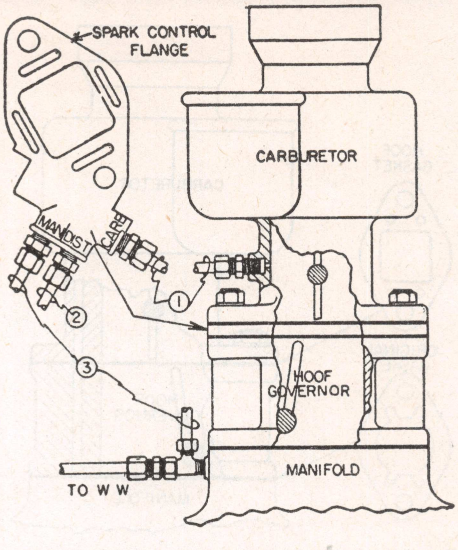
To clean the ball bearings, remove the throttle plate, remove the one bearing retainer holding screw under the operating lever, remove the welsh plug from the opposite side of the housing, after which, the shaft and lever assembly can then be driven out. The anti-cheat neoprene diaphragm cannot be serviced, as a heavy gauge steel cup is placed against the diaphragm, and then the housing is swaged over the cup. The pressure of the cup must form an air tight seal for the diaphragm, which has a ring gasket on each side. A test should be made for leakage, and can be accomplished by removing the perforated plug and air filter packing. Insert a soft rubber tube in this opening and test with hand vacuum pump. There should be no leakage.

SETTINGS AND ADJUSTMENTS

The turning of the speed adjusting screw moves a small block on its thread, on a horizontal plane. This small block is engaged in the spring block assembly, which pivots in the housing, and moves in a small arc, bringing more, or less, spring pressure on the operating lever ball bearing. Turning the speed adjustment to the right, or clockwise, increases the governed speed. Turning the adjustment to the left, or anti-clockwise, decreases the governed speed. The Cantilever spring assembly is made of special high grade blue tempered spring steel carefully rolled to very close tolerances. Each leaf is punched to proper length with a rounded end and a rivet hole. The leaves are completely assembled with spacing washers, and riveted together. The size and length of each leaf, and the number of leaves used, determine the calibration of each governor.



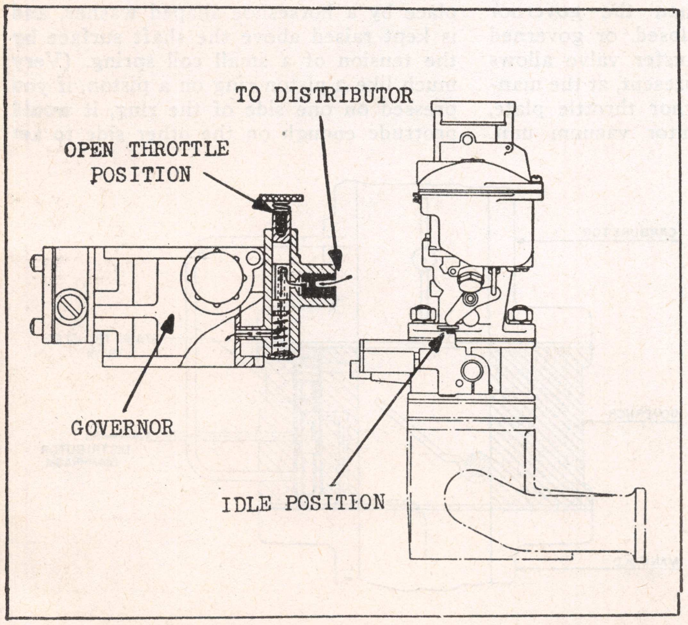
HOOF. Correct hook-up of transfer valve and carburetor vacuum lines.



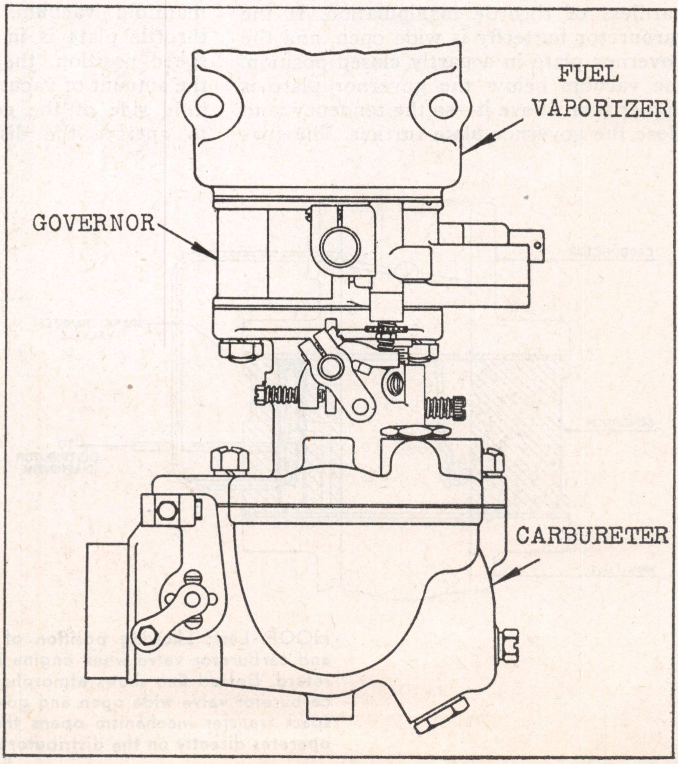
HOOF. When carburetor has vacuum take-off for spark advance, insert spark control flange between carburetor and governor. Take distributor line and fitting and connect on flange at (2). Connect carburetor with spark flange at (1). Insert tee in intake manifold at windshield wiper connection and connect with tube to spark flange at (3).

LEIBING

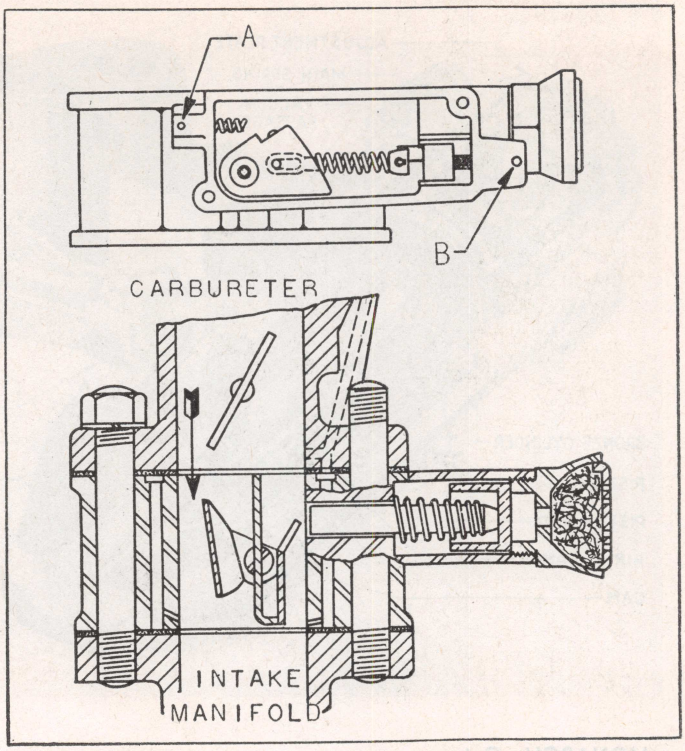
The Leibing governor is of the velocity type, used to prevent automatically an engine from exceeding a given speed (R.P.M.). It is placed between the carburetor and the intake manifold, and is operated by the flow, or velocity, of the intake air and fuel mixture passing through the throat of the governor. The governor has the marking "Engine Side" on the face of one flange, and this side must be against the intake manifold. The throttle plate, or blade, is made up of two, special shaped pieces, and assembled to a short shaft on each side, each shaft operating on ball



LEIBING. Showing installation of governor and bleeder valve.



LEIBING. Typical installation with updraft carburetor.



LEIBING. Sectional view of governor showing points of adjustment as indicated by "A" and "B".

bearings. Attached to one shaft is a special throttle lever, which is connected to the speed adjusting screw by a calibrated coil spring. The force of the inrushing mixture tends to close the throttle plate, this rotates the throttle lever against the pull, or tension, of the coil spring. A speed adjusting screw controls one end of the spring; turning this screw to the right, or **clockwise,** increases the tension on the spring, and allows a **higher** governed speed; turning to the left, or **anti-clockwise,** decreases the tension on the spring, for a **lower governed** speed.

Carburetor vacuum economizer by-pass channel is carried through each end of the governor, directly alongside, and in centerline with the governor mounting stud holes. The carburetor side has a machined recess, extending a short distance to each side of each channel. A **special gasket** must be used between the carburetor and the governor, with a proper opening in same, to connect the governor channel with the carburetor channel, without restriction. A plain gasket is used between governor and intake manifold.

The throttle steal device or anti-cheat vacuum piston assembly, consists of a push rod and spring, piston, and air filter. One side of the piston is open to intake manifold vacuum, and the other side to the atmosphere, through a removable air filter. Ordinarily, the spring tension keeps the push rod and piston toward the air filter end, but upon manipulation of the carburetor throttle, whereby a high vacuum is created above the governor throttle plate (stealing), the atmospheric pressure pushes the piston and rod (or high manifold vacuum pulls piston and rod) against a lip on the throttle plate, preventing the opening of same and maintaining the governed speed.

Bleeder valve attachment for vacuum spark advance is of the saxaphone key type and is mechanically operated through the carburetor throttle shaft lever. With the carburetor throttle plate closed, spark control vacuum line is connected in a normal position, to a point above the throttle plate. At all loads and speeds above idle however, vacuum is taken from below the governor.

A flywheel attachment for stabilization, is incorporated only in governors bearing the letter "W" in the model number. This has a counter balancing effect on the shaft and plate assembly.

SERVICE

Check housing cover for air leaks. If warped, straighten on a hot plate and install new gasket. A leak here will draw dirt into governor and upset carburetor idle mixture. **Vacuum piston air filter** should be removed with a 15/16" wrench, for a periodic cleaning. This can be done with governor on engine. To remove the piston, push it in against the spring with a pencil, and remove the pencil rapidly. **Do not bend** or stretch the coil spring on the push rod, as this is calibrated to resist a set amount of manifold vacuum. If the spring is squeezed together, low vacuum will keep the push rod continually fighting the throttle plate. If the spring is stretched, the push rod may not touch the plate at all. Do not lubricate this piston, or, to put it strongly, **do not lubricate** any part of a governor. To remove the throttle shaft lever, turn speed adjusting screw all the way out, releasing the spring holder. The lever is a slip fit on a square shaft, held in place with a steel lock ring. Moving the throttle plate to a closing position, be sure that the sharp point on the throttle lever enters in the center of the compensating spring, and that this spring does not buckle with closed throttle.

Ball bearings can be removed for cleaning, being careful not to lose any, as they are not in a cage. Outer ball races, or cups, are locked in place by a set screw, tightened against a brass jam plug. These screws are on the engine side of the governor. A spanner-type wrench is needed to unscrew the ball bearing cup, the balls will then fall out of place, but they cannot pass through to throttle plate side. To assemble, drop eight balls around throttle shaft (the shaft is hardened and acts as the inner race) and screw down the cup, while moving the shaft up and down to locate the balls properly. Allow end play of three to five thousandths when **adjusting throttle plate** and shaft assembly.

SETTINGS AND ADJUSTMENTS

Lip on the smaller throttle plate is properly bent to allow vacuum piston to hold throttle assembly at governed speed position when needed. The throttle plate separator, or bridge, has a lip on one end which acts as a throttle stop. This lip should prevent throttle shaft lever assembly from striking governor housing as the throttle plate is opened. There should be the same spacing at the spring end of the lever as there is at the shaft end. The **speed adjusting screw** is supplied normally with a broached hexagon hole taking a special adjusting key. Turn adjusting screw to the right, or clockwise, to increase governed speed, and to the left, or anti-clockwise, to decrease governed speed. When turning this screw you will feel the serrations that hold it in place, so be sure the screw feels locked in one of these serrations at the final setting.

All models use a seal pin (clevis pin) through the adjusting screw boss, and a seal wire. This adjustment can be made with cover in place. A **second adjustment,** or compensating spring, is a factory set adjustment, and is used to balance the unit—not to control speed. The cover plate must be removed, as this adjusting screw is sealed by means of a pin going through the boss and the slot of the screw. The head of the pin is covered by the plate. The setting can only be changed in half turns, as the screw slot must line up to replace the pin. The factory setting is usually flush with the boss. To eliminate a surge, turn the screw clockwise. To sharpen governing, turn anti-clockwise. To get the sharpest point of governing, turn this screw anti-clockwise until a surge comes in, then turn back clockwise, until it disappears.

MONARCH

The operating force for this type governor is derived from the intake manifold vacuum of the engine. It is a **vacuum type,** automatic engine speed governor, and can be set to prevent an engine from exceeding a maximum R.P.M. The vacuum is admitted into a cylinder from a passage below the governor throttle plate, and moves a piston which is constantly opposed by a calibrated coil spring. When the governor is idle, the calibrated coil spring tends to keep the throttle plate open, which is centrally mounted on a throttle shaft, the shaft operating through the center of the governor bore. In operation, as engine speed increases at full throttle, the vacuum increases, drawing the piston against the spring, closing the governor throttle plate to allow the governed engine speed. As the load increases, as would be the case when the vehicle is climbing a hill, the vacuum in the intake manifold decreases, allowing the governor throttle plate to open, permitting the use of more engine power.

MODEL "R"

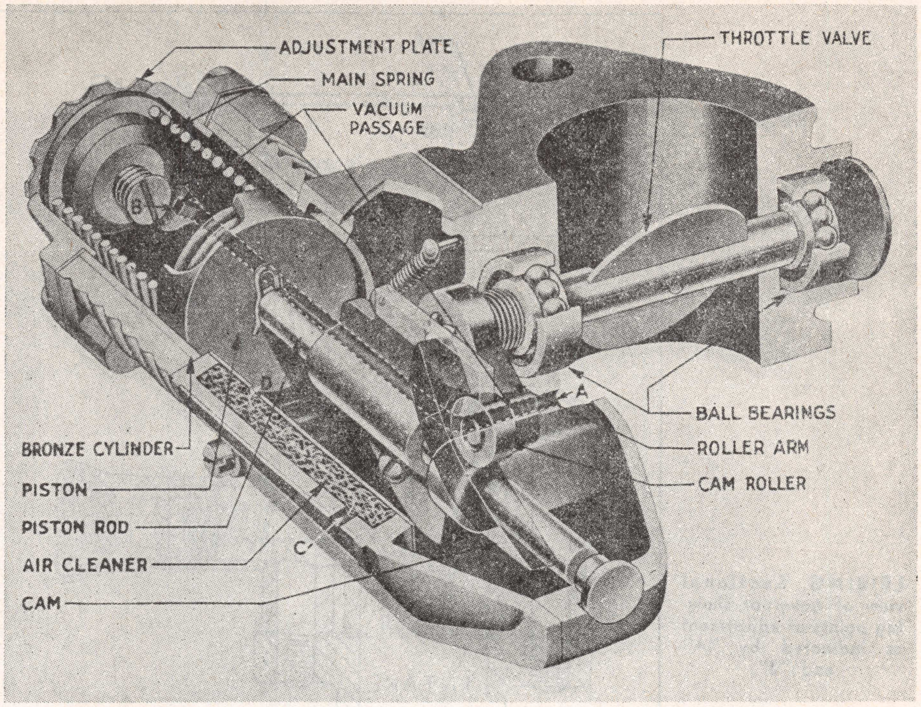
In this model the calibrated coil spring directly opposes the action of the vacuum piston. It is placed between the adjusting knob and the piston, so that turning the adjustment increases or decreases the spring tension directly on the piston. The movement of the piston carries with it the shaft and cam assembly. The cam rotates the throttle shaft through a roller on the shaft lever, the roller being held to the cam by a small spring.

To remove the piston, take out two screws that hold the adjusting knob assembly, remove the coil spring, remove the hairpin clip and the piston will come off the shaft; the cam assembly can then be removed from the other end of the cylinder.

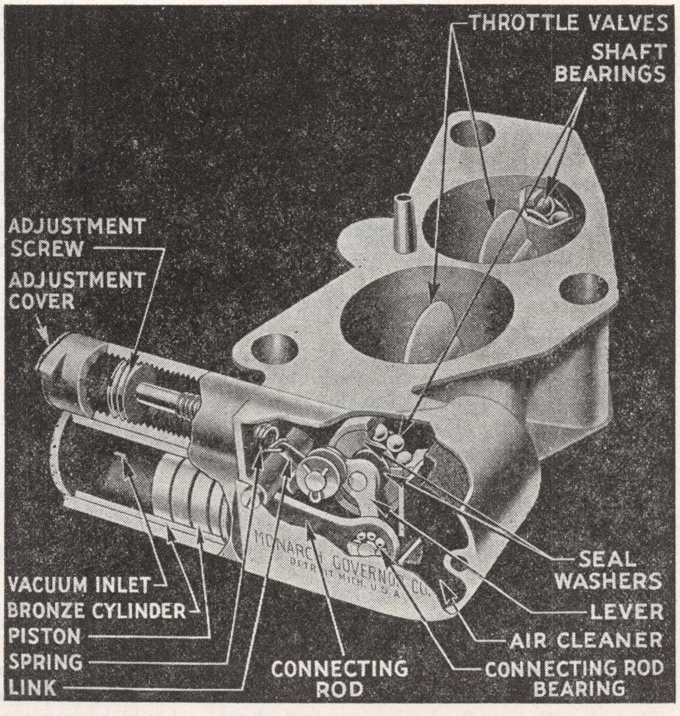
Provision is made in the cam assembly for adjustment, by pivoting one end of the cam, and locking it in a desired position by a screw. The throttle shaft ball bearings can easily be removed for cleaning, and the piston housing can be separated from the throttle housing by the removal of two screws. To change speed setting, remove the lock screw holding adjusting knob in place and turn to the right to increase governed speed and to the left for a lower governed speed.

MODEL S

In this model the calibrated spring is connected to the vacuum piston by means of links and a crank lever, which in turn is connected to the throttle shaft. When the governor is idle, a calibrated coil spring between the throttle shaft lever and the adjusting screw holds the throttle plate in a wide open position. The adjusting screw turns into the spring (like it would turn into a nut) and varies the length of the spring which is left active. The turns of spring that are on the screw are inactive.



MONARCH. Cutaway view of Model "R" governor.



MONARCH. Cutaway view of Model "S" governor.

When the engine is operating, and manifold vacuum is high, the piston is drawn toward the end of its travel, rotating the throttle shaft, through the link and crank arm connection, against the tension of the spring. This action carries the throttle plate to a closing position, and, depending on the setting of the spring, the plate closes to a position that allows enough fuel for the governed speed desired.

A by-pass—for carburetor vacuum piston that operates **power jet**—is provided by means of a passage through the governor housing, and a machined groove all around the face of the flange (carburetor side) so as to coincide with the vacuum passage in the carburetor body, regardless of location. The governor housing is marked "Carburetor Side" along the outside of one of the mounting bolt holes, with an indicating arrow.

A spark transfer valve and spring assembly

is built into the housing, for use on engines with vacuum spark control unit mounted at distributor. The shifting of this piston transfers the flow of vacuum to the distributor, from a location at the carburetor throttle plate to a location below the governor throttle plate.

CAUTION—Be extremely careful if you intend to remove the connecting link between the throttle shaft crank and arm and the vacuum piston. There are **nine ball bearings** (not caged) between the crank arm and pin and the link, and are only held in place by a flat washer and a hair pin clip.

The vacuum piston can be removed by taking out the welsh plug. To clean the throttle shaft ball bearings, remove the two links on the crank arm, take out the welsh plug on the other side of the housing, remove the U-shaped spring clip from the shaft, remove the throttle plate, after which, the throttle shaft and crank assembly can be pulled out of housing. When replacing the bearings they should **not** be oiled or greased. No parts of a governor should be lubricated. In very dusty operating conditions, the **air cleaner felt** should be washed in gasoline and dried at 10,000-mile intervals. For standard operation conditions, this need not be done oftener than every 25,000 miles. The felt can be slipped out after removal of cover plate.

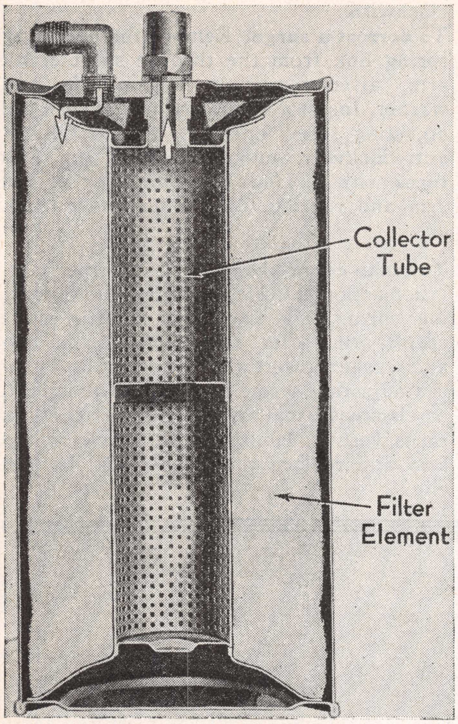
SETTINGS AND ADJUSTMENTS

The adjusting screw is covered by a plate, sealed with a wire through a hole in the plate and in the housing. For a higher governed speed, push this plate to one side, insert a screw driver, and turn the screw to the right, or clockwise. For a lower governed speed, turn to the left, or anti-clockwise.

To correct a surge: Remove the operating spring link from the throttle shaft crank arm, after removing hairpin clip and washer. Insert a screw driver and turn the adjusting screw one turn to the left, or anti-clockwise, making certain the **link turns** with it. Hook the link back on the arm and replace the washer and hairpin clip.

To make cutoff sharper: If a sharper governor action is desired, remove the operating spring link from the throttle shaft crank arm, after removing hairpin clip and washer. Insert a screw driver and turn the adjusting screw one turn to the right, or clockwise, making certain that the link turns with it. Hook the link back on the arm and replace the washer and hairpin clip.

OIL FILTERS

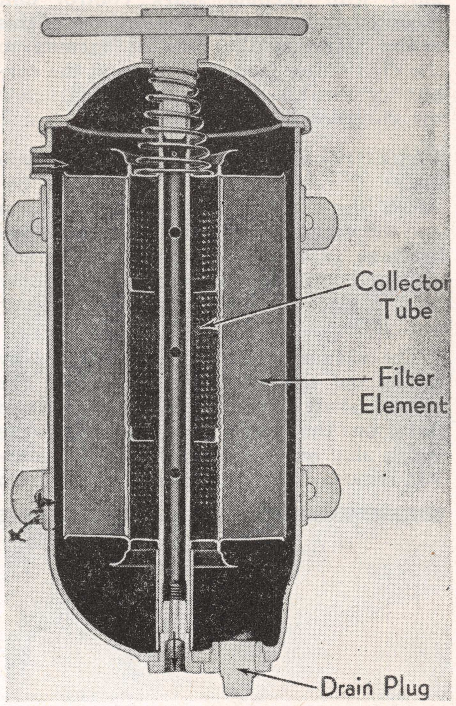


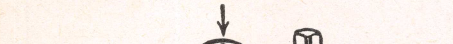
← AC

Oil enters the filter at one end and passes through the filter element into the perforated collector tube in the center. Oil passes through the filter element until it is clogged. This does not prevent the circulation of oil to the bearings but the oil is not filtered. It is therefore necessary to inspect the filter at frequent intervals and to replace it before it has been in service long enough to become clogged. When replacement is necessary, the complete filter should be installed. The life of a filter varies with operating conditions.

AC KLEER-KLEEN →

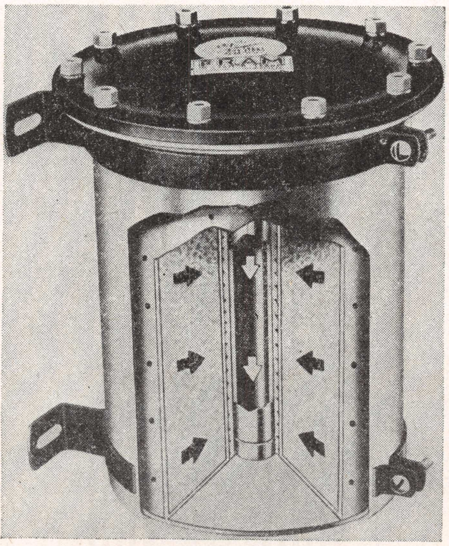
Part of the oil from the oil pump enters at the top of the filter and is forced through the filter element into the perforated collector tube in the center of the filter. Solid matter and water settle in the sump at the bottom of the filter and should be removed from the unit at frequent intervals by removing the drain plug. When the filter element becomes clogged, the cover can be removed and the filter element replaced without disconnecting the oil lines. If the filter element is drained completely, as when an element is renewed, add sufficient oil to the crankcase to bring the oil to its correct level.





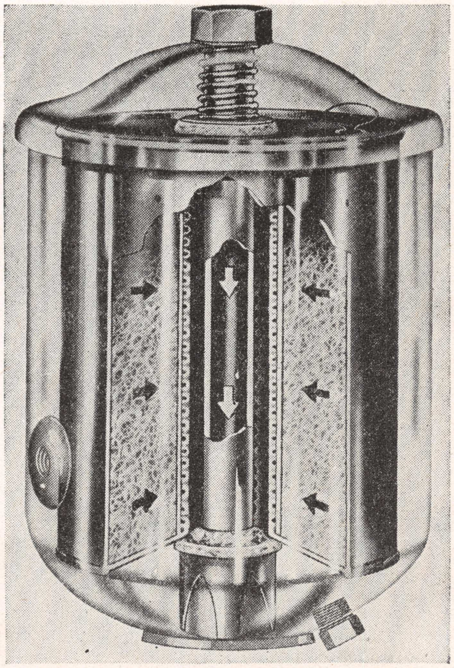
BRIGGS & STRATTON

Oil to the filter passes down through the filter element to the outlet at the bottom of the unit. When the filter element becomes clogged the complete unit should be replaced



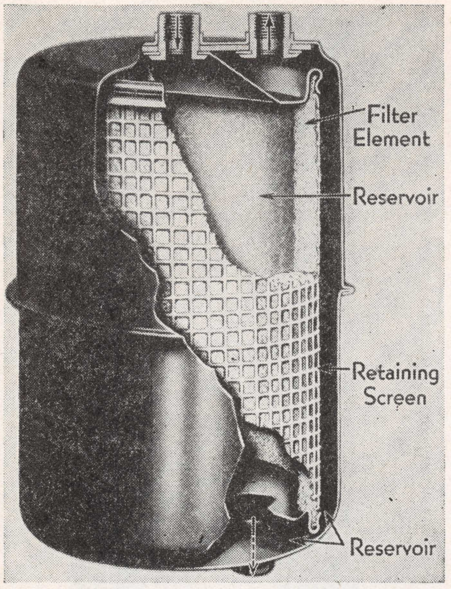
FRAM F 40

This is a by-pass type of filter.
Oil enters the side of the filter and is forced through the filter element to the collector tube in the center of the filter from where it is returned to the crankcase. When necessary the cover can be removed and the filter element replaced without disconnecting the oil lines.



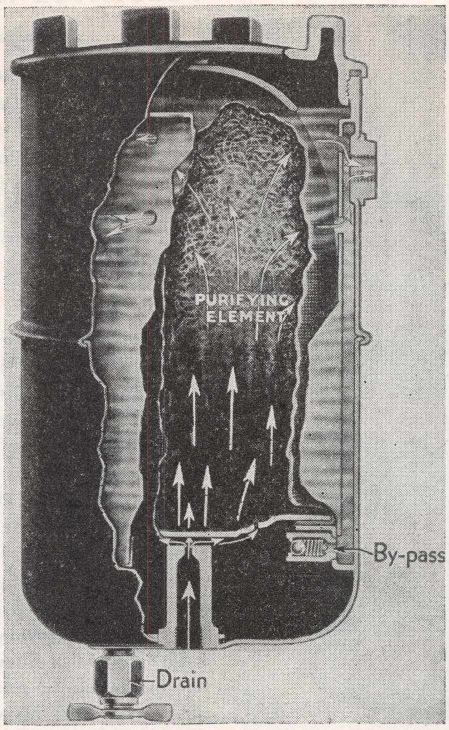
FRAM F 35

This is a by-pass type of filter. Oil enters the side of the filter and is forced through the filter element to the collector tube in the center of the filter from where it returns to the crankcase When the filter element becomes clogged, remove the filter cover. The filter element can be lifted out and replaced without disconnecting the oil lines.



HANDY

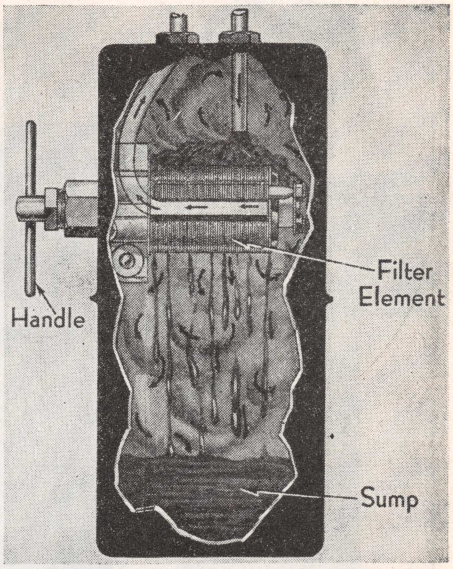
Oil enters the reservoir at the center of the unit and passes outward through the filter element to the outer reservoir. When the filter element is dirty the complete unit should be replaced.



HANDY OIL CONDITIONER

Oil enters at the bottom of the filter and passes up and out through the filter element. A by-pass valve controls the pressure of the oil through the filter element.

A drain at the bottom permits the removal of water and sludge from the filter. When necessary, the top can be removed and the filter element replaced without disconnecting the oil lines.



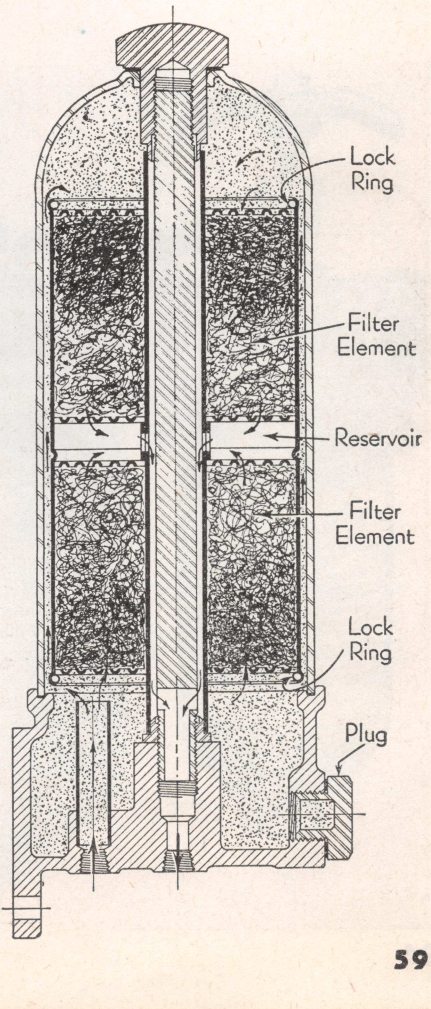
CUNO

Oil entering the filter passes through a filter element of metal discs before it returns to the engine. Turning the handle on the outside of the filter scrapes sludge or dirt from the filter discs and it drops to the bottom of the filter. This dirt can be cleaned from the filter when it is necessary.

MICHIANA (14) →

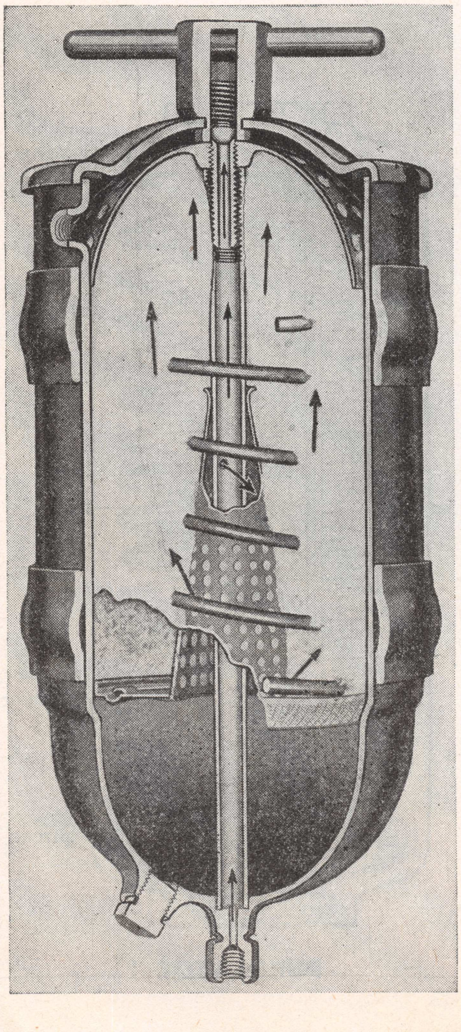
Some of the oil flowing into the filter is forced up through the lower filter element to the reservoir at the center while the balance of the oil passes up past the outside of the filter element container and down through the upper filter element to the reservoir at the center.

On some models the complete filter element is replaced when dirty. On others there is a wire ring at the top and bottom of the filtering element. When these rings are used they can be removed and the filter material replaced.

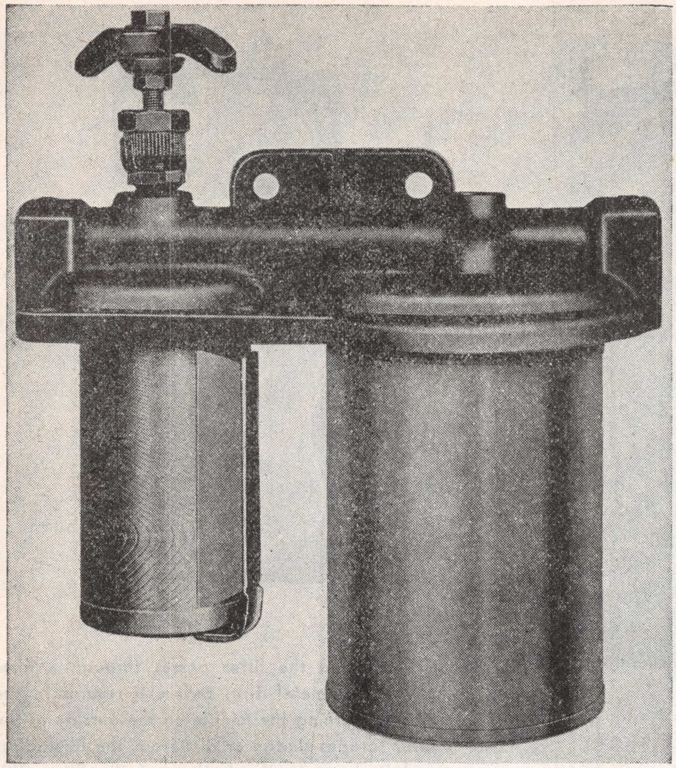


← DE LUXE

This is a partial flow type of cleaner, with an inlet at the bottom of the filter which controls the volume of oil entering. A valve in the outlet at the top of the filter controls the filtering pressure. Oil passes up through the filtering element and water and heavier than oil particles settle in the sump at the bottom of the housing. When it is necessary to replace the filter element the cover can be removed by hand without tools. A wire handle on the filter element permits easy removal and replacement.



OIL FILTERS

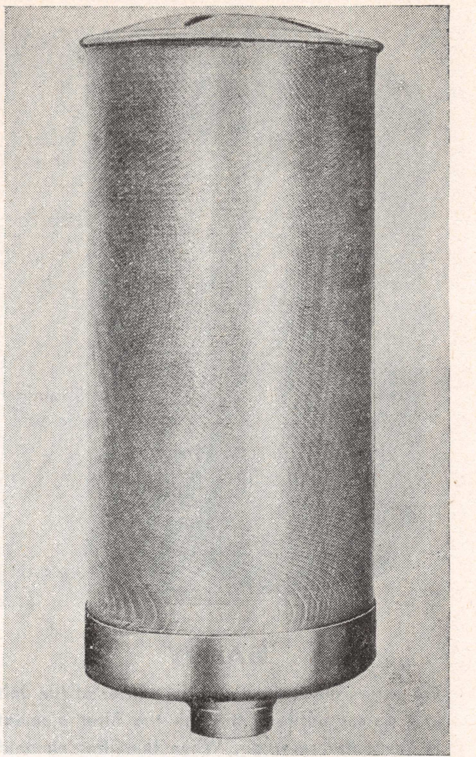


PUROLATOR JN-16

PUROLATOR K

→

The metal edge type element is used to filter either lubricating oil or fuel oil. When used for fuel oil, the openings in the element are smaller than those used for filtering lube oil.

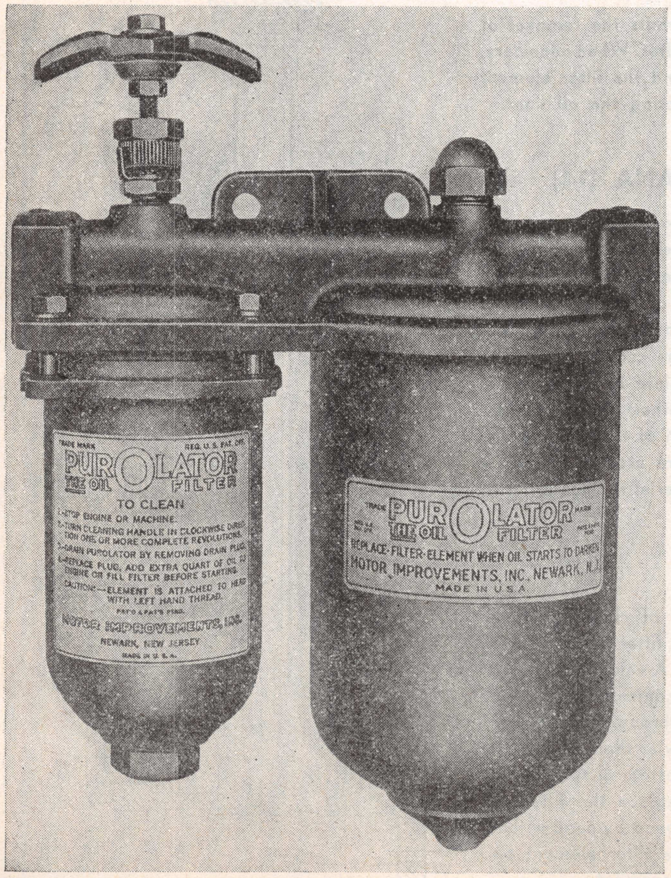


←

This filter provides two stages of filtration. The first stage is a knife-cleaned, metal element which filters all the oil. The second stage is a by-pass, absorption filter. A portion of the filtered oil from the metal edge unit is by-passed into the absorption filter. This provides a finer degree of filtration than would be possible were the metal edge used alone.

To clean the metal element, stop the engine. Turn the cleaning handle clockwise one or more complete revolutions. Drain the housing by removing the drain plug. Replace the plug and add an extra quart of oil to the engine or fill the filter before starting. The element is attached to the head with left-hand threaded bolts.

The absorption type filter should be replaced when oil on the dip stick shows dirt.

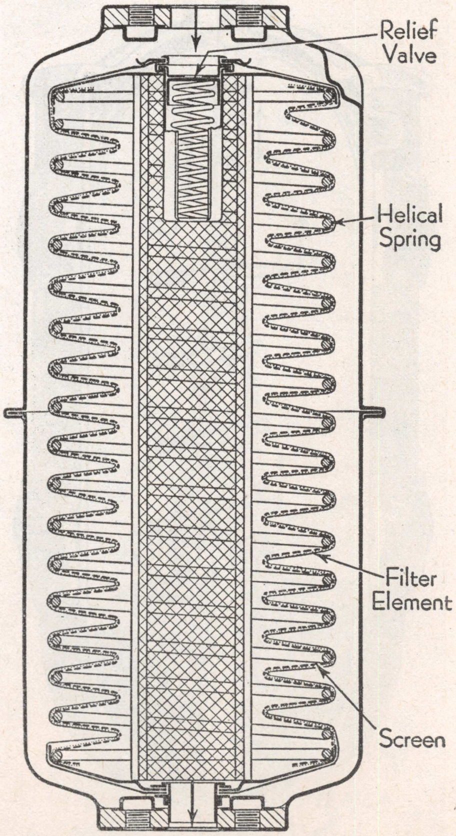

TRADE MARK
REG. U.S. PAT. OFF.
PUROLATOR
THE OIL FILTER
TO CLEAN
1-STOP ENGINE OR MACHINE.
2-TURN CLEANING HANDLE IN CLOCKWISE DIRECTION ONE OR MORE COMPLETE REVOLUTIONS.
3-DRAIN PUROLATOR BY REMOVING DRAIN PLUG.
4-REPLACE PLUG, ADD EXTRA QUART OF OIL TO ENGINE OR FILL FILTER BEFORE STARTING.
CAUTION:—ELEMENT IS ATTACHED TO HEAD WITH LEFT HAND THREAD.
PAT'D & PAT'S PEND.
MOTOR IMPROVEMENTS, INC.
NEWARK, NEW JERSEY
MADE IN U.S.A.
TRADE
MARK
PUROLATOR
THE OIL FILTER
REPLACE-FILTER-ELEMENT WHEN OIL STARTS TO DARKEN
MOTOR IMPROVEMENTS, INC. NEWARK, N.J.
MADE IN U.S.A.

←

→

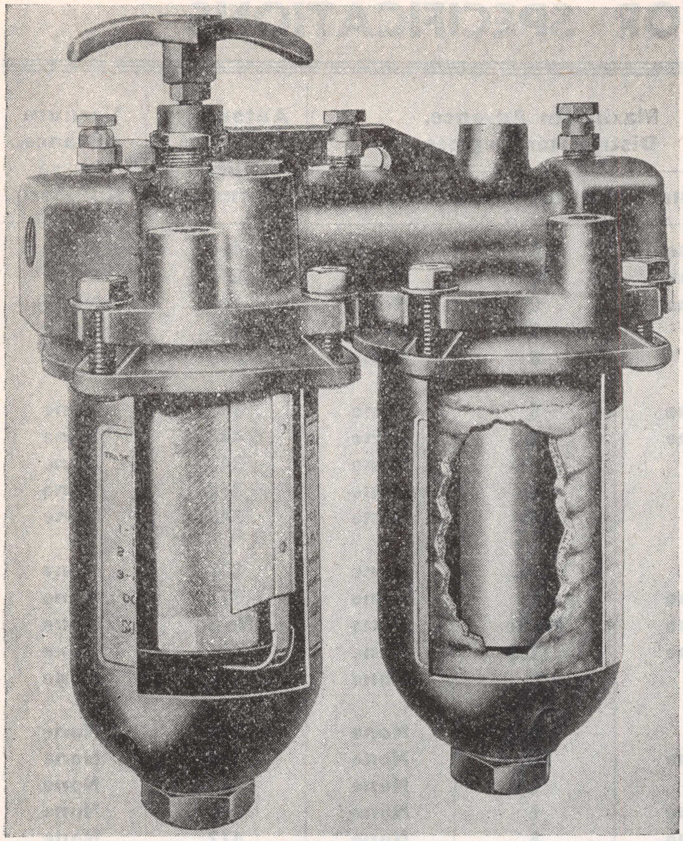
Oil enters the end of the filter and passes through the filter element to the inside of the filter. In the Full Flow type (shown) a relief valve permits an uninterrupted flow of unfiltered oil in case the filter element is clogged so that oil cannot pass through it.

When the filter element becomes clogged the complete unit should be replaced.

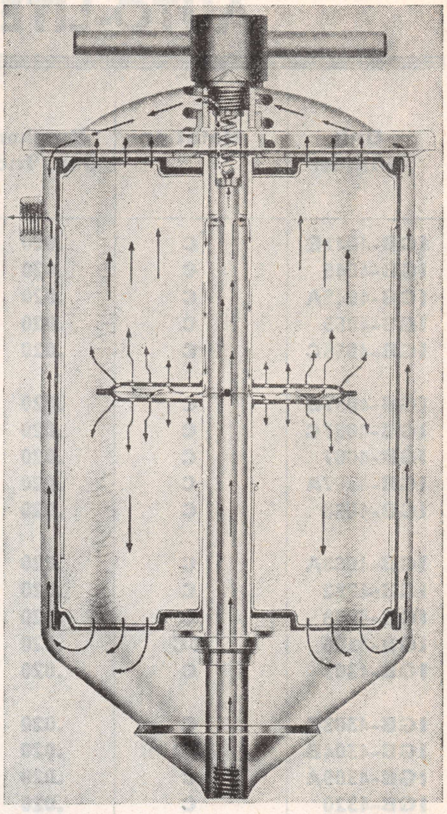

Relief Valve
Helical Spring
Filter Element
Screen

PUROLATOR E

OIL FILTERS



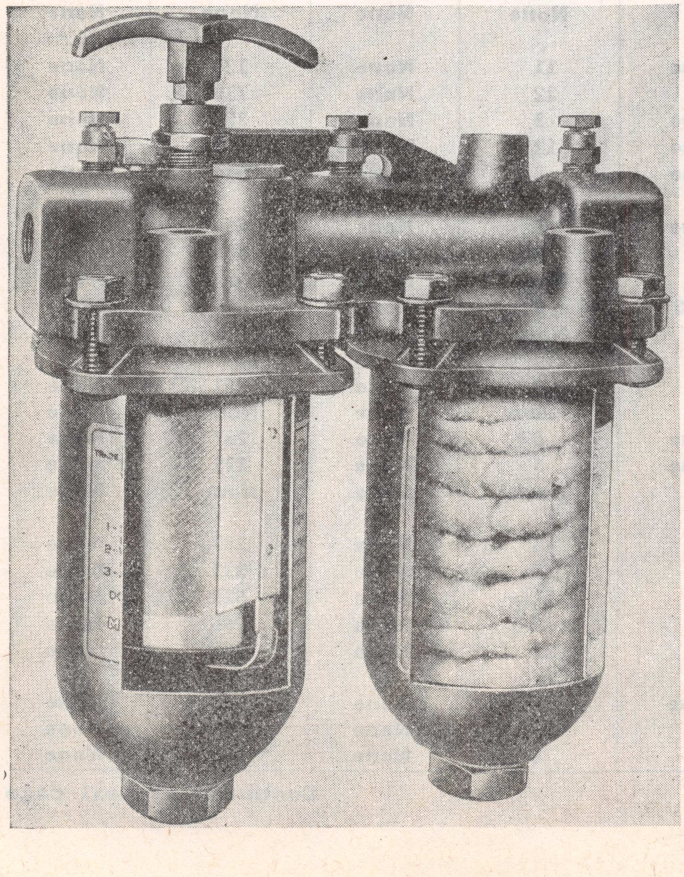
PUROLATOR D-23 JWM



PUROLATOR N

The cover is held to the case by a single nut. On some models it is a hexagon nut while on others the nut has a cross handle on it for easy turning. Remove this nut and lift off the cover. Hook a finger in the lifting ring and lift out the element, holding a rag under the element as it clears the case to prevent dripping any oil on the fender. Drop the new element into the case, noting that the lifting ring is at the top end of the element. Replace the cover, seating it properly, and tighten the nut. Start the engine and watch the cover where it fits the case to make sure it is replaced properly and that there is no leakage of oil.

This is a by-pass type where the dirty oil enters at the center of the unit and flows from the inside of the element to the outside. The flow of oil is from the inside to the outside to prevent matting and channeling. Because of the direction of flow, all the dirt is left within the element and when the element is removed it is not necessary to clean the outer housing.



The D-23-JWM is commonly used as a Diesel fuel filter. Three stages of filtration are provided within two filtering houses. The first unit is a metal edge, knife-cleaned, element. All the fuel passes through this unit and into the second unit, which houses a second and third stage of filtration, which is provided by a metal edge element surrounded by a fabric element.

If it is necessary to clean the second and third stages, they are to be removed and washed in Diesel fuel oil, gasoline, or a similar solvent. They do not need to be replaced unless the fabric element or the metal element is abrased to the point where it is too thin to provide adequate filtering or there is a complete hole.

IGNITION SYSTEMS (BATTERY)

AUTO-LITE DISTRIBUTOR SPECIFICATIONS

Unit Number	Rotation	Breaker Gap, Inch	Cam Angle, Degrees	Maximum Advance, Distributor Degrees			Automatic Advance Curve Number①	Vacuum Advance Curve Number②
				Manual	Automatic	Vacuum		
IGB-4041E	C	.020	46	None	10	None	406	None
IGB-4045	C	.020	46	None	10	None	247	None
IGB-4045A	C	.020	46	None	9	None	347	None
IGB-4055	C	.020	38	6	7	None	311	None
IGB-4055C	C	.020	38	6	6	None	368	None
IGB-4057B	C	.020	46	None	5	None	340	None
IGB-4057C	C	.020	46	None	6	None	445	None
IGB-4067	C	.020	38	10	9	None	341	None
IGB-4067A	C	.020	38	10	6	None	368	None
IGB-4068	C	.020	46	12	10	None	340	None
IGB-4068A	C	.020	46	12	10	None	371	None
IGB-4082	C	.020	46	None	5	None	371	None
IGB-4099	C	.020	44	None	None	None	None	None
IGB-4106	CC	.020	46	None	11.5	None	494	None
IGB-4303	C	.020	38	6	6	None	368	None
IGB-4303E	C	.020	38	6	6	None	368	None
IGB-4304B	CC	.020	38	None	10	None	440	None
IGB-4309A	C	.020	38	10	6	None	368	None
IGB-4320	C	.020	38	None	6	None	368	None
IGB-4325	C	.020	38	None	8	None	412	None
IGB-4337A	C	.020	38	5	5	None	489	None
IGB-4337B	C	.020	38	3	9	None	485	None
IGC-4005B	C	.020	41	6	6	None	256	None
IGC-4010C	C	.020	47.5	None	None	None	None	None
IGC-4032B	C	.020	47.5	25	None	None	None	None
IGC-4033A	C	.020	47.5	None	11	None	120	None
IGC-4054D	CC	.020	41	10	12	None	730	None
IGC-4060B	C	.020	47	None	9	None	358	None
IGC-4060C	C	.020	47	None	12	None	553	None
IGC-4062	C	.020	41	None	6	None	534	None
IGC-4062A	C	.020	41	None	8	None	554	None
IGC-4063	C	.020	41	10	6	None	534	None
IGC-4064	C	.020	41	10	None	None	None	None
IGC-4065	C	.020	41	7.5	6	None	605	None
IGC-4067	C	.020	41	10	None	None	None	None
IGC-4203A	C	.020	40	7	8.5	None	281	None
IGC-4205	C	.020	40	25	None	None	None	None
IGC-4209A	C	.020	47	None	5	None	287	None
IGC-4209B	C	.020	47	None	5	None	371	None
IGC-4210A	C	.020	40	25	None	None	None	None
IGC-4212A	C	.020	47	10	5	None	287	None
IGC-4212B	C	.020	47	10	5	None	371	None
IGC-4214A	CC	.020	40	10	11	None	515	None
IGC-4216B	C	.020	40	10	12.5	None	296	None
IGC-4220C	CC	.020	40	10	11	None	515	None
IGC-4224	C	.020	47	None	6.5	None	295	None
IGC-4225B	C	.020	40	10	11	None	293	None
IGC-4225D	C	.020	40	10	6	None	368	None

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AUTO-LITE DISTRIBUTOR SPECIFICATIONS

Unit Number	Rotation	Breaker Gap, Inch	Cam Angle, Degrees	Maximum Advance, Distributor Degrees			Automatic Advance Curve Number①	Vacuum Advance Curve Number①
				Manual	Automatic	Vacuum		
IGC-4227A	C	.020	40	None	12.5	None	296	None
IGC-4227B	C	.020	40	None	9	None	341	None
IGC-4227C	C	.020	40	None	6	None	368	None
IGC-4227D	C	.020	40	None	6	None	372	None
IGC-4227E	C	.020	40	None	6	None	605	None
IGC-4236	CC	.020	40	None	6	None	256	None
IGC-4236A	CC	.020	40	None	16	None	414	None
IGC-4236B	CC	.020	40	None	8.5	None	591	None
IGC-4236C	CC	.020	40	None	10	None	440	None
IGC-4240B	C	.020	40	3	9	None	358	None
IGC-4244A	C	.020	47	None	6.5	None	295	None
IGC-4245A	C	.020	40	10	11	None	293	None
IGC-4246B	C	.020	40	None	6	None	368	None
IGC-4246D	C	.020	40	None	9	None	341	None
IGC-4247	C	.020	40	10	11	None	293	None
IGC-4251B	C	.020	40	6	6	None	605	None
IGC-4253	C	.020	40	6	6	None	372	None
IGC-4253A	C	.020	40	6	6	None	605	None
IGC-4253B	C	.020	40	6	6	None	368	None
IGC-4253C	C	.020	40	6	6	None	475	None
IGC-4260A	CC	.020	40	8	12	None	411	None
IGC-4262	C	.020	40	None	None	None	None	None
IGC-4272	C	.020	40	6	6	None	256	None
IGC-4272A-1	C	.020	40	6	6	None	368	None
IGC-4274A	C	.020	40	7.5	6	None	605	None
IGC-4275	CC	.020	40	10	11	None	515	None
IGC-4278A	CC	.020	40	6	6	None	368	None
IGC-4281	C	.020	40	None	6	None	605	None
IGC-4281A	C	.020	40	None	7	None	761	None
IGC-4284A	C	.020	40	None	12.5	None	296	None
IGC-4285	C	.020	40	None	12	None	699	None
IGC-4285A	C	.020	40	None	6	None	368	None
IGC-4286	C	.020	40	6	6	None	368	None
IGC-4288	CC	.020	40	None	10.5	None	765	None
IGC-4401-1	C	.020	38	None	14	None	437	None
IGC-4402-1	C	.020	38	None	15	None	438	None
IGC-4404A-1	C	.020	38	None	15	None	438	None
IGC-4406-1	C	.020	38	None	14	None	439	None
IGC-4407-1	C	.020	38	None	12	None	423	None
IGC-4407D-1	C	.020	38	None	13	None	541	None
IGC-4408-1	C	.020	38	None	13	None	528	None
IGC-4409A	C	.020	38	8	11	None	293	None
IGC-4412	C	.020	38	None	9	None	516	None
IGC-4413	C	.020	38	None	9	None	516	None
IGC-4414-1	C	.020	38	None	13	None	528	None
IGC-4418	C	.020	38	None	13	None	528	None
IGC-4501	C	.020	38	None	12	None	423	None

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IGNITION SYSTEMS (BATTERY)

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AUTO-LITE DISTRIBUTOR SPECIFICATIONS

Unit Number	Rotation	Breaker Gap, Inch	Cam Angle, Degrees	Maximum Advance, Distributor Degrees			Automatic Advance Curve Number①	Vacuum Advance Curve Number⑤
				Manual	Automatic	Vacuum		
IGC-4501-1	C	.020	38	None	12	None	423	None
IGC-4502	C	.020	38	None	12	None	423	None
IGC-4502-1	C	.020	38	None	13	None	528	None
IGC-4502A-1	C	.020	38	None	15	None	678	None
IGC-4508-1	C	.020	38	None	15	None	678	None
IGC-4601	CC	.020	40	3	8.5	None	591	None
IGC-4601-1	CC	.020	40	3	8.5	None	591	None
IGC-4601-2	CC	.020	40	3	8.5	None	591	None
IGC-4602	CC	.020	40	3	8.5	None	591	None
IGC-4603	CC	.020	40	None	8.5	None	591	None
IGC-4604	C	.020	47	None	12.5	None	741	None
IGC-4701	C	.020	38	6	6	None	368	None
IGC-4702	C	.020	38	None	9	None	756	None
IGC-4703-1	C	.020	38	None	10	None	770	None
IGC-4704-1	C	.020	38	None	10	None	770	None
IGE-4003	CC	.020	35	10	15	None	229	None
IGE-4003F	CC	.020	35	10	11	None	481	None
IGE-4003G	CC	.020	35	10	12½	None	676	None
IGE-4007	C	.020	35	6	6	None	256	None
IGE-4007A	C	.020	35	6	6	None	368	None
IGE-4008	C	.020	35	None	6	None	256	None
IGE-4015	C	.020	35	3	9	None	358	None
IGE-4020	C	.020	35	6	6	None	368	None
IGS-4007	CC	.020	47	None	14	10	466	467
IGS-4010-1	C	.020	38	None	12	10	478	524
IGS-4010A	C	.020	38	None	11	10	480	524
IGS-4010A-2	C	.020	38	None	11	10	480	524
IGS-4010B-2	C	.020	38	None	12	10	423	524
IGS-4012	C	.020	38	None	9	7.5	516	517
IGS-4014-1	C	.020	38	None	12	10	478	524
IGS-4101B-1	C	.020	38	None	12	10	478	524
IGS-4102A-2	C	.020	38	None	13	10	541	524
IGS-4102B-2	C	.020	38	None	12	10	478	524
IGS-4102C-1	C	.020	38	None	12	7	478	614
IGS-1403-1	C	.020	38	None	11	10	480	456
IGS-4103A-1	C	.020	38	None	11	10	480	620
IGS-4103B-1	C	.020	38	None	12	10	423	524
IGS-4107-1	C	.020	38	None	12	8	478	584
IGS-4107A-1	C	.020	38	None	13	8	541	584
IGS-4108-1	C	.020	38	None	12	7	478	614
IGS-4108A-1	C	.020	38	None	12	11	478	619
IGS-4108B-1	C	.020	38	None	12	10	478	524
IGS-4108C-1	C	.020	38	None	11	10	480	524
IGS-4108D-1	C	.020	38	None	13	8	541	584
IGS-4109-1	C	.020	38	None	11	10	480	620
IGS-4111-1	C	.020	38	None	11	10	480	620
IGS-4112-1	C	.020	38	None	12	8	478	584
IGS-4113-1	C	.020	38	None	12	7	478	614

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AUTO-LITE DISTRIBUTOR SPECIFICATIONS

Unit Number	Rotation	Breaker Gap, Inch	Cam Angle, Degrees	Maximum Advance, Distributor Degrees			Automatic Advance Curve Number①	Vacuum Advance Curve Number②
				Manual	Automatic	Vacuum		
IGS-4114-1	C	.020	38	None	12	8	478	584
IGS-4202-1	C	.020	38	None	12	7	478	614
IGS-4202A-1	C	.020	38	None	11	6	774	527
IGS-4202B-1	C	.020	38	None	12	9	419	775
IGS-4203-1	C	.020	38	None	12	8	478	584
IGS-4204-1	C	.020	38	None	11	10	480	620
IGW-4001	CC	.020	35	None	10	None	469	None
IGW-4005A	C	.020	35	6	6	None	368	None
IGW-4006B	C	.020	35	5	9	None	485	None
IGW-4006C	C	.020	35	3	9	None	485	None
IGW-4008	CC	.020	35	None	10	None	440	None
IGW-4108A	CC	.020	35	None	8.5	None	560	None
IGW-4009A	C	.020	35	7	8.5	None	281	None
IGW-4011	C	.020	35	None	8	None	412	None
IGW-4015A	C	.020	35	6	6	None	368	None
IGW-4016	CC	.020	41	None	11	None	523	None
IGW-4017	C	.020	35	10	7	None	449	None
IGW-4018	CC	.020	40	None	None	None	None	None
IGW-4020	CC	.020	41	None	6.5	None	533	None
IGW-4022	C	.020	41	6	5	None	340	None
IGW-4025	C	.020	41	None	5	None	340	None
IGW-4025B	C	.020	41	None	6	None	445	None
IGW-4033	C	.020	35	10	6	None	368	None
IGW-4038A	C	.020	35	None	5	None	489	None
IGW-4038B	C	.020	35	None	6	None	368	None
IGW-4042	CC	.020	35	10	6	None	368	None
IGW-4044A	C	.020	41	None	8	None	554	None
IGW-4044B	C	.020	41	None	11	None	563	None
IGW-4045A	C	.020	35	None	6	None	368	None
IGW-4101	CC	.020	35	None	10	None	469	None
IGW-4107	C	.020	35	6	15	None	574	None
IGW-4107A	C	.020	35	3	8.5	None	732	None
IGW-4108	CC	.020	35	None	15	None	573	None
IGW-4110	C	.020	35	None	9	None	485	None
IGW-4110A	C	.020	35	None	9	None	485	None
IGW-4110C	C	.020	35	None	6	None	368	None
IGW-4114A	C	.020	35	6	6	None	605	None
IGW-4114B	C	.020	35	5	9	None	485	None
IGW-4114C	C	.020	35	5	9	None	485	None
IGW-4114D	C	.020	35	6	6	None	605	None
IGW-4114E	C	.020	35	1.5	9	None	695	None
IGW-4119	C	.020	35	6	15	None	574	None
IGW-4119A	C	.020	35	6	8.5	None	732	None
IGW-4119B	C	.020	35	10	8.5	None	752	None
IGW-4120	C	.020	41	None	5	None	340	None
IGW-4120B	C	.020	41	None	6	None	445	None
IGW-4120B-2	C	.020	41	None	6	None	445	None

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IGNITION SYSTEMS (BATTERY)

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AUTO-LITE DISTRIBUTOR SPECIFICATIONS

Unit Number	Rotation	Breaker Gap, Inch	Cam Angle, Degrees	Maximum Advance, Distributor Degrees			Automatic Advance Curve Number①	Vacuum Advance Curve Number②
				Manual	Automatic	Vacuum		
IGW-4120C	C	.020	41	None	4	None	734	None
IGW-4123B	C	.020	35	6	6	None	605	None
IGW-4137	CC	.020	41	None	12	None	638	None
IGW-4138	CC	.020	41	None	12	None	638	None
IGW-4139B	OC	.020	41	None	6	None	675	None
IGW-4154	CC	.020	35	None	7	Non	378	None
IGW-4157	C	.020	41	None	5	None	340	None
IGW-4158	C	.020	41	None	12	None	638	None

NOTE—Breaker arm spring tension on all units listed should be from 17 to 20 ounces as measured with a spring scale hooked at the contact point and in line with the center of the contacts. Take reading just as points open.

C—Clockwise.
CC—Counter-clockwise.
① See the Auto-Lite "Distributor Automatic Advance Curve" table.
② See the Auto-Lite "Vacuum Advance Curve" table.

AUTO-LITE VACUUM ADVANCE CURVE

Vacuum Curve Number ①	Zero Advance, Inches of Mercury	Start Advance		Intermediate Advance		Maximum Advance	
		Distributor Degrees	Inches of Mercury	Distributor Degrees	Inches of Mercury	Distributor Degrees	Inches of Mercury
452	5	2	6¾	4	8½	8	12
453	5¼	2	7⅝	4	10	8	15
454	5⅛	1	6¼	3	8⅝	6	12
455	5	2	7¼	4	9½	8	14
456	5	2	6¾	5	9½	10	14
464	4	2	5⅝	5	8	10	12
467	3½	2	5¾	5	9¼	10	15
472	5¼	1	7	2	8¾	5	14
491	4⅞	2	6⅛	4	7½	8	10
501	6	2	9	4	11⅞	7.5	17
505	3	2	5	3	6	6	12
517	5	2	8	4	11	7.5	16
524	4¾	2	6¼	5	8⅜	10	12
527	5⅛	1	6⅝	3	9⅝	6	14
532	5	1	6	3	8	7	12
550	7	1	8⅝	3	12	5.5	16
583	10	1	11⅛	3	13½	6	17
584	5	2	7¾	4	10½	8	16
593	4	1	5⅝	2	7¼	5	12
613	6	1	7	3	9¼	5.5	12
614	5	1	6½	3	9¼	7	15
619	5	2	7¼	5	10½	11	17
620	5	2	7⅜	5	11	10	17
621	5	2	8	4	11	8	17
622	5	1	7	3	11	6	17

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AUTO-LITE VACUUM ADVANCE CURVE

Vacuum Curve Number ①	Zero Advance, Inches of Mercury	Start Advance		Intermediate Advance		Maximum Advance	
		Distributor Degrees	Inches of Mercury	Distributor Degrees	Inches of Mercury	Distributor Degrees	Inches of Mercury
626	3⅝	2	6⅞	4	10⅛	7	15
633	4	2	5½	5	7¾	9	14¾
641	4	1	6⅜	2	8¾	5	16
655	2	1	4	3	8	6	14
661	6¾	2	7⅝	4	8½	7.5	10
740	8½	2	10¼	4	12	7.5	15
745	5	2	6⅞	4	9	7.5	15
749	4	2	5½	4	7	6.5	9
767	5	2	7⅝	4	10⅛	8.5	16
768	5	2	7	4	9	9	14
773	5	1	6⅝	3	10	6	15
775	5	2	7¼	4	9⅜	9	15
776	14	1	14⅝	3	15¾	6	17½
779	5	2	7¼	5	10½	10	16
783	5	2	7⅝	4	10¼	7.5	15
786	5	2	7½	5	11⅛	9	16

① See the "Auto-Lite Distributor Specifications" table for Vacuum Advance Curve number desired.

AUTO-LITE AUTOMATIC ADVANCE CURVES

Advance Curve Number①	Start Advance		Intermediate Advance		Maximum Advance	
	Distributor R. P. M.	Distributor Degrees	Distributor R. P. M.	Distributor Degrees	Distributor R. P. M.	Distributor Degrees
120	225	2	350	5	600	11
229	440	4	675	8	1075	15
247	710	2	1200	5	2000	10
256	420	1	650	3	1000	6
281	475	2	650	4	1050	8.5
287	360	1	525	2	1000	5
293	550	3	795	6	1200	11
295	290	1	475	3	800	6.5
296	425	3	655	6	1150	12.5
311	365	2	530	4	775	7
340	450	1	605	2	1100	5
341	500	2	700	4	1200	9
347	560	3	840	6	1400	12.25
358	450	2	610	4	1000	9
368	380	1	580	3	900	6
371	340	1	430	2	700	5
372	355	1	525	3	775	6
406	600	2	900	5	1400	10
411	575	3	850	6	1400	12
412	600	2	900	4	1500	8
415	270	4	335	8	450	15

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AUTO-LITE AUTOMATIC ADVANCE CURVES

Advance Curve Number①	Start Advance		Intermediate Advance		Maximum Advance	
	Distributor R. P. M.	Distributor Degrees	Distributor R. P. M.	Distributor Degrees	Distributor R. P. M.	Distributor Degrees
419	400	3	780	6	1530	12
423	400	3	715	6	1350	12
437	330	3	400	6	1400	14
438	330	3	400	6	1220	15
439	330	3	400	6	1600	14
440	450	2	675	5	1050	10
445	240	1	385	3	600	6
449	400	1	600	3	1000	7
466	420	4.4	770	7	1700	14
469	600	2	900	5	1400	10
475	410	2	650	5	975	9
478	400	3	850	6	1750	12
480	400	3	950	6	1850	11
481	365	3	530	6	800	11
485	600	2	800	4	1300	9
489	680	1	860	2	1400	5
494	535	3	770	6	1200	11.5
515	530	3	760	6	1150	11
516	540	2	915	5	1400	9
523	400	4	600	6	1100	11
528	375	3	400	6	1650	13
533	410	1	620	3	1000	6.5
534	560	2	800	3.5	1600	6
541	400	3	820	7	1450	13
553	360	3	400	5	1200	12
554	475	2	650	4	1000	8
560	440	2	580	4	900	8.5
563	405	3	500	5.5	1000	11
573	600	4	900	8	1425	15
574	625	4	945	8	1500	15
591	475	2	700	4	1200	8.5
605	450	1	725	3	1150	6
638	515	3	675	6	1000	12
675	450	2	600	4	1000	6
676	370	3	490	6	750	12.5
678	330	3	400	6	1350	15
695	570	2	970	5	1500	9
699	375	3	450	6	1050	12
730	330	3	420	6	1200	12
732	515	2	725	4	1200	8.5
734	375	1	450	2	600	4
741	655	3	810	6	1150	12.5
752	490	2	675	4	1100	8.5
756	480	2	680	4	1200	9
761	370	1	490	3	750	7
765	385	3	500	7	1200	10.5
770	400	3	620	5	1150	10
774	400	3	770	6	1400	11

① See the Auto-Lite "Distributor Specifications" for "Automatic Advance Curve Number" desired.

DELCO-REMY DISTRIBUTOR INDEX

Model No.	Direction of Rotation	Advance Curve No.	Cam Angle Deg.
368-D	CC	----	35
622-C	CC	932	35
622-D	CC	899	35
622-H	CC	1004	35
622-M	CC	962	35
622-R	C	1039	35
622-U	CC	1053	35
622-V	C	97	35
623-B	C	119	35
623-D	CC	124	35
623-G	CC	962	35
623-H	C	128	35
623-J	CC	899	35
623-K	CC	132	35
623-L	C	126	35
623-P	CC	143	35
623-R	C	144	35
623-T	C	14	35
625-E	C	122	32①
625-F	C	122	32①
625-H	CC	899	32①
625-J	C	133	32①
625-M	C	122	32①
629-A	CC	52	32①
629-D	C	911	32①
629-N	CC	962	32①
629-S	CC	812	32①
629-T	CC	812	32①
629-U	CC	812	32①
629-V	CC	812	32①
632-R	CC	804	35
632-S	CC	965	35
632-U	CC	973	35
632-Y	C	991	35
639-K	C	870	35
639-S	CC	818	35
640-C	CC	94	35
640-L	C	834	35
640-R	CC	835	35
640-Z	CC	94	35
642-G	C	902	35
642-S	CC	899	35
642-T	CC	835	35
643-A	CC	937	35
643-B	CC	861	35
643-C	C	938	35
643-D	CC	----	35
643-E	CC	888	35
643-F	CC	899	35
643-H	CC	----	35
643-J	CC	835	35
643-L	CC	960	35
643-R	CC	888	35
643-W	CC	993	35
643-X	CC	983	35
643-Y	C	990	35
643-Z	CC	994	35
644-A	CC	996	35
644-B	CC	1003	35
644-C	CC	1003	35
644-J	CC	1017	35
644-K	CC	1018	35
644-M	CC	1025	35
644-P	CC	875	35
644-R	CC	1034	35
644-S	CC	899	35
644-T	CC	1018	35
644-U	CC	1041	35
644-V	C	1037	35
644-W	CC	1050	35
644-X	CC	861	35
644-Y	C	1056	35
645-B	CC	1065	35
645-C	C	1060	35
645-D	CC	1062	35
645-E	CC	993	35
645-G	CC	1070	35
645-J	C	1071	35
645-K	CC	1075	35
645-M	CC	1041	35
645-N	CC	861	35
645-S	CC	878	35
645-T	CC	112	35
645-U	C	110	35
645-V	CC	994	35
645-W	C	118	35
645-Y	CC	835	35
645-Z	CC	----	35
647-F	C	141	35
647-G	CC	814	35
647-H	CC	900	35
647-T	CC	900	35
647-K	CC	814	35
647-L	CC	814	35
649-A	CC	1065	35
649-B	CC	1017	35
649-C	CC	129	35
649-D	C	1071	35
649-E	CC	91	35
649-F	CC	123	35
649-G	CC	131	35
649-J	CC	861	35
649-N	CC	914	35
649-P	CC	131	35
649-R	CC	12	35
649-S	CC	13	35
649-T	CC	1065	35
649-U	CC	16	35
649-V	CC	52	35
649-W	CC	123	35
649-X	C	121	35
649-Y	CC	861	35
649-Z	CC	111	35
662-M	CC	955	33
666-D	C	972	37
666-F	C	1035	37
666-H	C	130	37
696-D	CC	94	35
696-F	CC	94	35
696-G	CC	835	35
696-H	CC	908	35
4074	CC	917②	27
4078	CC	922	37
4097	CC	980	37
4098	CC	985	37
4099	C	986	37
4102	CC	1028	37
4109	CC	868	37
4116	CC	980	37
4119	CC	861	37
4123	CC	1028	37
4126	C	1054	37
4127	CC	1068	37
4128	CC	1068	37
4129	CC	1073	37
4130	CC	980	37
4131	CC	1073	37
4135	C	121	37
4136	CC	861	37
4137	CC	123	37
4140	CC	868	37
4142	C	40	37③
4144	C	1036	37
4150	CC	1077	37
4155	CC	868	37
4156	CC	861	37
4158	C	1089②	21④
4162	CC	970	37
4169	CC	1099	37
4170	CC	1109	37

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Model No.	Direction of Rotation	Advance Curve No.	Cam Angle Deg.
4171	CC	899	37
4172	C	1039	37
4173	CC	962	37
4174	CC	13	37
4175	CC	12	37
4176	CC	129	37
4177	CC	1112	37
4179	C	1106	37
4180	C	1089②	21④
4186	C	130	37
4188	C	1089②	21④
4191	C	1095	37
4194	CC	1068	37
4196	C	1095	37
4199	C	1054	37
4204	CC	1068	37
4205	C	1115②	21④
4209	C	863	37
4210	C	870	37
4213	C	1113	37
4215	C	115	37
4217	C	1089②	21④
4220	CC	----	37
4225	CC	1003	37
4233	CC	1131	37
SM1141	CC	94	36
SM1147	CC	94	36
SM1164	CC	868	35
SM1187	CC	94	48
SM1229	CC	----	35
SM1240	CC	922	35
SM1241	CC	899	--
SM1243	CC	922	35
SM1246	CC	888	35
SM1282	CC	904	35
SM1288	CC	94	35
SM1310	CC	980	35
SM1314	CC	875	35
SM1325	CC	----	35
SM1346	C	902	35
SM1376	CC	508	35
SM1379	CC	981	32①
SM1381	CC	94	35
SM1456	C	1060	35
SM1457	CC	945	35
SM1498	CC	----	35
SM1524	CC	980	35
SM1534	CC	835	35
SM1540	CC	225	35
SM1623	CC	1050	35
SM1659	C	1054	35
SM1667	CC	835	35
SM1683	CC	1073	35
SM1693	CC	1003	35
SM1700	C	511	51
SM1707	CC	899	35
SM1737	CC	868	35
SM1747	CC	1018	35
SM1882	CC	94	35
SM1885	CC	993	35
SM1911	C	----	35
SM1926	C	519	35
SM1934	CC	----	32①
SM1951	C	----	35
1110001	CC	123	35
1110002	C	149	35
1110006	CC	983	35
1110007	CC	12	35
1110008	CC	131	35
1110011	CC	1082	35
1110015	CC	1003	35
1110016	C	121	35
1110018	CC	131	35
1110019	CC	129	35
1110025	C	1095	35
1110027	CC	123	35
1110029	CC	----	35
1110031	CC	861	35
1110032	CC	861	35
1110033	CC	123	35
1110034	C	1091	35
1110036	CC	1109	35
1110037	CC	1109	35
1110039	CC	1109	35
1110041	CC	91	35
1110042	CC	1109	35
1110043	CC	91	35
1110044	CC	1112	35
1110045	CC	131	32
1110046	C	1095	35
1110047	C	1091	35
1110049	CC	1112	35
1110051	C	1113	35
1110052	CC	829	35
1110054	C	----	35
1110055	C	1091	35
1110056	C	1114	35
1110057	C	1091	35
1110059	CC	861	35
1110061	CC	829	33
1110062	CC	829	33
1110063	CC	829	33
1110064	CC	121	35
1110065	CC	878	35
1110067	CC	861	35
1110068	CC	861	35
1110070	CC	1003	35
1110071	CC	1109	35
1110073	CC	1125	35
1110075	CC	874	35
1110079	CC	861	35
1110083	CC	1109	35
1110086	CC	1109	35
1110087	CC	829	35
1110088	CC	1131	35
1110089	CC	1132	35
1110090	CC	1130⑤	38
1110094	C	1135	35
1110095	C	1135	35
1110097	C	91	35
1110098	CC	1082	35
1110100	CC	874	35
1110102	CC	874	35
1110104	CC	962	35
1110106	CC	1130	35
1110107	CC	1109	35
1110108	C	1126	35
1110110	CC	1130⑤	38
1110111	CC	1130⑤	38
1110112	CC	840	35
1110113	C	1135	35
1110114	C	121	35
1110115	C	1095	35
1110116	CC	1146	35
1110118	CC	1134	41
1110120	CC	874	35
1110123	C	1083	35
1110124	C	1141	35
1110125	CC	1131	35
1110133	CC	1003	35
1110135	CC	874	35
1110136	CC	1130⑤	38
1110137	CC	868	35
1110204	C	1091	35
1110205	CC	900	35
1110209	CC	1091	35
1110211	CC	38	35
1110212	CC	38	35
1110402	C	122	32①
1110403	CC	812	32①

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Model No.	Direction of Rotation	Advance Curve No.	Cam Angle Deg.	Model No.	Direction of Rotation	Advance Curve No.	Cam Angle Deg.	Model No.	Direction of Rotation	Advance Curve No.	Cam Angle Deg.
1110408	CC	1101	32①	1110510	C	1127	35	1111204	C	863	37
1110411	CC	1101	32①	1110511	C	962	35	1111404	CC	1082	37
1110414	C	1117	32①	1110513	CC	977	35	1111405	CC	94	35
1110501	C	----	35	1111201	CC	996	37				
1110509	C	1126	35	1111202	CC	970	37				

C--Clockwise. CC--Counter-Clockwise.

NOTE--Breaker gap on all units, unless otherwise indicated, is .018"-.024". The cam angle listed is subject to a variation of plus or minus 2 degrees and is based on a worn-in rubbing block. When a new breaker arm and rubbing block is being installed, cam angle must be set 3 degrees less than shown in the table.

① On early production units, set cam angle 49 degrees.
② Breaker gap, .0125"-.0175".
③ Firing interval, 30 and 30 cam degrees.
④ Maximum total for both levers.
⑤ Breaker gap, .015"-.021".

DELCO-REMY VACUUM CONTROL TEST SPECIFICATIONS

Model No.	Inches of Hg. to Start Movement of Plunger	Inches of Hg. for Full Plunger Travel	Total Plunger Travel (Inches)	Nominal Maximum Advance Degrees (Engine)
680-A①	5 min.	14 max.	¼	21
680-B②	3 min.	6 max	⅛	6
680-C②	3 min.	6 max	⅛	6
680-D③	3 min.	6 max.	⅛	6
680-E③	5 min.	14 max.	¼	21
680-F②	4 min.	12.5 max.	¼	12
680-G	5 min.	14 max.	¼	21
680-H	5–7	10–13	9/64	12
680-J②	3 min.	6 max.	⅛	6
680-K	4–6	16–21	17/64	20
680-L②	4.5	9–11	15/64	17
680-M	5–7	10–15	13/64	15
680-N②	7 min.	9–13	5/32	10
680-P②	10 min.	16 max.	5/32	11
680-R	5–7	10–13	9/64	12
680-S②	3 min.	6 max.	⅛	6
680-T②	6.5–9	16–19	¼	10
680-U	9–11	16–18	11/64	15
680-V②	5 min.	9–11	11/64	12
680-W②	1.5–2.5	11–13	5/16	14
680-X	9–11	16–18	3/16	15
680-Y	5 min.	14 max.	¼	21
680-Z	7–10	15–19	15/64	18
681-A	5–7	15.5–18.5	11/64	15
681-B	5–7	13–16	9/64	10
681-C②	5–7	12–16	7/64	10
681-D②	7 min.	9–13	5/32	10
681-E②	8–10	17–22	15/64	10
681-F②	4.5 min.	8–10	3/16	15
681-G②	5–7	14–18	5/32	10
681-H	5–7	10–13	⅛	11
681-K	5–7	15–19	9/64	15
681-L	6–8	14–18	⅛	11
681-M	7–9	13–16⑤	9/64	15
681-N	4–6	16–21	7/32	20
681-P	5–7	15.5–18.5	3/16	20
681-R	5–7	14–17	11/64	15
681-S②	5–7	11–14	¼	12
681-T②	4.5	11	9/32	21
681-U	5–6	15–17	⅜	--
681-V	4–6	9–11	9/64	15
681-W	4–6	15–17	9/64	15
1116001②	5–7	11–14	¼	12
1116002②	7.0 min.	9–13	5/32	10
1116003②	5–7	12–16	7/64	10
1116004②	5–7	11.5–14.5	15/64	11
1116005	3–5	10–14	7/64	10
1116006②	5–7	14–18	5/32	10
1116007	1.5–2.5	11–13	9/64	15
1116008	4–6	8–10	3/32	10
1116009②	4.5 min.	8–10	3/16	15
1116010②	4.5	11	9/32	21
1116011②	6.0 min.	12–15	7/32	16
1116012	3–5	10–14	7/64	10

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DELCO-REMY VACUUM CONTROL TEST SPECIFICATIONS

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Model No.	Inches of Hg. to Start Movement of Plunger	Inches of Hg. for Full Plunger Travel	Total Plunger Travel (Inches)	Nominal Maximum Advance Degrees (Engine)
1116013	4–6	9–11	9/64	15
1116014	7–9	10–12	3/32	10
1116015②	5–7	11–14	1/4	12
1116016	4–6	15–17	9/64	15
1116017②	5–7	11–14	1/4	12
1116018②	5.0 min.	14 max.	1/4	21
1116019②	5–7	11–14	1/4	12
1116020	5.5–7.5	15–18	13/64	18
1116021	7–9	16–21	7/32	20
1116022	9–11	16–20	13/64	18
1116023②	5–7	10–13	11/64	12
1116024	6–8	12.5–15.5	13/64	18
1116025②	4–6	10.5–13.5	7/32	16
1116026②	7–8.5	16–20	11/64	20
1116027②	5–7	11–14	1/4	12
1116028②	5–7	15–19	3/16	15
1116029②	3–5	14–17	23/64	17
1116030	5.5–7.5	15–18	13/64	18
1116031	5–7	10–13	11/64	15
1116032	5–7	11–14	17/64	12
1116033②	7–8.5	16–19	17/64	20
1116034③	5–7	15–19	3/16	15
1116035	7.5–9.5	14.6–16.6④	1/8	24
1116036	6.8–8.5	14.0–16.8⑤	9/64	24
1116037③	7.0 min.	9–13	5/32	10
1116038	5–7	10–13	1/8	11
SM-1896	5–7	14–18	3/32	10

① Action of control unit retards spark.
② Clamp arm type.
③ See notes 1 and 2.
④ At .103″ travel.
⑤ At .125″ travel.

DELCO-REMY DISTRIBUTOR ADVANCE CURVES

Advance Curve Number	Start Advance		Intermediate Advance		Maximum Advance	
	Engine R.P.M.	Engine Degrees	Engine R.P.M.	Engine Degrees	Engine R.P.M.	Engine Degrees
12	700	2.0	1000	10.0	2100	26.0
13	300	0.5	1000	14.5	1800	22.5
14	700	2.0	----	---	3800	22.0
16	600	2.0	1000	6.0	2200	22.0
38	600	3.0	----	---	2600	20.5
40	800	2.0	1400	8.0	2150	14.0
52	600	2.0	----	---	2400	20.0
91	600	3.0	1800	15.5	2200	17.0
94	600	1.0	----	---	2000	20.0
97	600	3.0	----	---	2600	24.0
110	500	0.5	----	---	2200	30.0
111	600	2.0	----	---	2000	17.0
112	600	2.25	----	---	3000	28.0
115	400	2.0	800	14.0	2000	36.0
118	500	2.0	800	7.5	2900	26.0
119	600	2.0	----	---	2100	23.0
121	400	2.0	800	8.0	2400	22.0
122	600	2.0	----	---	2400	23.0
123	400	2.0	800	8.0	2400	22.0
124	600	3.0	----	---	2200	20.0

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DELCO-REMY DISTRIBUTOR ADVANCE CURVES

Advance Curve Number	Start Advance		Intermediate Advance		Maximum Advance	
	Engine R.P.M.	Engine Degrees	Engine R.P.M.	Engine Degrees	Engine R.P.M.	Engine Degrees
126	800	2.0	----	---	2800	22.0
128	600	1.0	1200	9.0	2200	17.0
129	400	1.0	----	---	1800	27.5
130	400	2.0	----	---	1600	24.0
131	600	1.75	----	---	3600	50.0
132	600	2.0	----	---	3600	20.0
133	800	2.0	----	---	2000	18.0
141	400	2.0	800	6.0	3800	28.0
143	800	2.0	2400	11.5	2800	12.0
144	600	2.0	----	---	2200	16.0
149	500	3.0	1000	14.0	2000	20.0
225	600	8.0	800	14.0	2900	32.0
508	500	0.5	800	7.0	2200	30.0
511	600	2.5	----	---	2400	23.0
519	600	2.0	1000	6.0	2200	16.0
804	400	1.0	----	---	2500	20.0
812	650	2.0	1600	18.0	2300	27.0
814	500	3.0	800	14.0	2400	27.0
818	1000	2.5	----	---	2200	20.0
829	800	4.0	1200	11.0	3100	37.0
834	400	2.0	2000	21.0	2200	22.0
835	600	2.0	----	---	2800	20.0
840	600	2.0	----	---	2800	22.0
861	500	3.0	800	14.0	3200	34.0
863	400	2.0	----	---	1400	24.0
868	400	2.0	----	---	2000	32.0
870	600	1.5	----	---	2800	20.0
874	400	2.0	800	10.0	3400	32.0
875	600	3.0	2400	35.5	2800	40.0
878	400	2.0	----	---	2200	31.0
888	600	2.0	1600	15.0	2550	24.0
899	600	2.0	----	---	2200	16.0
900	600	2.0	----	---	2600	20.0
902	450	2.0	①	①	2400	22.0
904	500	3.0	800	14.0	2200	26.0
908	800	2.5	----	---	4000	17.0
911	600	2.0	----	---	2600	20.0
914	800	2.0	----	---	2400	17.0
917	600	3.0	----	---	2800	22.0
922	600	2.0	2000	13.5	2200	14.0
932	800	2.0	----	---	2600	16.0
937	600	2.0	----	---	2400	13.0
938	500	3.0	800	14.0	3200	34.0
945	600	3.0	1600	22.0	2000	27.0
955	600	2.5	----	---	3600	29.0
960	400	2.0	----	---	2900	24.0
962	600	3.0	1200	11.5	3000	28.0
965	900	2.0	2400	25.0	2700	28.0
970	600	2.0	----	---	3200	22.0
972	600	3.0	----	---	1800	34.0

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IGNITION SYSTEMS (BATTERY)

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DELCO-REMY DISTRIBUTOR ADVANCE CURVES

Advance Curve Number	Start Advance		Intermediate Advance		Maximum Advance	
	Engine R.P.M.	Engine Degrees	Engine R.P.M.	Engine Degrees	Engine R.P.M.	Engine Degrees
973	600	2.0	----	--	2400	30.0
977	600	2.0	1600	12.0	3000	22.0
980	400	2.0	----		1400	12.0
981	500	2.5	1200	12.5	1600	17.0
983	600	2.0	1600	15.0	2550	24.0
985	700	7.0	1000	14.0	3200	34.0
986	700	7.0	1000	14.0	3200	34.0
990	500	3.0	----	---	1600	42.0
991	600	2.0	----	---	2000	20.0
993	500	2.0	----	---	2200	22.0
994	400	2.0	800	12.0	2400	22.0
996	500	2.0	----	---	2200	20.0
1003	400	2.0	1000	14.0	1600	20.0
1004	800	2.0	2200	17.5	2400	18.0
1017	500	2.0	800	14.0	2800	32.0
1018	500	4.0	800	15.0	2400	32.0
1025	600	2.0	----	---	2900	18.0
1028	400	2.0	----	---	1600	28.0
1034	600	1.5	2200	21.5	3100	37.0
1035	500	2.0	800	13.0	2400	27.0
1036	400	2.0	1000	16.0	1400	22.0
1037	500	4.0	800	21.0	1900	32.5
1039	700	2.0	----	---	2600	14.0
1041	500	1.0	800	14.0	2800	30.0
1050	500	4.0	800	14.0	3200	30.0
1053	800	2.0	----	---	2400	20.0
1054	400	2.0	----	---	1400	12.0
1056	400	2.0	----	---	1600	17.0
1060	500	4.0	800	15.0	2600	34.0
1062	500	4.0	800	14.0	2600	26.0
1065	400	2.5	----	---	2800	36.5
1068	600	1.0	----	---	2000	20.0
1070	600	1.5	----	---	3000	32.0
1071	600	2.0	----	---	3200	27.0
1073	800	2.0	1400	8.0	2400	16.0
1075	600	2.0	1600	9.0	3200	14.0
1077	500	3.0	800	14.0	1800	22.0
1082	400	2.0	800	14.0	1800	24.0
1083	600	2.0	----	---	2200	17.0
1089	400	2.0	----	---	2800	22.0
1091	600	2.0	----	---	2200	22.0
1095	400	2.0	----	---	2200	18.5
1099	400	2.0	1200	17.0	1600	20.0
1101	650	3.5	----	---	1200	17.0
1106	600	3.0	----	---	1800	14.0
1109	600	2.0	----	---	2600	20.0
1112	500	2.0	1200	20.0	2400	38.0
1113	400	2.0	----	---	1400	24.0
1114	600	2.0	----	---	2350	20.0
1115	500	2.0	----	---	2050	30.0

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DELCO-REMY DISTRIBUTOR ADVANCE CURVES

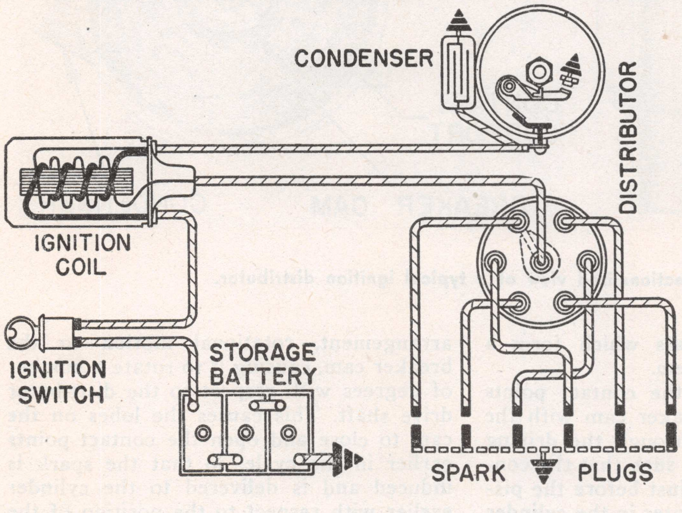
Advance Curve Number	Start Advance		Intermediate Advance		Maximum Advance	
	Engine R.P.M.	Engine Degrees	Engine R.P.M.	Engine Degrees	Engine R.P.M.	Engine Degrees
1117	550	3.0	②	②	2400	25.0
1125	400	2.0	2000	16.5	3350	24.0
1126	600	2.0	----	---	2000	9.0
1127	600	2.0	----	---	2400	20.0
1130	600	1.0	③	③	3450	39.5
1131	700	2.0	1000	8.0	2600	24.0
1132	500	2.0	1600	17.5	2800	29.0
1134	400	2.5	1800	22.5	2700	29.5
1135	600	2.0	1600	12.0	2600	18.0
1141	600	2.0	1200	10.0	2500	22.0
1146	400	2.0	800	10.0	2700	28.0

① Low intermediate 800 R. P. M., 9.5 degrees: high intermediate 1600 R. P. M., 17.5 degrees.

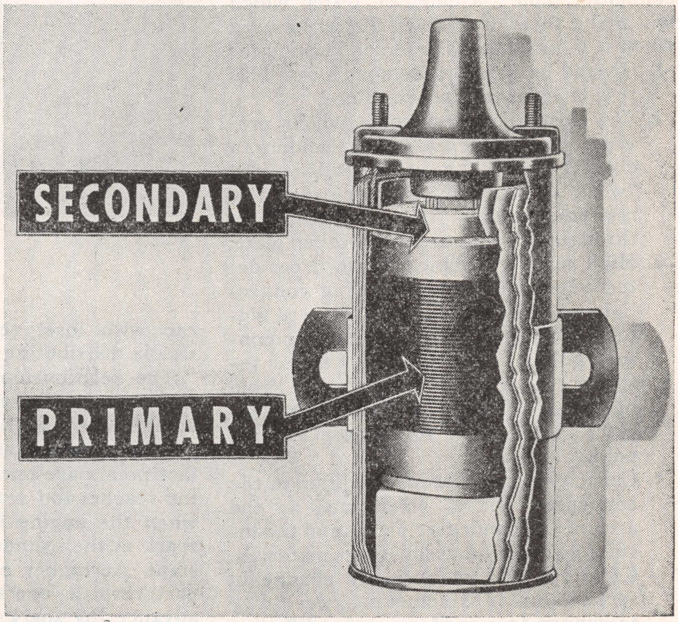
② Low intermediate 1600 R. P. M., 18.5 degrees: high intermediate 2000 R. P. M., 23.0 degrees.

③ Low intermediate 1200 R. P. M., 13.0 degrees: high intermediate 2000 R. P. M., 20.0 degrees.

NOTE--Refer to the Delco-Remy numerical index for the advance curve number desired.



Schematic wiring circuit of a typical battery ignition system.



Cutaway view of typical ignition coil, showing locations of primary and secondary windings.

IGNITION

The ignition system on any vehicle employing battery ignition consists of the source of power (battery or generator), ignition distributor, ignition coil, condenser, spark plugs, together with the low and high tension wiring and the ignition switch. The testing devices and procedures which may be used on these component parts of the ignition system will be discussed in the following paragraphs.

IGNITION COIL

The ignition coil terminals may be inspected to make sure they are tight and in good condition, the coil insulation checked for burned or chipped places or cracks, the coil case checked for loose seams, dents, or punctures, and the coil tested electrically.

Coil testers may utilize a spark gap, or they may be of the high frequency type. The spark gap coil tester measures the length of spark which the coil can produce, and this performance is checked against a coil which is known to be good, or against a predetermined specification. While this type tester successfully detects many defective ignition coils, it will not detect such defects as shorted primary or secondary coil turns, especially if only a few turns are shorted. A few shorted turns do not markedly affect the peak voltage which an ignition coil can produce, but they will seriously decrease the length of time each spark lasts since shorted turns have a dampening effect. In other words, the length in fractions of an inch, of the spark may not change noticeably, but the length of time, in fractions of a second, that the spark lasts, is considerably shortened by shorted turns in the primary or secondary winding. Thus a coil with shorted turns, while it could produce sparks of normal length, might not be able to provide good ignition because the sparks do not last long enough in the engine cylinder to ignite properly the compressed mixture of gasoline and air.

Also, it must be remembered that an ignition coil with shorted turns in the primary or secondary is on the road to failure, since these shorted turns tend to overheat the coil, causing additional turns to become shorted until finally enough turns are shorted to cause complete coil failure. The high frequency tester was developed to detect shorted turns, and it thus serves to detect ignition coils which are still good enough to operate the engine, but which will likely soon fail. This, of course, is valuable from the standpoint of avoiding road failure.

IGNITION CONDENSERS

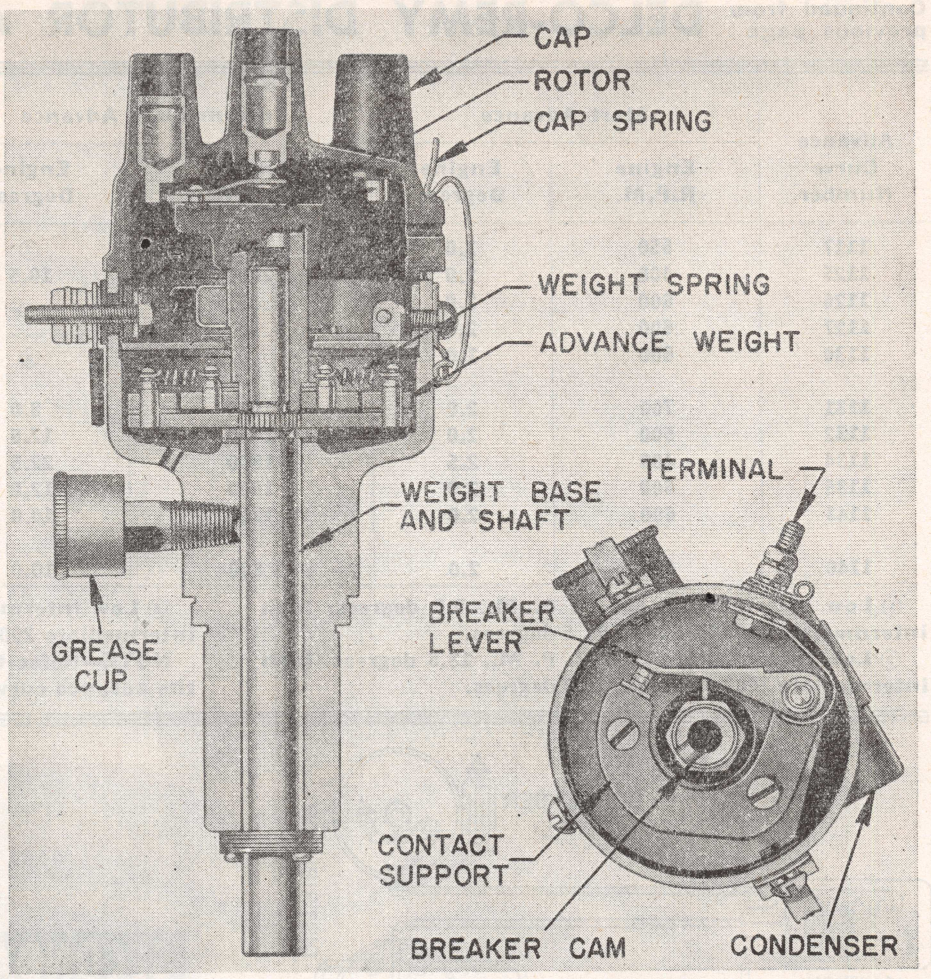
Condensers are often replaced during the course of an ignition or engine tune-up, without the condenser being tested to see whether it is good or bad. Thus many perfectly good condensers are thrown away which would provide many additional miles of normal service. Then too, it may be that some trouble has developed in the ignition system which requires analysis, and part of this analysis should embrace the testing of the condenser to determine whether or not the condenser is defective and is contributing to the trouble.

Four conditions may be checked in the condenser, and a condenser tester which will make these four tests should be used when it is available. These conditions are:

1. Ground or short in the condenser. This results from insulation failure.
2. Low insulation resistance which prevents the condenser from holding a charge, so that the condenser is termed "weak". The insulation is of such low resistance that the charge leaks through it from one to the other plate.
3. High series resistance results from defective condenser lead or poor connections in the condenser. This type defect may cause burned distributor contact points, since the high series resistance prevents the condenser from operating normally, so that arcing takes place across the distributor contact points.
4. Capacity is an inherent condition in the condenser, and is determined by the area of the condenser plates and the insulating and impregnating materials. Capacity will not normally change in service, but it is sometimes necessary to change to a condenser of a different capacity on an application to remedy point pitting, and consequently a condenser capacity meter is a valuable testing instrument.

IGNITION DISTRIBUTOR

The ignition distributor has two jobs. It contains contact points which close and open to cause a magnetic build-up and collapse in the ignition coil. This produces high voltage impulses in the coil secondary winding which are led through the distributor cap and rotor to the proper spark plug lead. Essentially, the ignition distributor is simple in design, being nothing but a rotating cam which opens and closes a pair of contact points, plus a rotor and a cap with inset terminals which form a simple distributing system.



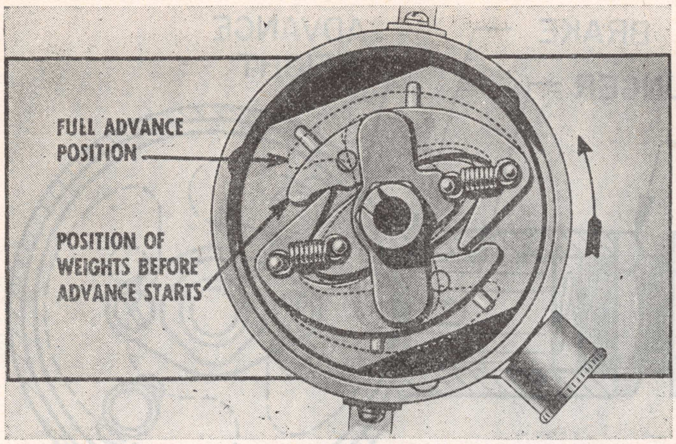
Sectionalized view of a typical ignition distributor.

The relationship of the contact points and the distributor breaker cam with the engine is established through the driving gear or coupling, and is such that the contact points are opened just before the piston reaches top dead center in the cylinder when the engine is idling. This causes a spark at the cylinder spark plug at this instant. At higher engine speeds, or under part throttle operation, it is desirable to advance the spark with respect to the engine, and centrifugal and vacuum advance mechanisms are provided to produce this advance. These devices are incorporated into and are a part of the ignition distributor.

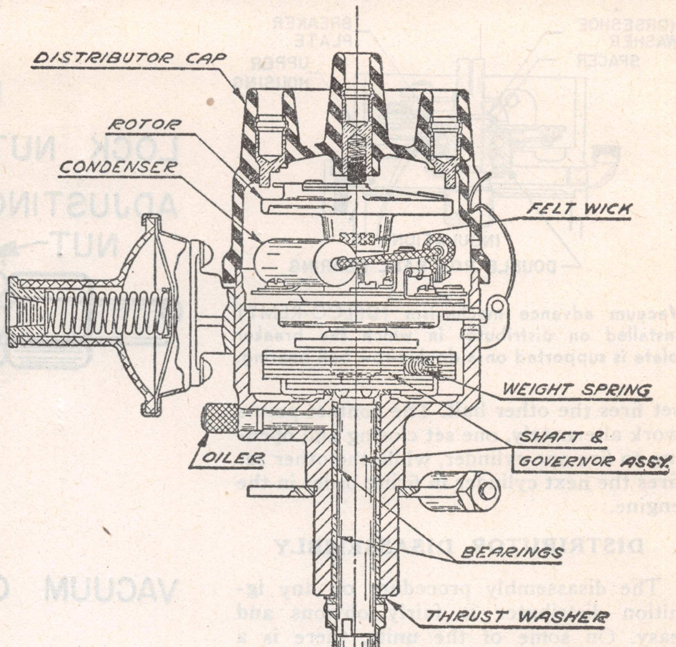
When engine speed increases, the spark must be introduced into the engine cylinder earlier in the cycle, in order that the charge can be ignited and will have time to burn and deliver its power to the piston. To provide this spark advance based on engine speed, a centrifugal advance mechanism is built into practically all modern ignition distributors. This centrifugal advance mechanism consists of centrifugal advance weights which throw out against spring tension as engine speed increases. This movement imparts, through a toggle arrangement, rotational motion to the breaker cam, causing it to rotate a number of degrees with respect to the distributor drive shaft. This causes the lobes on the cam to close and open the contact points earlier in the cycle, so that the spark is induced and is delivered to the cylinder earlier with respect to the position of the upward moving piston.

When the engine is operated under part throttle, there is vacuum in the intake manifold and consequently the charge taken into the cylinder is not so highly compressed. With lower compression in the cylinder, the spark must enter the cylinder earlier in the cycle so that the mixture can be ignited, burn, and give up its power to the piston. Lower compression means a slower rate of flame spread in the cylinder as the spark occurs. If the spark occurs earlier in the cycle, that is, if there is some additional spark advance, full burning of the charge and maximum economy is achieved. This advance is obtained by connecting into the intake manifold with a vacuum line, and running this line to the distributor vacuum advance mechanism.

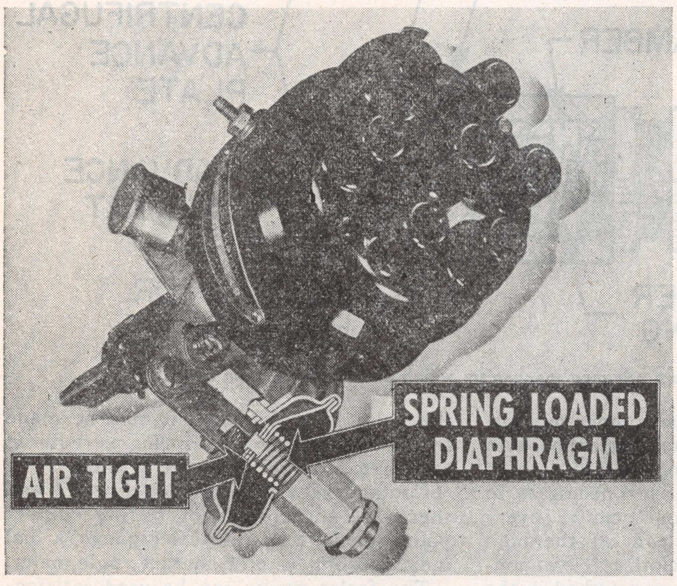
There are two types of vacuum advance mechanisms in widespread use. One type, used on Auto-Lite and Delco-Remy distributors, makes use of a spring loaded



Top view of distributor with breaker plate removed to show centrifugal advance mechanism.



Vacuum advance mechanism (AUTO-LITE) of the type which is mounted on the side of (and integral with) the distributor. Breaker plate is supported on a bearing, and the breaker plate alone rotates in the housing as vacuum conditions change.



Vacuum advance mechanism cut away to show internal parts. This type is clamped around distributor stem so that the distributor is rotated in its mounting as vacuum conditions change in the intake manifold.

diaphragm which is connected through linkage to the distributor. The spring loaded side of the diaphragm is air tight and is connected through the vacuum line to the carburetor. When vacuum from the intake manifold is introduced into the vacuum advance mechanism, the diaphragm is pulled in against the spring, causing the distributor to be rotated in its mounting. This rotational movement carries the breaker plate and contact points around to an advanced position, so that the breaker cam closes and opens the points earlier in the cycle.

One type of distributor used with this design of vacuum advance mechanism has the vacuum advance mechanism mounted about the stem of the distributor, so that the distributor complete is rotated in its mounting well. The other type of distributor has the breaker plate mounted on a bearing so it is free to rotate for a number of degrees within the distributor housing.

The second type of vacuum advance mechanism, which is used on Ford distributors, makes use of a mechanical brake operated by the vacuum in the intake manifold which tends to retard the centrifugal advance weight plate and thus counteract the effect of the centrifugal advance mechanism.

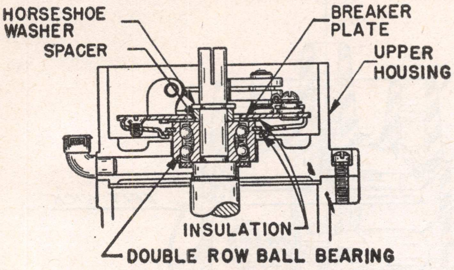
When the intake manifold vacuum is high, the vacuum operates the advance mechanism, pulling the plunger out against the spring so that the spring tension is relieved and the braking effect eased off. This allows the centrifugal advance mechanism to operate and advance the spark. When the intake manifold vacuum is lowered, as for example when the engine is operated under load at wide open throttle, the vacuum plunger comes into operation, and the plunger spring forces the brake shoe against the centrifugal advance plate so that the centrifugal advance mechanism cannot advance the spark quite so much, with the result that the spark occurs later in the cycle than would otherwise be the case. This type vacuum advance mechanism is adjustable, since the spring tension may be increased or decreased as necessary.

Some distributors have two sets of contact points. Such distributors are used on three types of applications, with either one or two ignition coils.

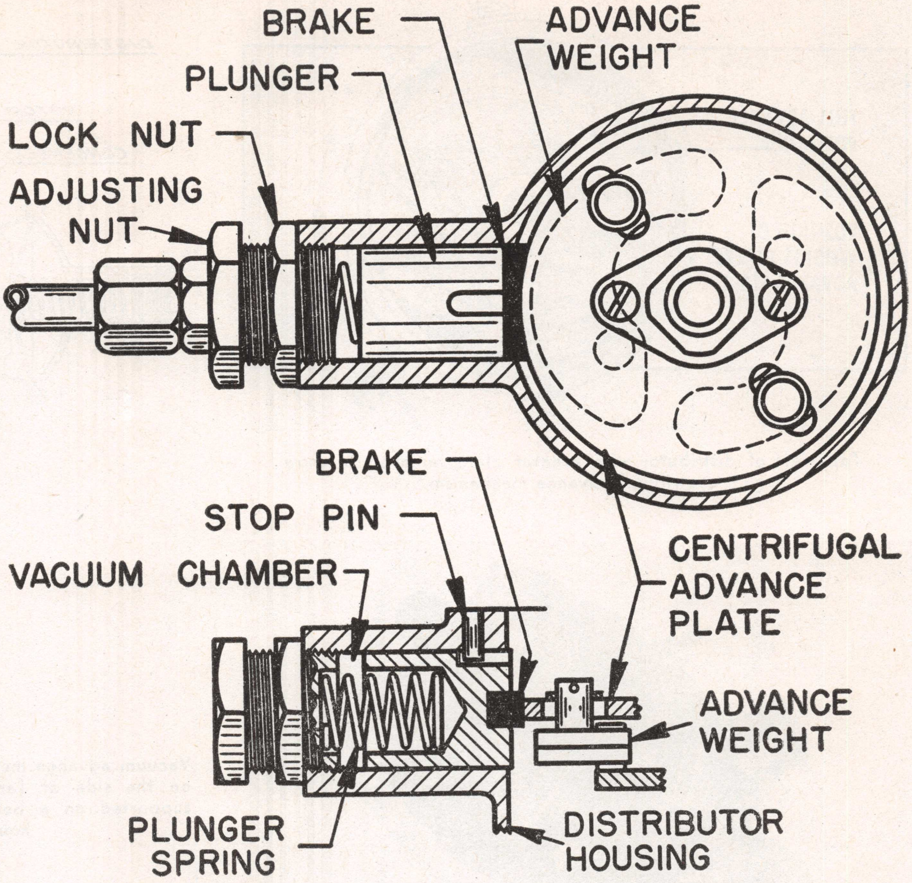
The most common is the application in which the contact points are connected in parallel, as in the Ford ignition system, with one set closing the circuit from the battery to the ignition coil, and the other set opening the circuit. By this arrangement, the ignition coil is kept connected to the battery for a somewhat longer interval of time, permitting a longer coil build-up time. This is designed to produce a greater magnetic strength in the ignition coil, so that a stronger spark is created, especially at higher speeds.

A second application of the dual breaker distributor makes use of two ignition coils and two sets of spark plugs for twin ignition, such as is used on Nash. This is, in effect, two separate and distinct ignition systems. The two sets of contact points close and open simultaneously, causing high voltage surges to be created in each ignition coil and the simultaneous appearance of sparks at both spark plugs in the cylinder.

The third application of the dual contact point distributor might be termed the double alternate, since one set of points fires one half the cylinders, while the other



Vacuum advance mechanism (DELCO-REMY) installed on distributor in which the breaker plate is supported on a double-row ball bearing.



Type vacuum advance mechanism which employs a vacuum brake.

set fires the other half. The contact points work alternately, one set closing and opening to fire one cylinder, while the other set fires the next cylinder in firing order in the engine.

DISTRIBUTOR DISASSEMBLY

The disassembly procedure on any ignition distributor is fairly obvious and easy. On some of the units, there is a rather complex stack-up of insulating, lock, and flat washers at the terminal, but a moment's study of this before the parts are detached from each other will aid in reassembling them correctly. On Delco-Remy and Auto-Lite distributors, the cap and rotor should be removed as the first step in disassembly. Next, the breaker plate, together with the contact points and, on many distributors, the condenser, should be detached from the housing. The drive gear or coupling may then be removed from the drive shaft and the drive shaft with the centrifugal advance mechanism lifted from the distributor housing. Further disassembly of the breaker plate and the centrifugal advance mechanism is obvious.

Ford ignition distributors, also, are easy to disassemble. Remove the cap or caps (on V8's previous to 1942) and snap springs. The coil and condenser may be disconnected and detached. The breaker plate locking bolt and vacuum advance mechanism may be removed. The snap ring on the under side of the distributor may be pried out so that the breaker plate and advance mechanism, as a unit, can be removed from the housing. The advance mechanism may be separated from the breaker plate. If points are removed from the breaker plate, note the relationship of the insulators and leads. The stationary contact assembly has insulators on which the spring of the breaker arm is attached with a screw, lockwasher, and washer. The 1942 Ford V8 distributor is similar to earlier units, except that a single cap and rotor is used in place of the dual cap and rotor setup of former years.

CHECKS OF DISTRIBUTOR PARTS

The molded parts such as cap, rotor, insulating washers, bushings, etc., should be checked for cracks, chips, burned places indicating high tension leakage to ground. The parts should be wiped with a clean soft cloth. Other parts may be cleaned with carbon tetrachloride or some similar cleaning compound. The contact points should be examined for excessive burning, pitting, or wear. Points may be cleaned with a few strokes of a clean, fine-cut contact file or contact stone. It is not necessary to file the points down and remove every trace of pits. Merely clean off the high spots. Never use emery cloth to clean contact points, since emery may embed in the points and cause rapid contact point burning and wear. The rubbing blocks and bushings should be tight and not excessively worn. Bushings or bearings should be replaced, as needed.

REASSEMBLY AND ADJUSTMENT OF DISTRIBUTOR

Bushings and bearings should be lubricated on reassembly. In addition, a drop of oil may be added to the breaker arm pivot, and several drops to the felt wick at the top of the breaker cam. A trace of petrolatum or similar grease may be put on the breaker cam. Avoid excessive lubrication. On Auto-Lite distributors with laminated centrifugal advance weights, the pockets in the weights should be filled with grease. Distributors having a breaker plate mounted on a ball bearing should have the ball bearing repacked with ball bearing grease if of the non-sealed type.

After the contact points have been reinstalled on the breaker plate, the point spring tension should be measured by pulling on the movable point with a spring scale hooked on the arm at the point, with the pull being exerted in a line vertical to the point face. Adjustment may be made by carefully bending the spring as required to increase or decrease the tension.

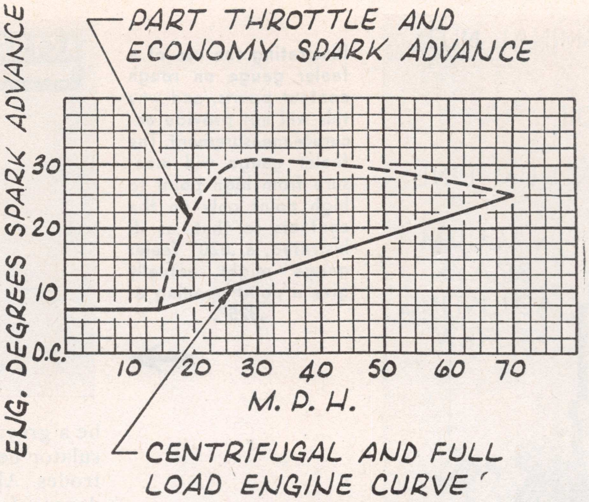
Contact point opening should be set, and there are three ways of setting contact point opening: by the feeler gauge, a dial indicator, or a cam or contact angle meter.

The feeler gauge can be used satisfactorily on new points, or points which have not become rough in service. Using a feeler gauge on rough points means that the point opening will be set too wide. The feeler gauge measures only from high point to high point on the contacts, and not the true point opening.

Dial indicators are supplied in various designs, and can be attached to the distributor so that, as the breaker cam is rotated, the actual movement of the contact point on the breaker arm can be measured in thousandths of an inch. By using a device of this sort, very accurate contact point adjustment can be made.

The third method of measuring contact point opening is by electrically measuring the cam or contact angle or dwell. This is the number of degrees in breaker cam rotation through which the contact points remain closed. There is a definite relationship between the cam or contact angle and the contact point opening. As contact point opening is decreased, the contact points remain closed longer, which means that the cam angle is increased. Increasing the contact point opening lowers the cam angle.

Curves of centrifugal and vacuum advances. The total advance obtained is the result of the centrifugal, plus the vacuum advance, produced by any particular combination of operating speed and intake manifold vacuum conditions. The centrifugal advance mechanism produces a certain definite amount of spark advance for any particular speed. Added to this spark advance will be the advance contributed by the vacuum mechanism.



Contact point opening (or cam angle) is adjusted on many distributors by loosening the stationary contact support lock screw, and turning the eccentric so that the stationary contact point is moved closer to or further from the breaker arm contact point. On other distributors, the stationary contact point is mounted on the end of a contact screw which is locked in place by a locking nut. When the nut is loosened, the contact screw may be turned in or backed out to adjust the contact point opening.

After the distributor has been reassembled and the contact point opening and point pressure checked and adjusted, the distributor should be checked on a distributor tester so that the action of the centrifugal and vacuum advance mechanisms can be studied through the operating range.

SYNCHRONIZING FORD DISTRIBUTOR CONTACT POINTS

In addition to setting the contact point opening, Ford distributors, having dual contact points, must have the points synchronized. A distributor tester is required for this operation. The approved method is as follows:

After installing the distributor on the tester, block open the contact points which close first as the cam rotates in its normal direction of rotation, using a piece of fibre or bakelite. Operate distributor and adjust other set of points to the specified cam angle or dwell. Remove the fibre and adjust the second set of points so that the total cam dwell, with both sets of points operating, is within the specifications. Stop the tester, block open the set of points which close last, then test the cam angle of the other set. The cam angle of this set should be within a few degrees of the cam angle of the set of points which were adjusted first. If they are not, the indication is that the breaker plate is in error. The distributor is timed after the points have been set and synchronized by moving the timing screw on the side of the distributor to a position so that the points open at zero degrees. The vacuum brake may then be installed and adjusted to provide the proper vacuum advance.

DISTRIBUTOR DEFECTS REQUIRING FURTHER ANALYSIS

Certain defects which develop in the distributor in operation on the vehicle are an indication of conditions in the engine or on the applications which are abnormal and which should be corrected in order to prevent a repetition of the trouble.

Rapid centrifugal advance mechanism wear, for example, may indicate loose or worn timing or driving gears, or a worn oil pump which produces torsional vibration in the distributor, thus causing rapid centrifugal advance mechanism wear.

Burned contact points may be produced by excessive resistance in the condenser circuit (high series resistance) which requires replacement of the condenser or tightening of the condenser lead.

If oil or crankcase vapors get into the distributor they may deposit on the contact point surfaces, causing them to arc and burn rapidly. A glance at the breaker plate and point support will disclose this condition, for oil produces a smudgy line under the contact points. Careless handling of contact points during installation may also cause oil or grease to get on the contact surfaces to produce this condition.

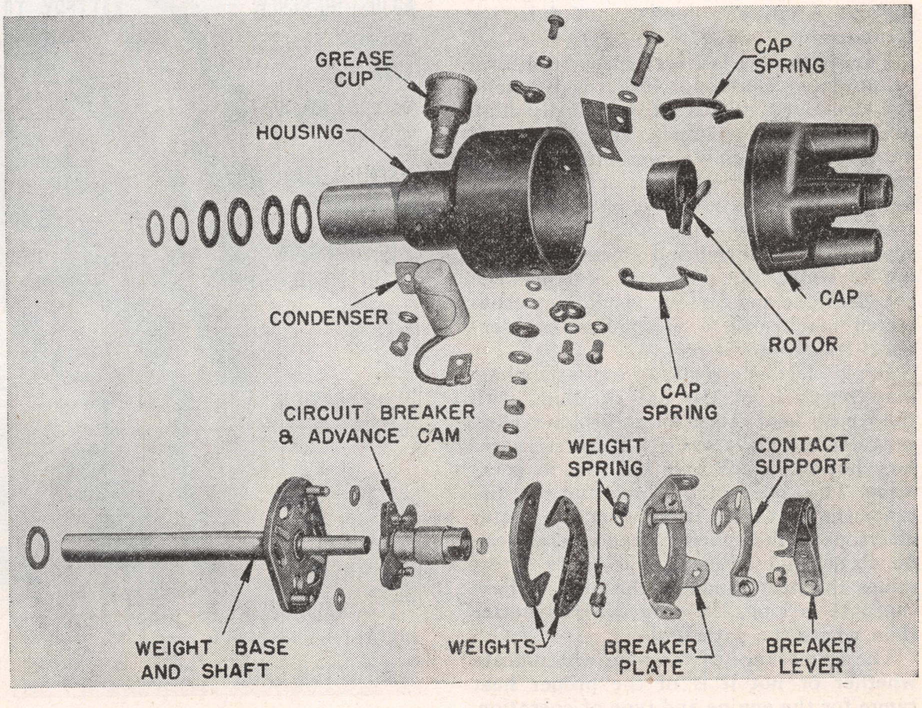
If the contact points are set too close, the contact angle will be so large that excessive current will flow through the points, causing them to burn with excessive rapidity. Another cause of burned contact points is high voltage in the electrical system, produced by a high voltage regulator or third brush setting.

Weak contact point spring tension may permit the contacts to bounce and chatter, particularly at high speed, so that heavy arcing and rapid burning of the points takes place.

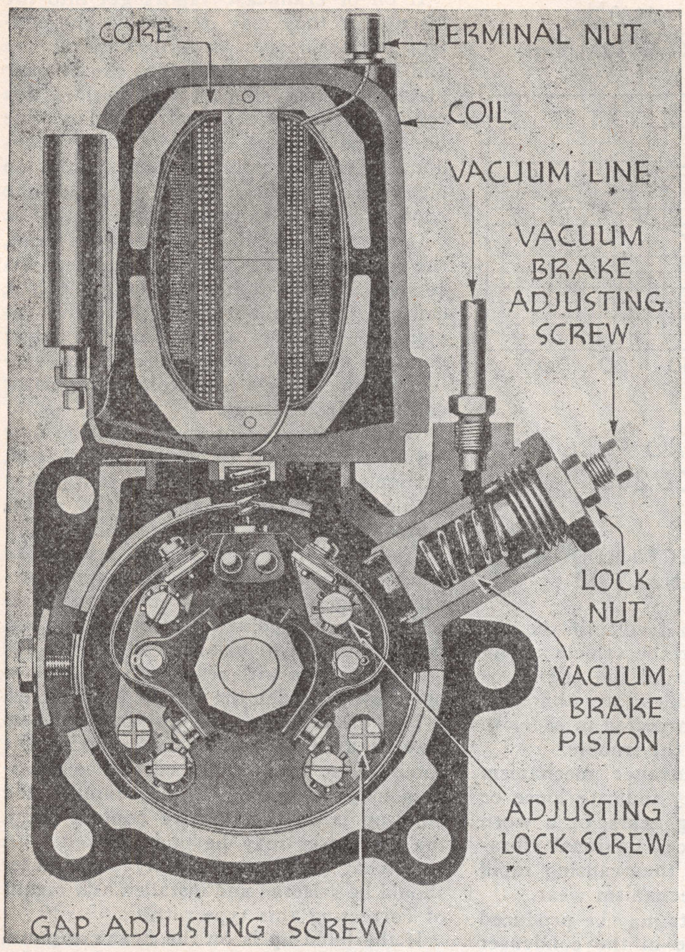
Contact point pitting may take place where abnormal operating conditions exist. Pitting is the transfer of contact material from one point to the other, and is a result of an out-of-balance condition in the ignition system with respect to the type of operation to which the vehicle is subjected.

The direction of the pit and build-up may be used as a guide in analyzing the condition so that proper corrective measures may be taken. If, for example, the build-up is on the positive contact point, the condenser may be undercapacity. A somewhat higher capacity condenser should be selected and installed as a means of correcting this type pitting.

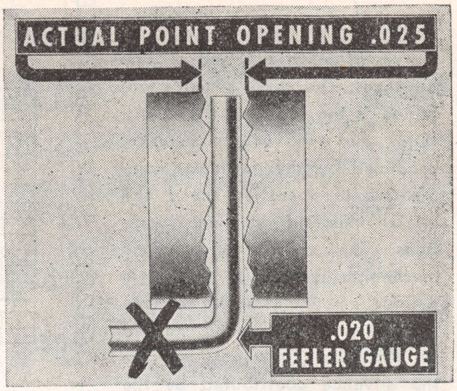
If the build-up is on the negative point, the condenser may be overcapacity, and a lower capacity condenser should be installed.



Exploded view of a typical ignition distributor.


CORE
TERMINAL NUT
COIL
VACUUM LINE
VACUUM BRAKE ADJUSTING SCREW
LOCK NUT
VACUUM BRAKE PISTON
ADJUSTING LOCK SCREW
GAP ADJUSTING SCREW

FORD. 1937-41 V8 distributor and coil.


ACTUAL POINT OPENING .025
.020 FEELER GAUGE

Illustrating the use of a feeler gauge on rough contact points, and why this will not provide accurate measurement. The feeler gauge will measure from high point to high point only on the contacts so that, as illustrated, a .020" feeler gauge might actually give a point opening of .025".

SPARK PLUGS

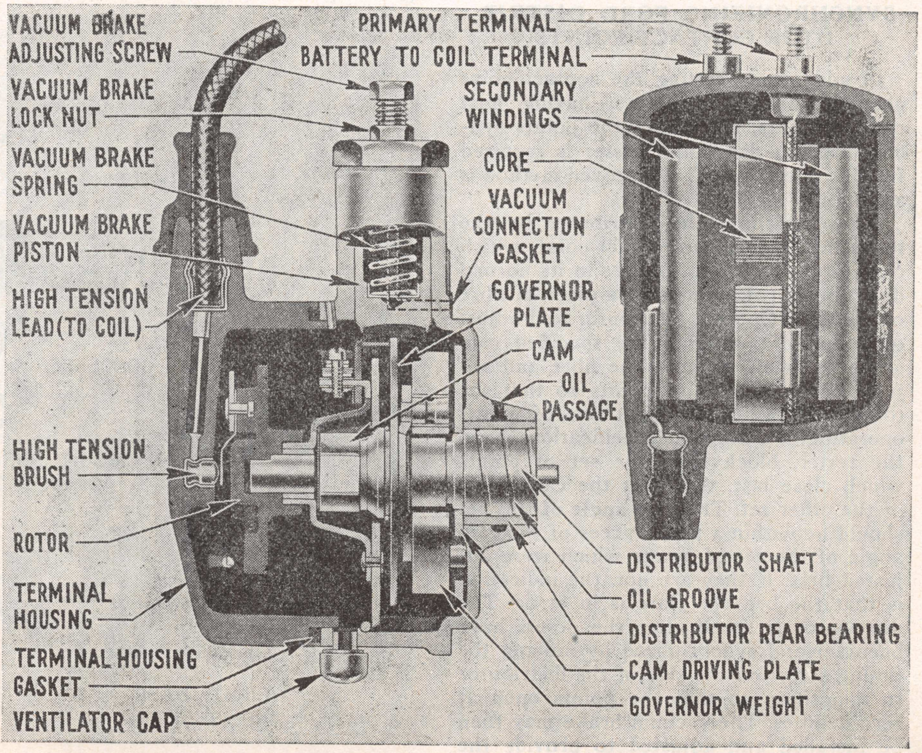
The various types of defects which may develop in spark plugs may be grouped into four general categories; normal wearing out, wrong gap, fouling, and defective insulator.

The spark plug is a very specialized form of insulated electrode; it must withstand the combined effects of terrifically high pressures, high voltages, and high temperatures. Ultimately, these conditions will cause the plug to wear out or become defective. The electrodes may wear away due to the high voltage and temperatures. The repeated mechanical and electrical stressing to which the plug and seal between the electrode and ceramic insulation is subjected may cause a mechanical or electrical leak to develop.

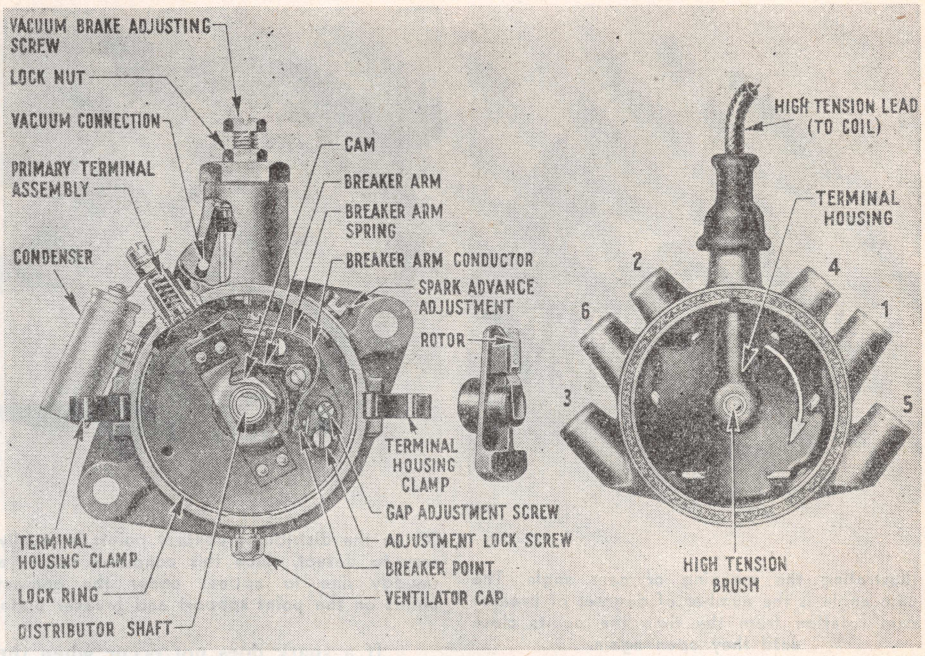
Rapid electrode wear, as well as fouling, may result from the use of plugs with the wrong heat range for the engine. Heat range is merely a term which designates how hot the spark plug will run in operation. The shape of the plug and the distance the heat must travel from the center electrode to the cylinder head where it can be absorbed by the cooling water determines the heat range of the plug. Where the path is long, the plug will run hotter than where the path is short.

The appearance of the plug will indicate whether or not it is of the proper heat range for the engine and type of operation. If the plug is operating too hot, there will be a greyish or nearly white cast on the insulator between the center and outer electrodes. Also, the electrodes will show evidence of rapid burning away, since plugs operating too hot will have rapid electrode wear. If the plug is operating too cold there will be a carbon deposit on the insulator between the center and outer electrodes, since there will not be sufficient heat developed and retained to burn away this carbon deposit. This carbon deposit may provide a leak-over path so that the high voltage surge may leak from one to the other electrode instead of firing the charge in the cylinder in the normal manner. Excessive oil in the cylinder, or excessive choking of the engine on starting or running, will also cause the plug to foul up. If a hotter plug is installed, carbon formation will be prevented.

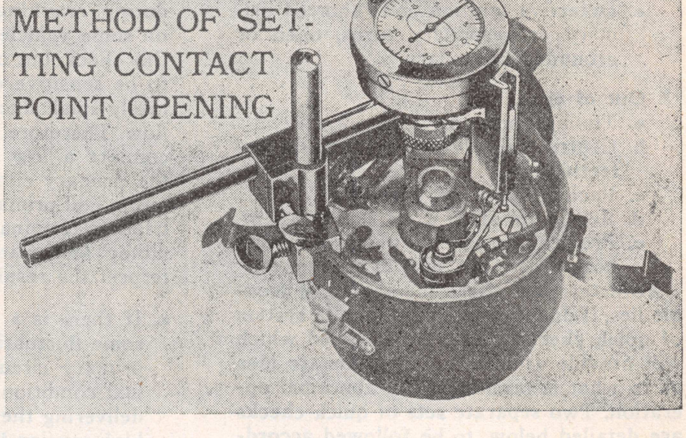
If the electrodes do not appear to be excessively worn away, and if the insulator is not cracked, chipped, or loose, the plug may be cleaned in a plug-cleaning machine,


VACUUM BRAKE ADJUSTING SCREW
VACUUM BRAKE LOCK NUT
VACUUM BRAKE SPRING
VACUUM BRAKE PISTON
HIGH TENSION LEAD(TO COIL)
HIGH TENSION BRUSH
ROTOR
TERMINAL HOUSING
TERMINAL HOUSING GASKET
VENTILATOR CAP
PRIMARY TERMINAL
BATTERY TO COIL TERMINAL
SECONDARY WINDINGS
CORE
VACUUM CONNECTION GASKET
GOVERNOR PLATE
CAM
OIL PASSAGE
DISTRIBUTOR SHAFT
OIL GROOVE
DISTRIBUTOR REAR BEARING
CAM DRIVING PLATE
GOVERNOR WEIGHT

FORD. Sectional view of 1942-46 V8 distributor and coil.



FORD SIX. Distributor.



Dial indicator in use on a distributor, measuring the contact point opening.

and the plug gap reset. In resetting the gap, care must be taken to bend the outer electrode only. If the center electrode is bent in any way, it may crack or chip the ceramic insulation so the plug is ruined. On reinstallation of the plug on the engine, be careful to draw the plug up only to the manufacturer's specified tightness, using a new gasket.

CHEVROLET REVERSING SWITCH

Chevrolet adopted, in 1941, a current reversing switch which is an integral part of the ignition system, and which is designed to reverse the flow of current through the distributor contact points every time the engine is started. It thus provides an effective control of contact point pitting. The reversing switch is mounted on the starting motor, and linked to the starting motor shift lever so that it operates each time the starting motor shift lever is depressed for starting the engine.

The switch contains three contactors mounted symmetrically on an insulating contactor plate which rotates 60 degrees each time the switch is operated. The illustrations show positions of the contactors with the direction of current flow through the ignition distributor contact points indicated by arrows. The distributor breaker plate is insulated so that both contact points, the movable and the stationary, are insulated from ground and are connected to two separate insulated terminals.

When the engine is stopped and started again with the starting motor, the reversing switch contactors rotate 60 degrees so that the current flows in the opposite direction through the distributor contact points. This cancels out any tendency there might be for contact point pitting to occur, so the points remain serviceable for a longer period of time.

The connector link from the cranking motor shift lever and the reversing switch contains a spring which compresses after the reversing switch lever reaches the limit of its travel and comes up against the switch stop. This compensates for any variation in the switch mounting, and takes care of whatever wear may occur.

The reversing switch operation should be checked on the vehicle, as follows:

1. Turn on ignition switch. The dash ammeter will indicate an ignition load if the contact points are closed. Contact points will normally be closed.
2. Slowly depress the starting motor switch pedal. After the switch pedal becomes partly depressed, the ammeter needle will return to zero, indicating that the reversing switch contactors have begun to rotate in the switch.
3. Further movement of the pedal recloses the ignition primary circuit as the contactors complete their 60 degrees of rotational travel. This will indicate on the dash ammeter.
4. Additional movement of the pedal (5 degrees rotation of the reversing switch lever) will cause the reversing switch to click as the switch ratchets.
5. After the click, only about ⅛ inch additional movement of the starting motor switch pedal will close the starting motor switch so that cranking takes place.

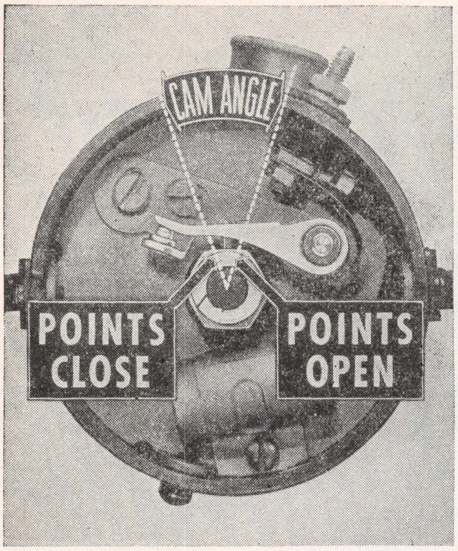
If the switch does not operate in the manner detailed above, first check the leads, connections, and mounting, to make sure all are in good condition. If the switch appears to be defective, replace it. The condenser on this application using the reversing switch has a somewhat higher capacity than the condenser used on most trucks and passenger cars. Consequently, if for any reason the reversing switch is shorted out or removed from the application, the condenser must also be changed, and a condenser of standard capacity (approximately .20 mfds.) installed.

CAUSES OF IGNITION TROUBLES

The ignition system is closely tied in with the engine, so that it is sometimes difficult to tell off-hand whether some defective engine operation is the result of trouble in the ignition system or in some other component of the engine. Below is a detailed analysis of ignition troubles, with a quick check procedure which may aid in locating many of the abnormal conditions in the ignition system which could cause defective engine operation.

Failure of the ignition system to perform in a normal manner may be attributed to any of three general causes, as follows:

1. **Loss of energy in the primary circuit.**
   - a. Resistance in circuit due to loose connections, defective leads, burned contact points or ignition switch contacts, open or high resistance connection in coil primary winding, improperly set contact points.
   - b. Condenser defective; shorted, low insulation resistance, high series resistance.
   - c. Run-down battery.
   - d. Grounded primary circuit in the coil, wiring or distributor insulated terminal.
2. **Loss of energy in the secondary circuit.**
   - a. Defective high tension wiring.
   - b. Defective connections in high tension circuit.



Illustrating the meaning of cam angle. The cam angle is the number of degrees of breaker cam rotation from the time the points close until they open again.

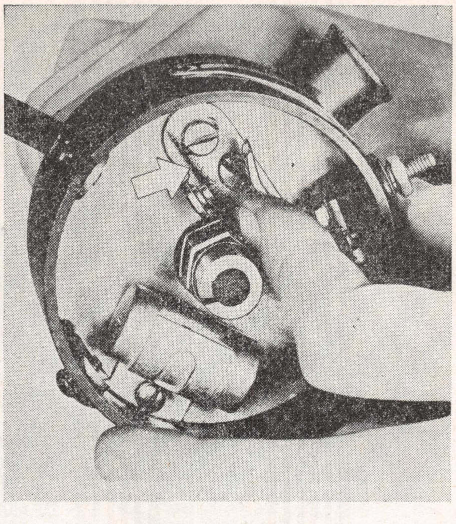
- **c.** Plugs defective; fouled, cracked, out of adjustment.
- **d.** High tension leakage across coil head, distributor cap or rotor.
- **e.** Defective ignition coil; shorted primary or secondary turns, open or grounded secondary.

3. Out of time.

- **a.** Timing improperly set.
- **b.** Centrifugal advance mechanism defective.
- **c.** Vacuum advance defective.
- **d.** Bearing or shaft worn, or shaft bent.
- **e.** Pre-ignition due to plugs of wrong heat range, hot spot in engine, etc.

To determine where the source of trouble lies, if due to ignition, a definite system of quick checking may be followed which will provide at least an approximate idea as to what is producing the abnormal operation. Two separate sets of quick checks are detailed below, to be followed according to whether the engine does or does not run.

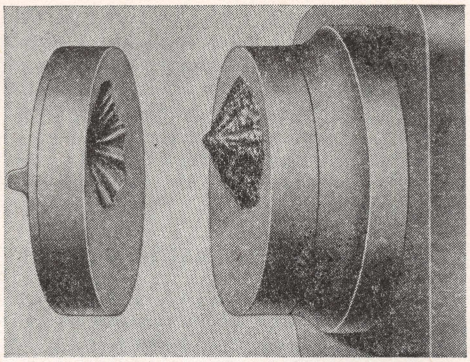
1. If the engine does not start, even though the starting motor cranks the engine at normal cranking speeds, the lead should be removed from one spark plug and held about 3/16 inch from the engine block while the engine is being cranked. If a good spark occurs while the engine is being cranked, then the ignition primary and secondary circuits can be considered as being okeh. The trouble here is likely arising from some condition in the engine such as carburetion, fuel line, etc. There is also the possibility that the ignition is very much out of time, or that all the spark plugs have become defective at once so they will not fire. These latter two conditions, however, would be rather unusual, since it would be rare that all plugs would become defective simultaneously, or that the ignition timing would get so badly out of adjustment as to fail to fire the plugs at all.



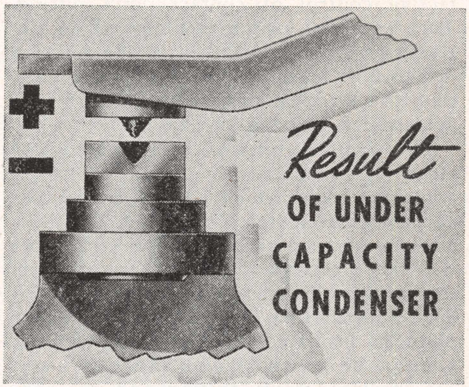
Oil on the distributor contact points is usually easy to detect, since this condition causes a smudgy line to appear under the contact points on the point support and breaker plate.

If a spark does not occur when the engine is being cranked and a spark plug lead is held 3/16 inch from the engine block, the current draw of the ignition primary circuit should be checked during cranking. The dash ammeters on some vehicles can be used to make this check, but others will not be found to be sensitive enough to detect accurately small fluctuations in the current flow. Therefore, it may be necessary to connect a low reading ammeter into the primary circuit at the exposed ignition coil primary terminal or the distributor terminal. Operate the starting motor and watch the ammeter. Interpret the results as follows:

- **a.** If there is a small reading showing some fluctuation while cranking, the primary circuit is probably in normal condition. The secondary is not delivering the spark due to defective high tension leads or connections, to a defective ignition coil or condenser, or to high tension leakage across the coil head or distributor cap or rotor.
- **b.** If there is no reading at all, the primary circuit is open, due to loose connections, defective wiring or switch, distributor contact points out of adjustment, oxidized, or dirty so they are not making contact, or an open coil primary winding. The contact points may be inspected and the open circuit in the primary located by using a voltmeter. Check from each exposed terminal to ground. Approximate battery voltage means the circuit is complete up to that terminal. No voltage reading means the circuit is open at that place.



Pitted contact points. Material transfers from one to the other point.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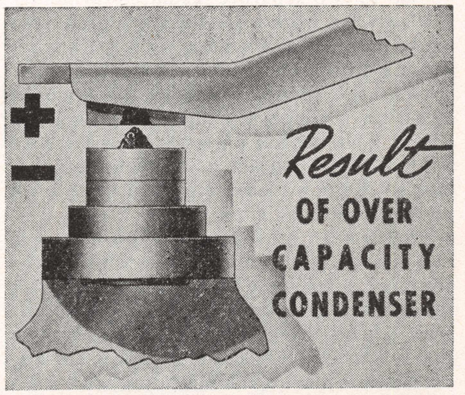
Result OF UNDER CAPACITY CONDENSER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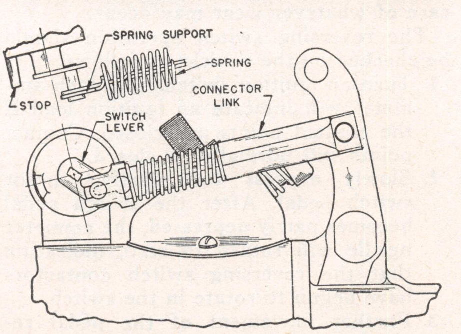
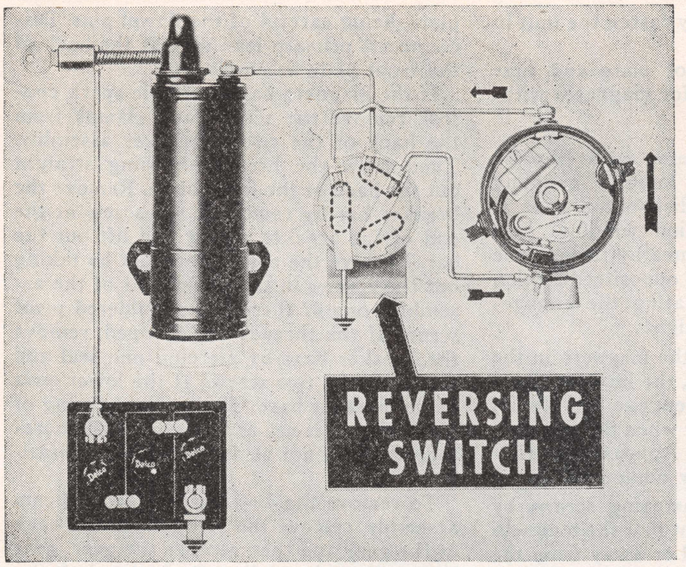
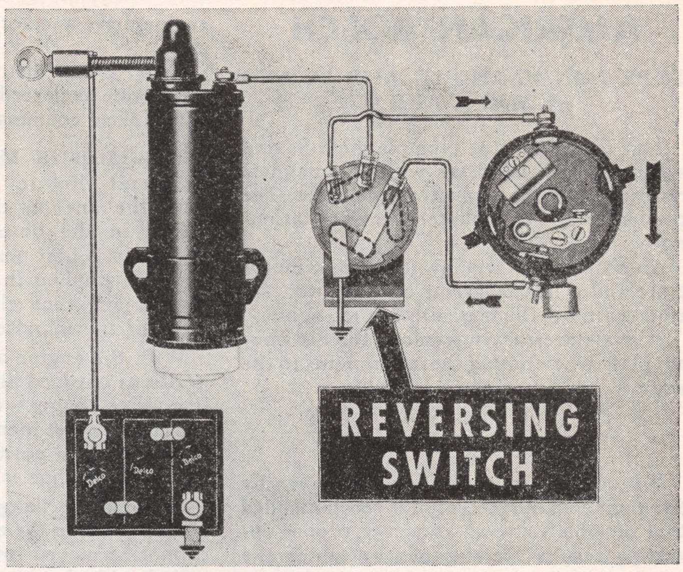


Reversing switch mounted on starting motor and linked to the starting motor shift lever

- **c.** If the ammeter shows a steady reading of several amperes without fluctuation as the starting motor operates, the contact points are out of adjustment so they are not opening, or the coil primary winding or circuit is grounded, either in the coil, the wiring, in the distributor, or the condenser. If the starting motor cranks the engine slowly or not at all, then the trouble probably lies in the battery, the battery cables, connections, or in the starting motor itself.



Wiring circuit of reversing switch and ignition primary circuit. With the reversing switch contactors in the positions shown in the dotted lines, the current flows through the distributor contact points as shown by the arrows.



Wiring circuit of reversing switch with the contactors rotated 60° so that the current flows through the contact points of the distributor in the opposite direction.

2. If the engine runs, but does not perform, satisfactorily, some idea of the cause of trouble, if it is due to ignition, may be gathered by noting the manner in which the engine is performing. Since so many other factors besides ignition enter into the engine operation, it is often difficult to detect the source of trouble without making a complete and comprehensive engine check and tune-up. The following conditions may be kept in mind:

a. Detonation or spark rap, other than that caused by certain grades of fuel, may be caused by improper timing, improper operation of the centrifugal or vacuum advance mechanisms, points out of adjustment, worn distributor shaft or bearing or bent shaft, or plugs of wrong heat range. The variations in octane ratings of various fuels may require some re-adjustment of the spark timing as the vehicle is changed from one to another grade of fuel. If the centrifugal or vacuum advance mechanisms are not performing properly, the spark may be advanced too far for the operating condition, with a consequent pinging or knocking. Misadjustment of the contact points may have a similar result. Worn distributor shaft or bearing, or a bent shaft may cause the contact points to open earlier in the cycle for some of the cylinders than for others, with the result that spark rap will be noticed in those cylinders. Hot spots in the cylinder or plugs may cause misfiring which may seem to be spark rap.

b. Improper ignition timing may cause the engine to overheat. It is not justifiable to say, however, that all engines which overheat do so because of improper setting of the ignition timing, since many other conditions in the engine will also cause overheating.

c. If the engine is hard to start, or misses, or shows loss of power, a complete check of the ignition system is in order, along with a regular engine tune-up.

MAGNETOS

AMERICAN BOSCH

TYPE MJA 4C AND 6C, MJB 4A AND 6A, MJC 4C AND 6C

This is an inductor type magneto having stationary coil windings with the magnets rotating between laminated pole shoes. The condenser and interrupter are also stationary.

An observation window in the distributor plate and a line or arrow on the rotor, facilitate timing the magneto to the engine.

It is unnecessary to remove the distributor plate when timing these magnetos to the engines.

TIMING THE MAGNETO

Where specific instructions are given by the engine manufacturer, it is recommended that they be followed. However, proper operating results are obtained by timing the magneto to the engine, as follows:

Turn the engine until No. 1 piston comes up on its compression stroke and reaches T.D.C. or some other ignition mark on the flywheel. Set the spark control in its retarded position.

Base-Mounted Magnetos without Impulse Coupling: Rotate the magnet rotor until the line on the distributor gear is visible in the observation window.

Mesh the drive coupling on the magneto with the engine drive. Approximate timing to the engine is now obtained. Carefully align the magneto with the engine drive and securely fasten the unit in place.

Remove the distributor plate by loosening the four screws. This will expose the interrupter assembly.

To obtain the exact timing, the interrupter points must just begin to open. It may be necessary, in order to get that position, to loosen the adjustable drive member and turn the magnet rotor in a clockwise or anti-clockwise direction.

Reinstall the distributor plate and insert the cable between outlet No. 1 and cylinder No. 1 which is then timed to fire correctly.

Complete the installation by connecting the remaining cables of the magneto to the spark plugs in their proper firing order. The firing sequence on the distributor or high-tension end of the magneto follows the opposite direction of rotation from that indicated by the arrow on the magneto name plate, and must be taken into consideration when the cables are connected to the spark plugs.

Base-Mounted Magnetos with Impulse Coupling: Rotate the impulse coupling until the line on the distributor gear is visible on the observation window. This operation is best performed by turning the impulse coupling in the opposite direction of rotation to that in which it will be driven by the engine, thus eliminating the engagement of the impulse weights.

Mesh the impulse coupling with the engine drive. Approximate timing is now obtained. Carefully align the magneto with the engine drive and securely fasten the unit in place.

Remove the distributor plate and time the engine as described for magnetos without impulse couplings.

Flange-Mounted Magnetos with Impulse Coupling: Rotate the impulse coupling until the line on the distributor gear is visible in the observation window. This operation is best performed by turning the impulse coupling in the opposite direction of rotation, thus eliminating the engagement of the impulse weights.

With the engine and the magneto in the positions outlined above, the impulse coupling drive tongues will engage the slot in the engine drive member when the magneto is flanged into position. Approximate timing to the engine is now obtained.

Tighten the flange fastening screws by hand but not to the extent that the magneto cannot be moved toward or away from the cylinder block.

Remove the distributor plate and expose the interrupter assembly.

To obtain the exact timing, the interrupter points must just begin to open. It may be necessary, in order to get that position, to turn the magneto slightly toward or away from the cylinder block. Tighten flange fastening screws.

Reinstall the distributor plate and insert the cable between outlet No. 1 and cylinder No. 1 which is then timed to fire correctly.

Complete the installation by connecting the remaining cables of the magneto to the spark plugs in their proper firing order. The firing sequence on the distributor or high-tension end of the magneto follows the opposite direction of rotation from that indicated by the arrow on the magneto name plate.

Interrupter: To adjust the contact point opening gap, rotate the magneto until the fibre bumper is on the highest point of the cam. The gap can be adjusted by the adjustable bracket which can be shifted by an eccentric screw.

The interrupter point gaps are as follows: Type MJA, standard duty, .014" to .018". Type MJA, heavy duty, .012" to .016". Type MJB, .014" to .016". Type MJC .014" to .018".

EDISON-SPLITDORF

The Edison "CD" magneto is designed for practically all standard types of one to six cylinder engines, with base or flange type mounting. A fully automatic and sealed impulse starter is included and the circuit breaker is mounted at the distributor.

Dismantling: Before undertaking any repairs, remove all external dirt and provide a clean shallow pan in which the parts may be placed as they are removed. Remove the impulse coupling, if one is fitted. Remove two screws and draw the distributor block straight forward. Then draw the distributor rotor straight forward. Remove the safety gap disc. Pierce the seal at the front plate screws and remove the screws. Pry off the plate, being careful of the dowel pins. Disconnect a primary lead wire at the back of the front plate assembly.

If the magneto has a variable spark control, remove the screws and clamps from the back of the circuit breaker assembly. Then draw the breaker housing straight out the back of the front plate. Remove the breaker bar by removing the screw at the end of the breaker spring and lift out the bar. Remove the contact bracket by taking out the screws in the upper half of the assembly; one of these is a shouldered pivot screw. If the threads are stripped, remove the breaker base by piercing one seal and removing the two screws at the lower ends of the breaker base. The internal timing of the magneto is set at this point and therefore it should not be disturbed unnecessarily.

To remove the distributor shaft and cam assembly, remove the screw from the back of the gear and then remove the gear, gear key and spacing collar. Push the shaft assembly straight out toward the front. Where there is a bronze cam, it may be slipped off the shaft. Remove the distributor bearing by pushing it out in a press.

To take out the condenser, remove the screw at the bottom and disconnect the lead at the top of the condenser. After removing the pinion screw, it can be pulled off the shaft. To remove the magnet, pierce the top seal, remove the screw and then lift off the magnet. Use a keeper if no charger is available. To remove the front bearing plate and rotor, remove the main drive key. Remove the two side screws at the front and tap the drive end of the shaft forward. Both the front bearing plate and rotor can be drawn straight out.

Remove the metal grease sealing ring from both main bearings with a special tool. Do not attempt to preserve these sealing rings, as they must be replaced with new ones. Remove the assemblies of balls in the ball retainers. At the drive end, hook out a metal felt retaining ring and the felts. At the gear end, remove the felt at the bearing side.

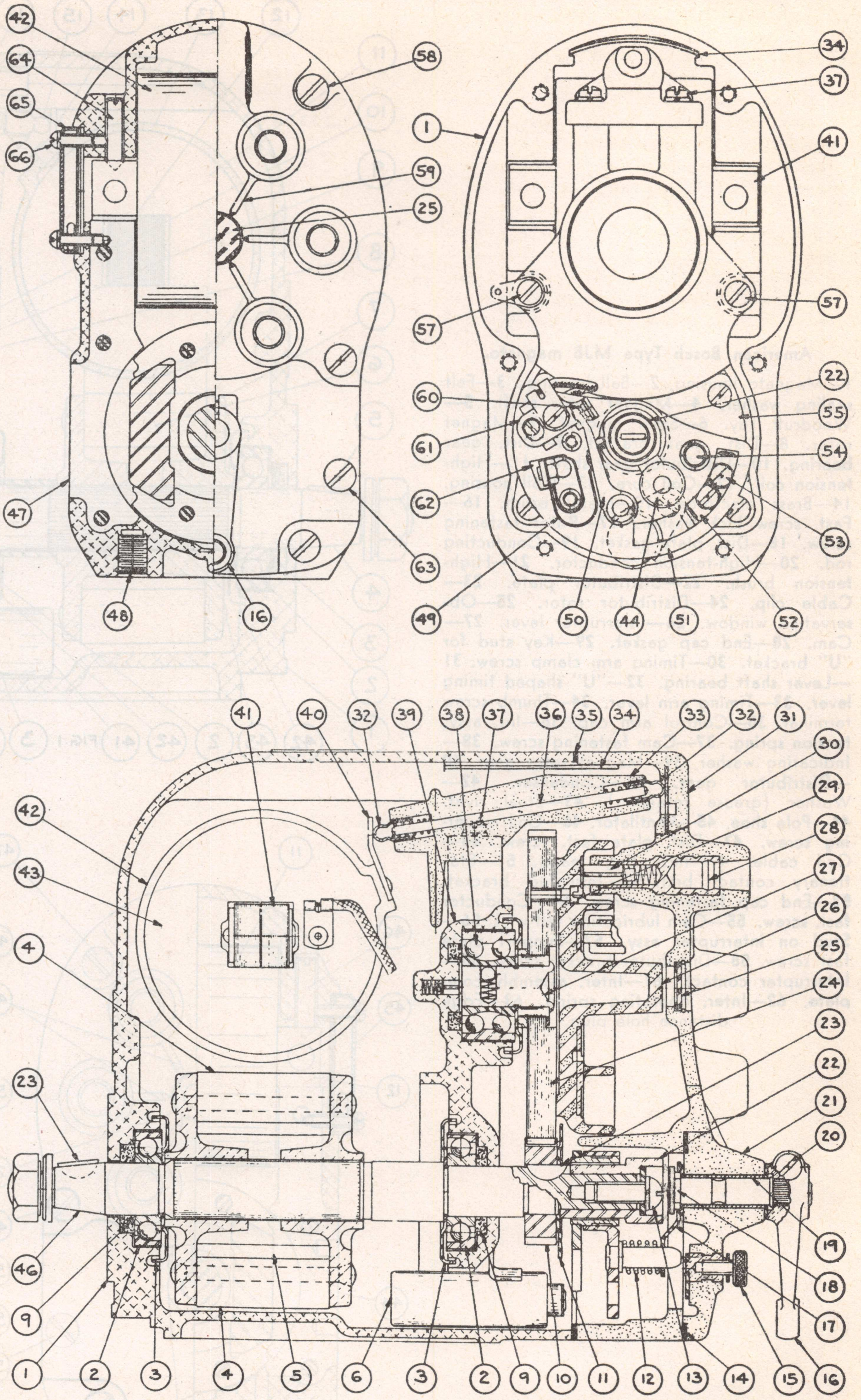
Examine all parts of the bearings for wear or other faults. If all parts are in good condition, they may be used again and it will not be necessary to remove the outer races from the castings nor the inner races from the shaft. If any parts of either bearing are worn, it is advisable to replace both complete bearings. To remove the outer races, tap them gently out of the castings with a small punch operated through the three holes behind the race. At the drive end these holes are closed by three screws which must be removed before the punch can be used. To remove the inner races, pry them off carefully by using two screwdriver blades entered behind the races at two holes provided for this purpose.

It will seldom be necessary to dismantle the magneto beyond this point.

The coil may be tested without removing it from the magneto.

INSPECTION AND RE-ASSEMBLY

Do not soak felt parts or moulded insulating materials in gasoline. Subject in-



American Bosch Type MJA magneto.

1—Magneto housing. 2—Ball bearings. 3—Washer (grease retaining). 4—Magnet rotor. 5—Cast magnets. 6—Condenser. 9—Felt sealing washer. 10—Magnet rotor gear. 11—Indicating washer. 12—Int. assy. tension spring. 13—Cam fastening screw. 14—End cap gasket. 15—Thumb screw terminal. 16—Timing arm lever. 17—"U" shaped timing lever. 18—Key stud for "U" bracket. 19—Lever shaft bearing. 20—Timing ram clamp screw. 21—Control arm cap. 22—Cam. 23—Woodruff key. 24—Distributor gear. 25—Observation window. 26—Distributor rotor. 27—Distributor gear shaft. 28—Cable clip. 29—Rotor fastening screw. 30—High-tension brush. 31—Distributor plate. 32—Contact terminal. 33—High-tension conductor. 34—Insulation. 35—Dist. plate gasket. 36—Conducting rod. 37—Conductor fast. screw. 38—Dist. gear ball. brg. 39—Distributor gear brkt. 40—Brass electrode. 41—Coil core. 42—Coil housing. 43—High-tension coil. 44—Cam lubricating felt wick. 46—Magnet rotor shaft. 47—Pole piece. 48—Edge distance hole screw. 49—Inter. operating spring. 50—Interrupter lever. 51—Inter. assembly complete. 52—Stop angle plate. 53—Support plate fast. screw. 54—Stud on inter. assembly. 55—Inter. support plate. 57—Dist. bracket screw. 58—Dist. plate fast. screw. 59—Indicating marks. 60—Interrupter contacts. 61—Adjustable contact brkt 62—Insulated bracket. 63—End cap fastening screw. 64—Coil mounting screw. 65—Ventilator. 66—Ventilator fast. screw.

sulating parts to electrical test before reusing them.

Clean the magneto housing and rotor thoroughly but do not allow gasoline to get into the oil compartment of the housing. Blow out the oil holes at each end. Install ball races as follows, using the original ones if the bearings are in good condition, or new ones if the bearings are to be replaced. Press the outer races into their seats. Press the inner races on the shaft ends.

Apply the front bearing plate and check the rotor for play. With the front bearing plate screws tight, the rotor should turn freely with not more than the slightest trace of end play or up-and-down play. If such play exists the bearings must be shimmed. The shims go between the inner ball race and the rotor casting at the drive end. To apply them, draw the inner race off, insert shim, re-apply the inner race, and re-check until the desired fit is attained.

After the main bearings are fitted, remove the rotor to grease and seal the bearings. Apply a 3/16 inch, or two 3/32 inch, felt washers at the outside drive end of the housing. Oil them. Press in the felt seal retaining ring. Replace the three screws around the outer race. At the front bearing plate, insert a 3/32 inch felt in the recess in

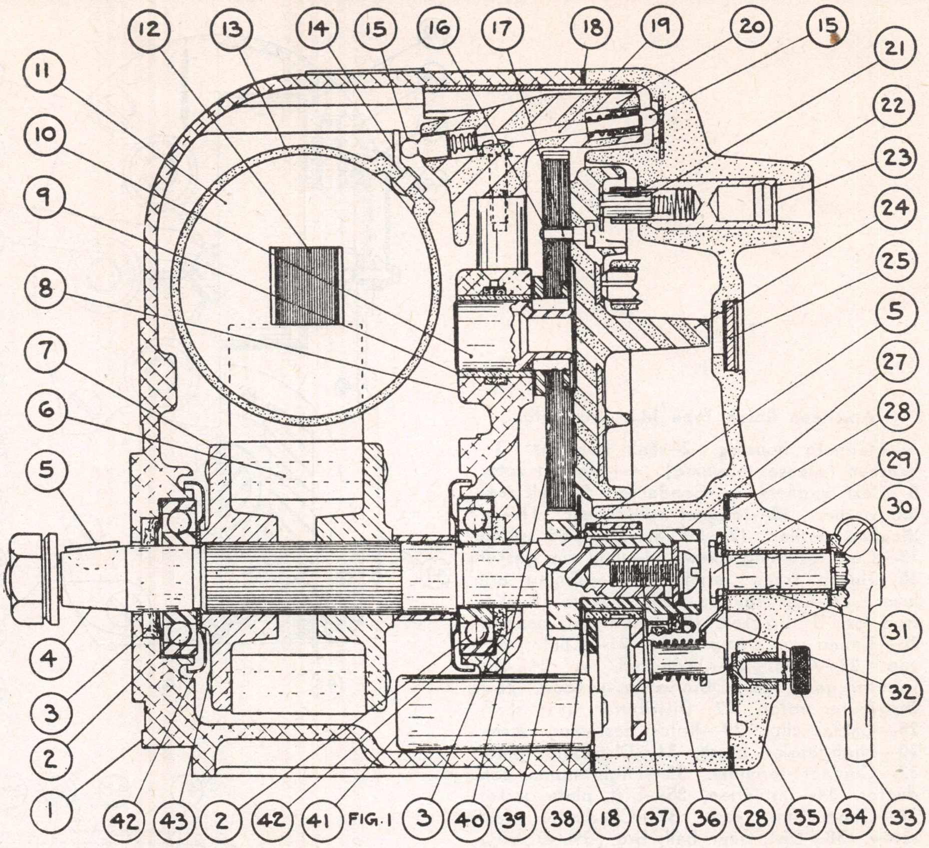
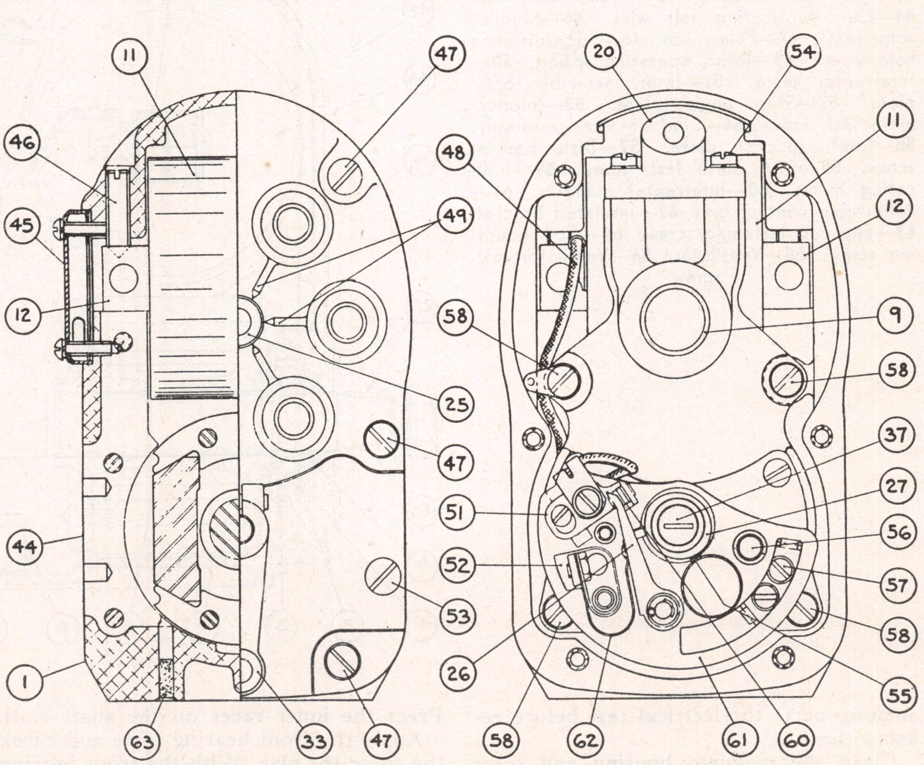


FIG. 1

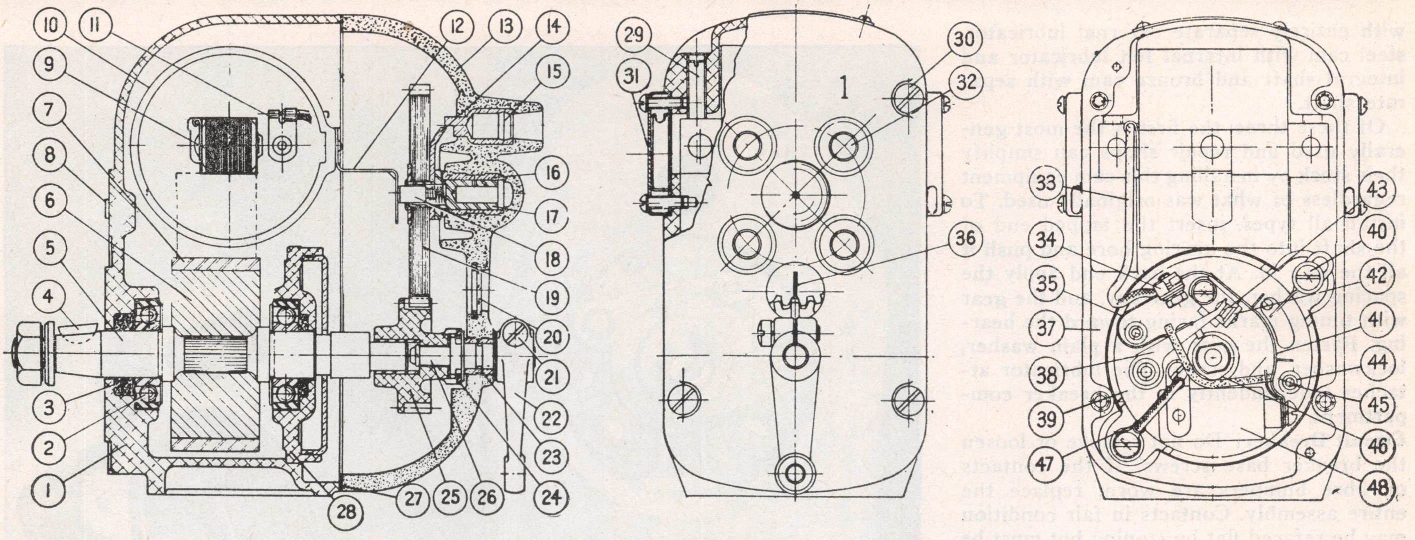


American Bosch Type MJB magneto.

1—Magneto housing. 2—Ball bearings. 3—Felt **sealing washer. 4—Magnet rotor shaft. 5—** Woodruff key. 6—Steel magnet. 7—Magnet rotor. 8—Dist. gear bracket. 9—Dist. gear **bearing. 10—Distributor gear shaft. 11—High-tension coil. 12—Coil core. 13—Coil housing.** 14—Brass electrode. 15—Metal brush. 16—Fast. screw lock washer. 17—Rotor fastening screw. 18—Dist. plate gasket. 19—Conducting rod. 20—High-tension conductor. 21—High-tension brush. 22—Distributor plate. 23—Cable clip. 24—Distributor rotor. 25—Observation window. 26—Interrupter lever. 27—Cam. 28—End cap gasket. 29—Key stud for "U" bracket. 30—Timing arm clamp screw. 31—Lever shaft bearing. 32—"U" shaped timing lever. 33—Timing arm lever. 34—Thumb screw terminal. 35—Control arm cap. 36—Int. assy. **tension spring. 37—Cam fastening screw. 38—** Indicating washer. 39—Magnet rotor gear. 40—**Distributor gear. 41—Condenser. 42—** Washer (grease retaining). 43—Steel rivet. **44—Pole shoe. 45—Ventilator. 46—Coil mounting screw. 47—Dist. plate fast. screw. 48—** Coil cable. 49—Indicating marks. 51—Stationary contact brkt. 52—Insulated bracket. **53—End cap fastening screw. 54—Conductor fast. screw. 55—Cam lubricating felt wick. 56—Stud on interrupter assy. 57—Support plate fast screw. 58—Distributor bracket screw. 60—Interrupter contact. 61—Inter. assembly complete. 62—Inter. operating spring. 63—Edge** distance hole plug.

the casting around the shaft hole. Oil the felt. Working one at a time, pack each ball and retainer assembly full of a medium soft grease of high melting point. A grease recommended for automobile front wheel bearings is suitable but a straight grease is better than a fibrous one. Place the grease packed ball assembly in place in the outer race. With a special tool, press in a metal grease retaining ring which will press down exactly flush with the rim of the outer race. The exact quantity of grease per bearing is that which will fill about 50% of the total free space—or approximately a cube 7/16 inch on a side.

Assemble the rotor and front bearing plate after first wiping the exposed laminated shoes of both the housing bore and the rotor with a very light film of oil to retard rusting. Make the front bearing plate tight and re-check the bearing fit. It may



American Bosch Type MJC variable spark magneto

1—Magneto housing. 2—Ball bearings. 3—Felt sealing washer. 4—Woodruff key. 5—Magnet rotor shaft. 6—Alnico magnet. 7—Steel pole shoe. 8—Indicating mark on hsg. 9—Coil core. 10—High-tension coil. 11—Terminal clip. 12—High-tension conductor. 13—Distributor plate. 14—Electrode. 15—Cable clip. 16—Distributor gear bearing. 17—Distributor gear shaft. 18—Dist. gear brush & spring. 19—Distributor gear. 20—Observation window. 21—Timing arm clamp screw. 22—Timing arm lever. 23—Lever shaft bearing. 24—"U" shaped timing lever. 25—Magnet rotor gear. 26—Magnet rotor gear shaft. 27—Distributor plate gasket. 28—Int. assy. holding brkt. 29—Coil mounting screw. 30—Dist. plate fast. screw. 31—Ventilator. 32—Cable tower. 33—Coil cable. 34—Insulated bracket. 35—Interrupter oper. spring. 36—Line on dist. gear. 37—Pole shoes. 38—Interrupter lever. 39—Inter. assy. complete. 40—Inter. holding brkt. screw. 41—Felt wick. 42—Adj. contact bracket. 43—Tungsten contacts. 44—Int. assy. tension spring. 45—Stud on interrupter assy. 46—Cam. 47—Ground wire. 48—Condenser.

seem tight because of the felts but it is usually easy to tell the difference between that and an actual tight bearing.

If the coil has been removed from the magneto, test it. Clean out the coil compartment and slide the long insulating sheet into the arch of the housing. Clean the coil pole shoes and slide the coil into its compartment so that the coil core catches under the ledge at the back. Lift the front of the coil enough to slide in the under coil insulator. The coil should go back to engage firmly but do not force it back enough to lift the shoe perceptibly off the front housing insert. Apply the hold down clamp with the ground lead under the screw at the right. Be sure that the under coil insulator is not pinched between the coil and housing shoes. Finally, examine and test the ground terminal group in the top front of the housing, and connect the coil primary lead to the left hand screw of the terminal plate. Under the right hand screw install the short lead which will later connect to the circuit breaker.

Test: The entire magnetic circuit and coil can be tested at this point. Apply a key and drive member to the shaft and set the partially assembled magneto; rotor, coil, and charged magnet in place without the circuit breaker, on the test stand. If a fully assembled magneto is tested, hold the contacts open.

Voltage test: Rotate the shaft at 800 RPM. Voltage from primary or grounding terminal to magneto frame should be not less than 7 volts. If voltage is low, re-magnetize the magnet, change magnets, or check for the following troubles:

Magnet not down on shoes, coil not down on shoes, or coil is damaged.

Current test: Rotate the shaft at 800 RPM. Current between the grounding terminal and magneto frame should be not less than 1.65 amperes. If current is low be sure that the meter is of good quality and low resistance and that the points of contact of meter leads at the magneto are firm and clean. If low current persists, change the coil.

Secondary test: Turn the magneto at 3,000 RPM. Hold one end of a short ignition cable to the magneto frame and the outer end on the high tension terminal at the coil quill end. Slowly draw the latter end away from the quill to form an arc. This arc should draw out about ⅛ inch. If an arc cannot be drawn nearly ⅛ inch, replace the coil. This is a very severe test since the circuit breaker is not in use. Do not expect the spark to jump ⅛ inch—it should slowly draw out to that length. A magneto which will pass this test will produce a very strong spark when the circuit breaker is in use.

Pinion: Install the pinion gear key and pinion gear with the timing mark facing toward the front of the magneto. Fasten the pinion with plain washer, lockwasher and screw.

Condenser: Test the condenser for insulation by using a special test set. Another practical condenser test is to connect the condenser in series in one side of a circuit containing a low wattage 110 volt lamp plugged in on a regular 110 volt AC or DC lighting circuit. In such a test the condenser is subjected to the full line voltage. If there is any breakdown in the condenser current will pass and the lamp will light. If the insulation of the condenser is good, no current can pass and the lamp will not light. Attach the condenser at the bottom screw of the front bearing plate and connect the condenser lead to the left hand screw of the terminal plate inside the housing at the top front, locating the lead neatly along the side of the housing.

Front Plate, Fixed Spark: Clean the plate thoroughly, inspect and test the breaker terminal group parts and insulation located in the breaker housing at the top, see that dowel pins are present and straight, and stick on a new gasket with shellac.

Variable Spark: Clean the front plate, inspect and oil advance lever shaft parts and replace worn members, check the dowel pins, and install a new gasket. Note the stops cast on the front plate for regulating the range of advance. The one on the advance side requires no attention. At the retard side a steel plate stamped with number of degrees and number of cylinders is held in place to intercept the advance mechanism at the retard position. This plate should be securely in place and the degrees marked on it should not be more than the lag angle degrees stamped on the impulse starter. Usually the stop plate is 5 degrees less than the starter.

Distributor Bearing: Clean the distributor bearing thorougly with gasoline and blow it out dry. Inspect for wear and replace it even if wear is only slight. Pack the ball retainer with grease the same as described for main bearings using about the same quantity. Press the bearing into its holder, being sure that it presses home firmly with the closed side toward the back. Proceed at once to install the camshaft so that dirt will not enter the bearing.

Distributor and Cam Shaft Group: Several types of cam assemblies have been used, as follows: Steel cam on integral shaft with entirely separate external lubricator, steel cam with internal felt lubricator and integral shaft and bronze cam with separate shaft.

Of these three, the first is the most generally used and repair shops can simplify their stock by installing this cam equipment regardless of what was originally used. To install all types, insert the tapped end of the shaft into the bearing bore and push it all the way in. At the back end apply the spacing washer, the gear key, and the gear with timing marks facing toward the bearing. Fasten the gear with a plain washer, lockwasher, and screw. The lubricator attaches independently in the breaker compartment.

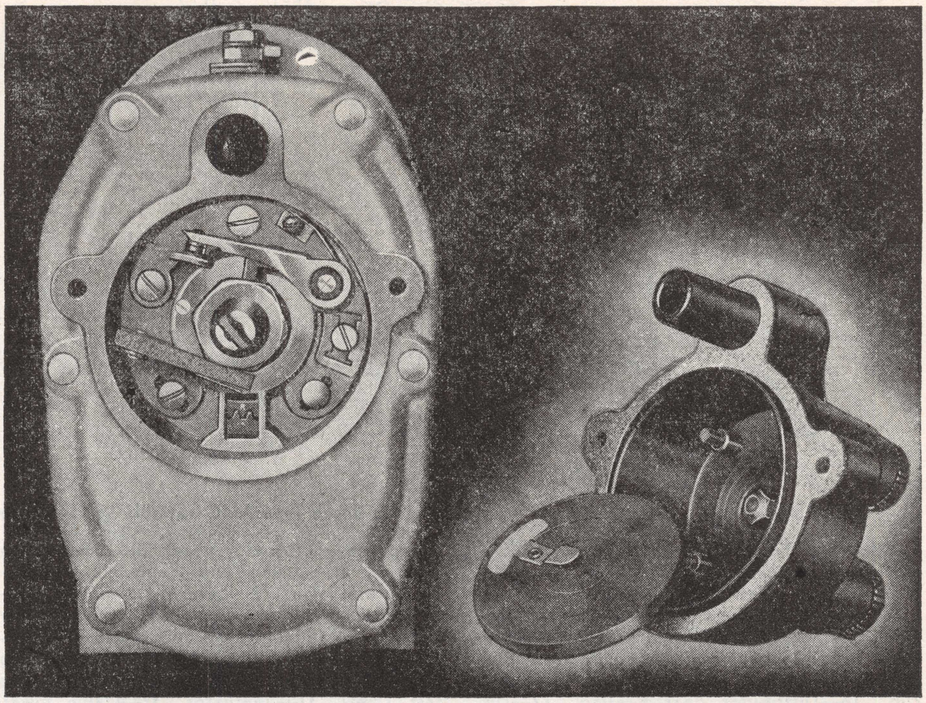
Circuit Breaker: Do not remove or loosen the breaker base screws. If the contacts or fibre bumpers are worn, replace the entire assembly. Contacts in fair condition may be refaced flat by stoning but must be kept square and true. Set the opening gap to .014" to .016" by loosening the screws holding the breaker points and swinging the contact bracket. Tighten the screws and check the adjustment.

Wipe the operative cam surface with a light film of soft grease applied with the finger. If an external cam lubricator is to be installed be sure that it is clean and oiled so that the felt is nearly saturated but not wet with free oil at the surface. This lubricator goes under the head of the lower left breaker base screw. It should be so wet as to make a sure but not a hard contact with the cam noses. This lubricator can be installed in any standard CD Magneto regardless of whether it was originally present or not.

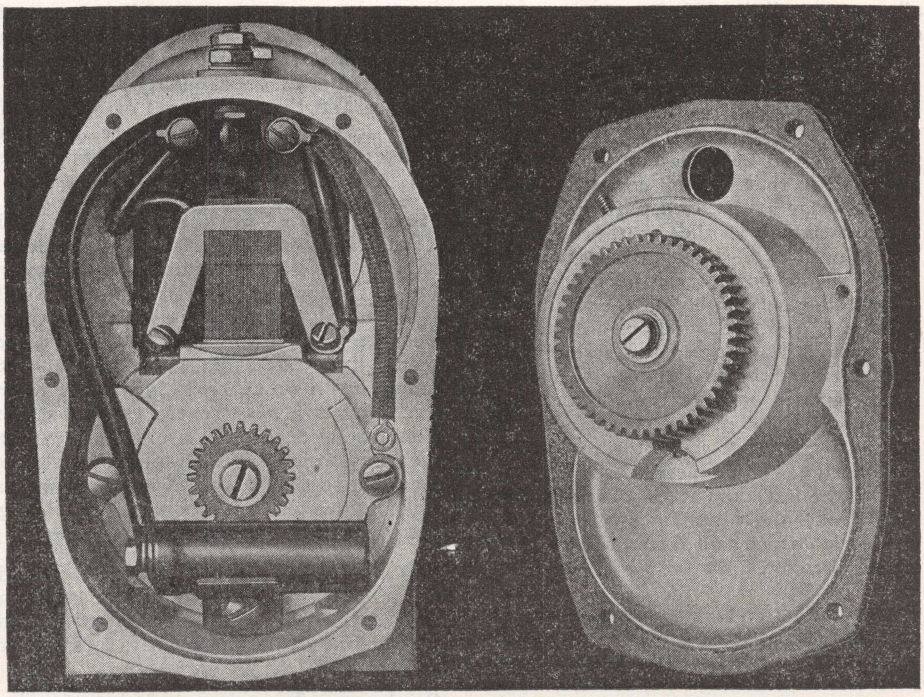
Variable Spark: Apply light grease to the outer surface of the breaker housing and insert it in the front plate casting with the pin of the advance lever rig in the slot of the bracket. Apply the two hold down clamps being sure that they give a light but secure clamping action. Apply grease to the running surfaces and to the operative surfaces of the advance linkage. Finally, apply the pig tail grounding lead. Arrange this lead to form a spiral of two turns about ¼ inch in diameter, so arranged as to pull evenly and smoothly when the advance mechanism is operated.

Timing Gears: Turn the magneto shaft until the mark on the pinion gear is at the top. Turn the distributor shaft until the letter "R" or "L", depending upon whether the magneto is right or left hand, lies behind the window in the breaker housing casting. Enter the front plate dowels a very little to locate the front plate on the housing. Sight through the window and mesh the gears properly. Force the front plate back and fasten with six screws and lockwashers.

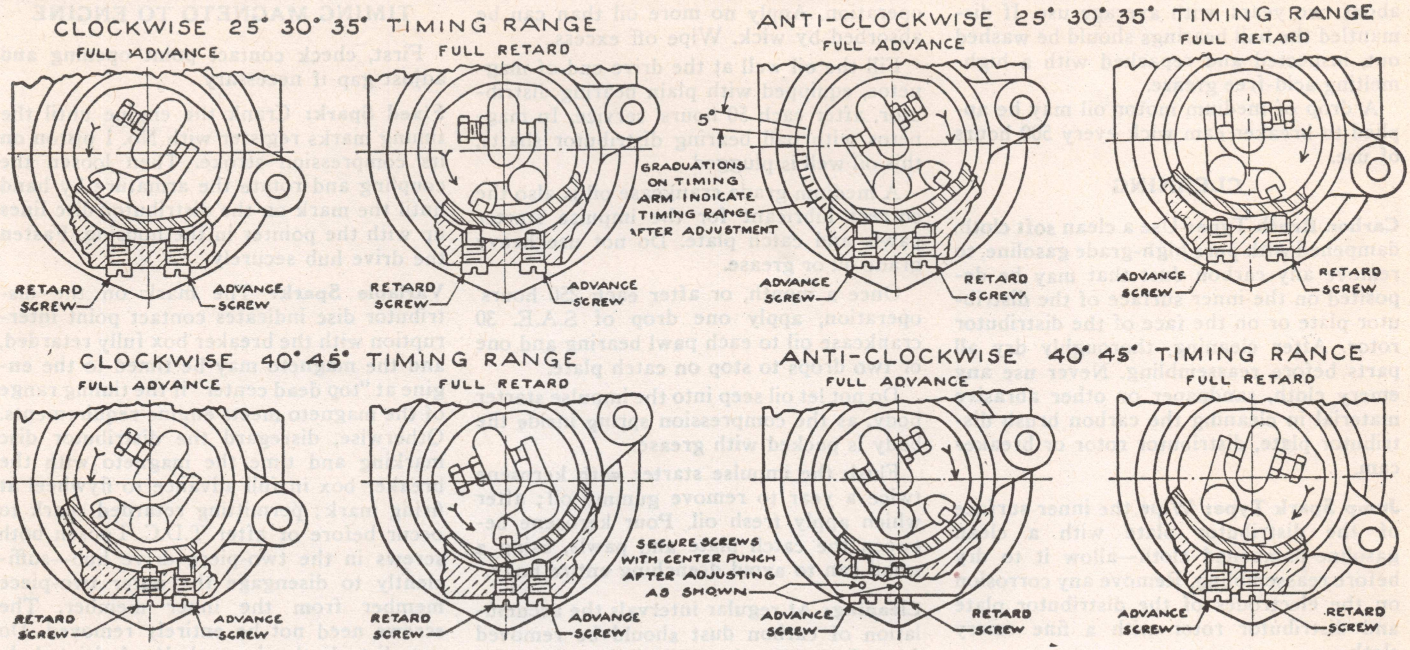
Internal Timing: Remove the cover plate under the magnet on the side toward which the rotational direction arrow points. Viewed from the drive end this is the right side for right hand and the left side for left hand. The lobes of the rotor are thus exposed. For all magnetos that fire at regular angles only the rear lobes as seen at the drive end of the slot are to be used. Connect leads from a series lamp, as previously described for condenser testing, or to the frame of the magneto and to the grounding terminal. Thus the test lamp is in series with the contacts and as the latter open and close, the test lamp will give a signal. Turn the magneto shaft in the running direction until a sharp rotor edge comes into view at the top of the slot. About this time the contacts should open and the test signal should operate. The distance between the top of the slot and the rotor edge is called the "magnetic break". It should measure not less than .040 nor more than .080 inch for all fixed spark magnetos and for all variable spark magnetos **when the spark is fully advanced.** To alter the "magnetic break," loosen the two breaker base screws, at the lower ends of the horseshoe and the one at the top center. Keeping the advance mechanism fully in advance, if it is a variable



Edison Type CD magneto showing circuit breaker with distributor block and rotor removed.



Edison Type CD magneto with front plate removed.


CLOCKWISE 25° 30° 35° TIMING RANGE
FULL ADVANCE
FULL RETARD
RETARD SCREW
ADVANCE SCREW
RETARD SCREW
ADVANCE SCREW
ANTI-CLOCKWISE 25° 30° 35° TIMING RANGE
FULL ADVANCE
FULL RETARD
5°
GRADUATIONS ON TIMING ARM INDICATE TIMING RANGE AFTER ADJUSTMENT
ADVANCE SCREW
RETARD SCREW
ADVANCE SCREW
RETARD SCREW
CLOCKWISE 40° 45° TIMING RANGE
FULL ADVANCE
FULL RETARD
RETARD SCREW
ADVANCE SCREW
RETARD SCREW
ADVANCE SCREW
ANTI-CLOCKWISE 40° 45° TIMING RANCE
FULL ADVANCE
FULL RETARD
SECURE SCREWS WITH CENTER PUNCH AFTER ADJUSTING AS SHOWN
ADVANCE SCREW
RETARD SCREW
ADVANCE SCREW
RETARD SCREW

Eisemann breaker box adjustment.

spark machine, rotate the circuit breaker base very slightly until the contact points just start to open within the range of magnetic break given above. When the proper magnetic break is found, retighten the three screws which hold the breaker base, apply a seal to the head of one of them and replace and seal the cover plate under the magnet.

Distributor Rotor and Block: Install the safety gap disc on the distributor shaft next to the cam. Examine the distributor rotor. Replace it if the metal segment is much worn, if the path of the brush travel is worn or rough, or if the center spring is in poor condition. If clean and in good condition the rotor may be given a single drop of oil at the bottom of the shaft and be installed on the end of the shaft. If excessive backlash occurs at the rotor, replace it.

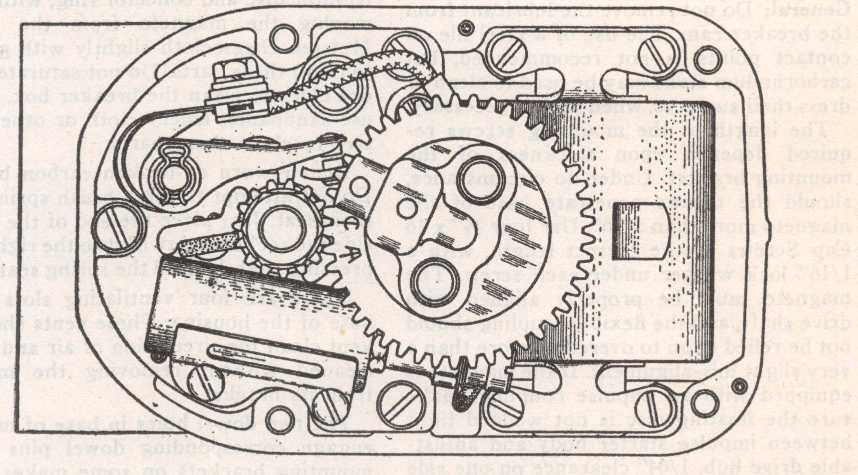
Clean out the distributor block and examine it for burns or damage. Replace worn brushes and see that all brushes work freely. If the center brush is much worn, pry out the cap which retains it and install a new brush and cap. Examine the spring at the bottom of the high tension connecting tube. Apply a new gasket. Install the block, noting that the distributor rotor spring projects to engage the center brush lightly and that the high tension spring connection is operative. Fasten the block with two screws and lockwashers drawn up evenly and firmly but do not break the block.

MAGNET

The magnetic circuit includes the magnet, coil and rotor. Opening any part of this circuit will result in loss of magnetism.

Install magnet on magneto with pole marked "N" on the correct side. When viewed from drive end, "N" is on the right side of right hand magnetos and on the left side of left hand magnetos.

Magnetize the magnet with the coil and rotor in place. The "N" on the charger must be opposite the "N" on the magneto.



Eisemann Type AM magneto.

MAGNETO TEST

Run the magneto at 1,500 RPM for one hour before starting tests. If the magneto has been overhauled so that the primary circuit voltage and current readings were checked, omit the first two checks. Otherwise proceed as follows:

Run the magneto at 800 RPM with contacts held open. The voltage across the contacts shall be not less than 6.5 volts, and the current between firm contacts taken across the contacts shall be not less than 1.6 amperes.

Connect leads to three point open gaps set at 5/16 inch and test for minimum sparking speed. The magneto should fire regularly at 150 RPM for 2 or 4 cylinder machines, or at 225 RPM for 6 cylinder machines, always in the fully advanced position. Test that sparking can be stopped by the operation of whatever grounding device is involved. Operate the magneto at 2,500 RPM and see that regular firing occurs. Apply seals to screws at front plate, timing slot covers, and magnet.

EISEMANN

TYPE AM

All "AM" models are fixed spark and should be timed to engine with the flywheel in the firing position recommended by the engine manufacturer.

Rotate the engine to the flywheel mark with No. 1 cylinder on compression stroke. Then turn the magneto rotor by hand in the reverse direction, to avoid Impulse Starter engagement, until the metal insert in the distributor disc is at No. 1 cable position, with points just about to break. Engage the impulse starter lugs in the slot with the magneto slightly off its vertical position.

The contact point gap at full separation should be within .019" to .021". To adjust the gap, loosen breaker plate fastening screw, and move the entire breaker assembly with the breaker lever fibre resting on highest point of cam lobe. Recheck gap after tightening fastening screw. Clean by stoning. The ball bearings are grease packed at the factory and should last for

about two years, with average use. If dismantled the ball bearings should be washed out, inspected and repacked with a high-melting acid-free grease.

A drop of medium motor oil may be applied to breaker cam wick every 500 hours of use.

CLEANING

Carbon Brush Type: Use a clean soft cloth, dampened with pure high-grade gasoline, to remove any carbon dust that may be deposited on the inner surface of the distributor plate or on the face of the distributor rotor. After cleaning, thoroughly dry all parts before reassembling. Never use any emery cloth, sandpaper or other abrasive material in cleaning the carbon brush distributor plate, distributor rotor or breaker cam.

Jump Spark Type: Wipe the inner surface of the distributor plate with a clean gasoline-dampened cloth—allow it to dry before reassembling. Remove any corrosion on the electrodes of the distributor plate and distributor rotor with a fine emery cloth.

General: Do not remove the lubricant from the breaker cam. The use of a steel file on contact points is not recommended, but carborundum stone may be used to clean or dress their surfaces, when such is necessary.

The length of the mounting screws required depends upon thickness of the mounting bracket. Under no circumstance, should the screws penetrate base of the magneto more than 5/16". Use four 3/8" x 16 Cap Screws of the correct length, with a 1/16" lock washer under each screw. The magneto must be properly aligned with drive shaft, and the flexible coupling should not be relied upon to overcome more than a very slight mis-alignment. If the magneto is equipped with an impulse coupling, make sure the floating disc is not wedged tight between impulse starter body and adjustable drive hub. 1/64" clearance on one side of floating disc is recommended.

TYPE GV

Lubrication: Use medium grade oil, S.A.E. 30, to lubricate breaker cam and plain bearing on distributor shaft. The ball bearings are grease-packed and should not require attention for a long period.

Apply oil to wick encircling the outer surface of the breaker cam, through a countersunk hole in housing after each 250 hours' operation. Apply no more oil than can be absorbed by wick. Wipe off excess.

Fill the oil well at the drive end of magnetos, equipped with plain bearing distributor, after each 50 hours' service. In magnetos with ball bearing distributor shafts, this oil well is plugged.

A medium grade crankcase oil is also the correct lubricant for the impulse starter pawls and catch plate. Do not use heavy grade oil or grease.

Once a month, or after each 250 hours' operation, apply one drop of S.A.E. 30 crankcase oil to each pawl bearing and one or two drops to stop on catch plate.

Do not let oil seep into the impulse starter body, as the compression spring inside the body is packed with grease.

Flush the impulse starter with kerosene twice a year to remove gummy oil; after which apply fresh oil. Pour kerosene between the catch plate and pawls, using a small can to avoid drenching entire body.

Cleaning: At regular intervals the accumulation of carbon dust should be removed from the breaker box, distributor plate, distributor disc and collector ring, without removing the magneto from the engine. Moisten cheesecloth slightly with gasoline to clean these parts. Do not saturate. Use a dry cloth to clean the breaker box. Do not use sandpaper, emery cloth or other abrasive to clean these parts.

Renew worn or broken carbon brushes. Do not attempt to force brush springs into their seat. Just place the end of the coil inside the socket and twirl it to the right while pressing slightly until the spring seats itself.

There are four ventilating slots in the base of the housing. These vents should be kept clean for circulation of air and can be cleaned without removing the magneto from its bracket.

The two dowel holes in base of magneto engage corresponding dowel pins in the mounting brackets on some makes of engines to assure correct alignment of the magneto with the drive shaft. When removing the magneto it is necessary to lift it straight up from mounting bracket.

Flexibility in the coupling is very essential and the floating disc should not be wedged tight between the impulse starter and adjustable drive hub. Insert a 1/64" thickness gauge between the floating disc and drive hub, or use the .125" contact point leaf gauge.

TIMING MAGNETO TO ENGINE

First, check contact point opening and adjust gap if necessary.

Fixed Spark: Crank the engine until the timing marks register with No. 1 piston on its compression stroke. Then loosen the coupling and rotate the armature by hand until the mark on the distributor disc lines up with the pointer in the housing. Fasten the drive hub securely.

Variable Spark: The mark on the distributor disc indicates contact point interruption with the breaker box fully retarded, and the magneto may be timed to the engine at "top dead center" if the timing range of the magneto meets engine requirements. Otherwise, disregard the distributor disc marking and time the magneto with the breaker box in full advance to flywheel at firing mark; permitting retarded spark to occur before or after T.D.C. Loosen both screws in the two-piece drive hub—sufficiently to disengage the outer two-piece member from the inner member. The screws need not be entirely removed. Do not disturb the inner half of drive hub. After loosening the coupling, turn the armature in reverse of operating direction to avoid tripping the impulse starter, until the white mark on the distributor disc lines up with the set screw. The arrow across the hand indicates an anti-clockwise movement of a clockwise armature.

Contact Points: Loosen the lock nut to adjust the contact screw. With the breaker lever fibre in the middle of the cam, adjust the gap to .012" to .014". Tighten lock nut.

If the magneto is coupled to the engine, depress the short, exposed, end of the impulse starter pawl with the finger, as the engine is cranked, to prevent the pawl from latching. Position the breaker lever fibre on the highest part of the cam.

To Adjust Timing Range: Loosen both stop screws. Position armature in correct relation to pole shoes, 2.5 m/m to 3.5 m/m, measuring with shank of No. 31 drill. Move breaker box in advance direction until contact point interruption occurs. Tighten the advance screw. Scratch a line on housing end plate opposite one graduation mark on timing control arm. Move breaker box in retard direction as much as necessary to give the timing range desired, measured by the 5 degree graduations on control arm. Tighten retard screw. Stake both screws with center punch.

DELCO-REMY STARTING SWITCHES

STARTING MOTOR SWITCH INDEX

Model No.	Spec. No.	Model No.	Spec. No.	Model No.	Spec. No.	Model No.	Spec. No.	Model No.	Spec. No.
1335	506-A	1525	518	1561	530	1118019	565	1118050	517
1336	506	1526	520	1562	517	1118020	544	1118051	560
1367 to 9	506-A	1527	522	1563	511	1118021	565	1118052	560
1370 to 2	506	1528	507	1564	507	1118025	536	1118053	517
1421	506	1530	514	1565	522	1118026	520	1118054	520
1422 to 3	506-A	1531	517	1566	510	1118027	524	1118055	560
1424	551	1532	514	1567	536	1118028	533	1118056	557
1430	539	1533	525	1568	530	1118029	520	1118057	543
1431	506-A	1534	526	1569	537	1118030	543	1118058	567
1432	538	1535	528	1570 to 1	507	1118031	514	1118060	517
1433	543	1536	517	1572	538	1118032	517	1118061	508
1434	551	1537	526	1573	541	1118033	520	1118101	514
1450	511	1538	528	1574	530	1118034	550	1118102	565
1451 to 3	507	1539 to 41	507	1118001	537	1118035	514	1118104	565
1456 to 8	511	1542	529	1118002	520	1118036	520	1118106	548
1459 to 61	507	1543	530	1118003	551	1118037	552	1118108	548
1501 to 2	508	1544	511	1118004	544	1118038	553	1118109	565
1503	507	1545 to 8	529	1118005	548	1118039	528	1118110	551
1504 to 6	508	1549	507	1118006	506-A	1118040	555	1118111	506
1507	510	1551	526	1118007	549	1118041	557	SM-1351	510
1508	507	1552	517	1118008	506-A	1118042	557	SM-1411	508
1509	511	1553	527	1118009	539	1118043	517	SM-1587	524
1510	510	1554	533	1118010	551	1118044	530	SM-1794	514
1511	513	1555	514	1118011	551	1118045	559	SM-1839	527
1512 to 9	514	1556 to 7	520	1118012	554	1118046	560	SM-1852	518
1520	511	1558	542	1118013	537	1118047	517	SM-1853	527
1521 to 3	514	1559	520	1118014	556	1118048	557		
1524	517	1560	507	1118015	544	1118049	557		

MAGNETIC SWITCH AND SOLENOID SPECIFICATIONS

Specification Number	Maximum Volts to Close①	Air Gap Inch	Pounds Tension	Current Consumption				Relay on Solenoid②	
				Both Windings		Hold-In Winding		Points Close Volts	Points Open Volts
				Amperes	Volts	Amperes	Volts		
506	3.5	---	--	17.6–20.0	6	----	--	---	----
506-A	7.0	---	--	12.0–13.0	12	----	--	---	----
507	4.7	---	--	3.1– 3.7	4	----	--	---	----
508	5.0	.5	90	58.0–64.0	5	10.0–12.0	5	---	----
510	10.0	.5	90	33.0–39.0	10	6.0– 8.0	10	---	----
511	10.0	---	--	1.4– 1.5	8	----	--	---	----
513	5.0	.25	40	11.0–13.0	5	.9– 1.1	5	---	----
514	5.0	.5	70	65.0–71.0	5	12.0–14.0	5	4.0	1.6–2.0
517	20.0	.375	85	19.5–23.0	20	4.5– 5.0	20	---	----
518	3.5	---	--	5.7– 6.3	6	----	--	---	----
520	10.0	.5	70	40.0–46.0	10	8.0– 9.0	10	8.5	3.5–4.2
522	10.0	.5	70	40.0–46.0	10	8.0– 9.0	10	7.8	3.0
524	53.0	.375	90	9.0– 9.5	53	1.0– 1.2	53	---	----
525	4.3	---	--	1.3– 1.4	4	----	--	---	----
526	27.0	.5	85	14.0–17.0	27	2.5– 3.5	27	---	----

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STARTING SWITCHES DELCO—REMY

MAGNETIC SWITCH AND SOLENOID SPECIFICATIONS

Continued from previous page

Specification Number	Maximum Volts to Close①	Air Gap Inch	Pounds Tension	Current Consumption				Relay on Solenoid②	
				Both Windings		Hold-in Winding		Points Close Volts	Points Open Volts
				Amperes	Volts	Amperes	Volts		
527	7.0	---	--	2.7– 3.0	12	----	--	---	----
528	10.0	.5	90	33.0–39.0	10	6.0– 8.0	10	---	----
529	5.0	.5	70	65.0–71.0	5	12.0–14.0	5	1.9	1.0–1.2
530	9.0	---	--	2.4– 2.6	6	----	--	---	----
533	13.5	---	--	2.0– 2.2	12	----	--	---	----
536	8.5	.25	--	1.4– 1.5	12	----	--	---	----
537	6.3	.375	16	28.0–34.0	6	.9– 1.1	6	---	----
538	10.0	---	--	.8– .86	10	----	--	---	----
539	12.5	---	--	1.2– 1.3	12	----	--	---	----
541	12.6	.375	16	24.5–27.5	12	.6– .72	12	---	----
542	5.0	---	--	1.6– 1.75	5	----	--	---	----
543	12.0	.5	7	2.4– 2.7	12	----	--	---	----
544	6.3	.375	16	28.0–34.0	6	.9– 1.1	6	---	----
548	4.9	---	--	31.0–34.0	6	1.4– 1.6	6	---	----
549	9.8	---	--	15.0–16.0	12	1.0– 1.2	12	---	----
550	8.7	---	--	3.2– 3.8	8	----	--	---	----
551	4.0	---	--	12.0–13.0	12	----	--	---	----
552	4.5	.5	--	4.7– 5.1	4	----	--	---	----
553	5.0	.25	--	1.3– 1.4	12	----	--	---	----
554	5 amp.	.375	4.25	3.7– 4.0	6	----	--	---	----
555	12.0	.5	35	14.1–15.4	12	----	--	---	----
556	4.9	---	--	31.0–35.0	6	1.4– 1.6	6	---	----
557	28.0	.375	85	21.0–22.0	28	3.5– 4.0	28	---	----
558	8.0–9.0	---	--	4.9– 5.1	12	----	--	---	----
559	27.0	.5	85	14.0–17.0	27	2.5– 3.5	27	---	----
560	10.0	.5	70	50.0–53.0	10	13.0–14.0	10	8.5	3.5–4.2
565	5.0	.5	70	65.0–70.0	5	12.0–14.0	5	3.0	1.9
567	21.0	---	--	1.25–1.35	20	----	--	---	----

NOTE—Refer to the Delco-Remy numercial index for specification number desired.

① At room temperature.

② See the Delco-Remy Solenoid Relay Specifications table for complete data.

LEECE—NEVILLE
MAGNETIC SOLENOID SWITCH SPECIFICATIONS

Switch Type	Amperes at Volts①	Coil Amperes at Volts②	Contacts to Close at Volts, Maximum	Contact Gap, Inch	Contacts Remain Closed Until Voltage Drops to	Operating Coil Amperes	Remarks
11MS6	500@4	6@6	4	3/32	2	-----	⑧
11MS6	--------	4.2@4	----------	--	-----	-----	⑧
11MS12	500@7	5.2@12	6	3/32	3	-----	⑧
11MS12	--------	4.5@10	----------	--	-----	-----	⑧
11MS24	500@18.6	3.2@25	18 to 20③	5/16	13–15	-----	⑨
11MS24	--------	2.5@18.8	12 to 15④	3/16	8–10	-----	⑨
11MS24	--------	1.7@12.5	----------	--	-----	-----	--
11MS32	500@18.6	3.2@25	18 to 20③	5/16	13–15	-----	⑨
11MS32	--------	2.5@18.8	12 to 15④	3/16	8–10	-----	⑨
11MS32	--------	1.7@12.5	----------	--	-----	-----	--

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MAGNETIC SOLENOID SWITCH SPECIFICATIONS

Switch Type	Amperes at Volts①	Coil Amperes at Volts②	Contacts to Close at Volts Maximum	Contact Gap, Inch	Contacts Remain Closed Until Voltage Drops to	Operating Coil Amperes	Remarks
19MS12	500@7	3.0@12.0	6⑤	3/32	4.5	1.5–1.6	⑩
19MS12	---------	2.5@10	-----------	--	-----	-----	⑩
19MS24	240@24	40@2	16	3/32	6	-----	--
19MS24	---------	20@4	-----------	--	-----	-----	--
19MS32	150@32	---------	25	3/32	11	-----	--
20MS12	750@7	5.2@12	7.5⑤	5/32	3.5	-----	⑩
20MS12	---------	4.5@10	-----------	--	-----	-----	⑩
25MS6	500@4	6@6	4	3/32	2	-----	⑧
25MS6		4.2@4	-----------	--	-----	-----	⑧
25MS12	500@7	5.2@12	6	3/32	3	-----	⑩
25MS12	---------	4.5@10	-----------				⑩
27MS6	500@4	22@6	4.5⑤	3/8	2.5	14–15	⑩
27MS6	---------	18@5	-----------				⑩
27MS12	1000@7	20@12	7.5⑤	3/8	4	10–12	⑧
27MS12	---------	17@10	-----------	--	-----	-----	⑧
27MS24	500@18.6	9.8@24	14.3⑤	3/8	8.2	6–8	⑩
27MS24	---------	7.4@18	-----------		-----	-----	⑩
27MS32	500@24	9@30	17.5⑤	3/8	10	4–5	⑩
27MS32	---------	7@24	-----------		-----	-----	⑩
28MS12	500@7	20@12	7⑤	3/8	4	10–12	⑩
28MS12	---------	17@10	-----------	--	-----	-----	⑩
28MS24	500@18.6	9.8@24	14.3⑤	3/8	8.2	6–8	⑩
28MS24	---------	7.4@18	-----------	--	-----	-----	⑩
28MS32	500@24	8.0@30	17.5⑤	3/8	11	4–5	⑩
28MS32	---------	6@24	-----------	--	-----	-----	⑩
29MS12	750@7	5.2@12	7.5⑤	5/32	3.5	-----	⑩
29MS12	---------	4.5@10	-----------	--	-----		⑩
31MS12	1000@7	20@12	7.5⑤	3/8	4	10–12	⑩
31MS12	---------	17@10	-----------	--	-----	-----	⑩
31SPS(E)	5000@18.6	20@12	8⑤	3/8⑥	4.5	10–12	⑪
31SPS(E)	---------	17@10	-----------	3/16⑦	-----	-----	⑪
33MS12	1000@7	20@12	7.5⑤	3/8	4	10–12	⑩
33MS12	---------	17@10	-----------	--	-----	-----	⑩
33MS24	500@18.6	9.8@24	14.3⑤	3/8	8.2	6–8	⑩
33MS24	---------	7.4@18	-----------	--	-----		⑩
33MS32	500@24	9.0@30	17.5⑤	3/8	.10	4–5	⑩
33MS32	---------	7.0@24	-----------		-----	-----	⑩

NOTE—All switches must withstand 550 volt A. C. test. Mount all switches with terminals down.

① Switch to carry current at voltage shown without arcing.

② If current is greater than shown, some of the windings are shorted out.

③ Bronze contacts.

④ Carbon contacts.

⑤ With no load.

⑥ Large contacts.

⑦ Small contacts. Set when large contacts are closed.

⑧ Be sure coil is securely wedged and that the plunger works freely and does not strike the core.

⑨ In addition to note ⑧ above, be sure that the carbon and bronze contacts are loose on the plunger assembly. The carbon contact should move within the bronze contact. This permits the carbon contact to make and break while the bronze contact carries the load.

⑩ Be sure coil is securely wedged. The contact assembly should be loose on the plunger assembly in order to make an even contact when closed. Be sure the plunger works freely without striking the core.

⑪ In addition to note ⑩, be sure the upper contacts open before the lower contacts close.

MAGNETIC SOLENOID SWITCH WITH KNOCKOUT COIL

Switch Type	Maximum Contact Gap, Inch①	Voltage to Close Contacts②	Locked Motor Voltage to Check Switch	With Locked Motor, Voltage Should Drop to Voltage Shown③	Knockout Coil Operating Voltage④	Knockout Coil Voltage⑤
18MS24	½	12	24	12	-	--
18MS32	½	14	30	9	-	--
18MSN24	½	12	24	12	-	--
21MS24	½	12	24	12	6	24
21MS32	½	14	30	9	6	32
26MS32	½	14	30	9	6	32

NOTE—All switches must withstand 550 volts A. C. test.

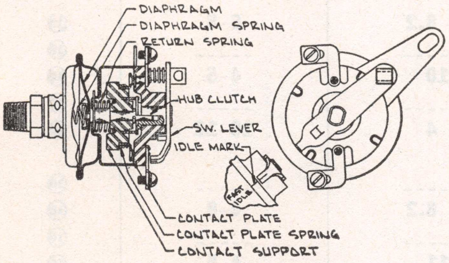
① Set gap when open at closest point.

② Without load. Check switch with voltage and with locked starter; voltage will drop but armature should remain against stop pin.

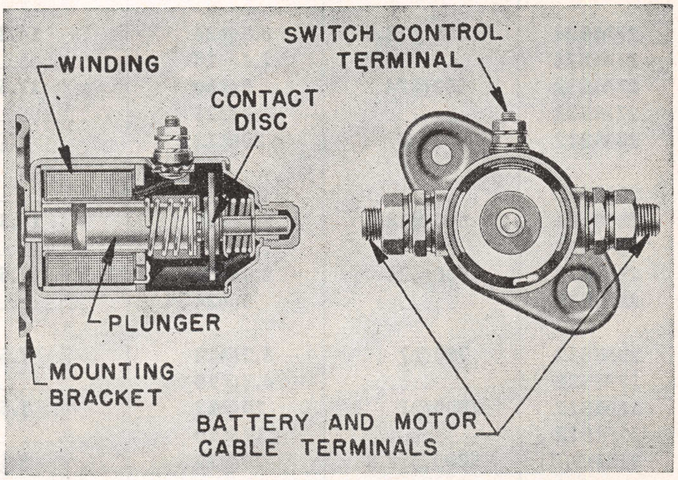
③ Adjust armature compression spring nut so that when voltage is applied without load and armature is pushed to the core by hand, the armature will remain against the core stop pin. A lower voltage than that shown will not hold the armature to the stop pin.

④ Will not close at lower voltage.

⑤ Apply this voltage to be sure plunger does not stick.



A typical starting motor control vacuum switch. Switch is adjusted with engine idling so marks on pointer and housing align.



Sectional view of magnetic switch.

STARTING MOTOR CONTROLS

Starting motor controls may vary from a simple switch on the toe-board or starting motor frame, to the series-parallel switch which breaks parallel connections between two batteries and connects them in series when operated so that a higher voltage is applied to the starting motor. Controls considered herein are (1) Vacuum switches, (2) Magnetic switches, (3) Solenoid Switch with Relay, and (4) Series-Parallel Switch.

VACUUM SWITCH

The vacuum switch is mounted on or connected with the intake manifold, and is linked by a rod or rods to the throttle or accelerator pedal. The vacuum switch may be used in starting motor solenoid or magnetic switch circuits to protect the starting motor from accidental operation when the engine is running. When the throttle is opened for initial engine starting, the linkage to the vacuum switch causes the vacuum switch contacts to close, completing the starting motor control circuit, so that the starting motor operates and the engine starts. After the engine has started, vacuum develops in the intake manifold, and this causes the vacuum switch contacts to open and latch. This opens the control circuit so that the starting motor stops operating.

The vacuum switch may be tested on the vehicle by starting the engine, disconnecting the leads from the two switch terminals, and connecting a test lamp to these terminals. The lamp should not light as the engine is operated from idle to high speed. Stop the engine with the throttle held half open. After the engine comes to rest, slowly release the throttle. The test lamp should not light. Slowly open the throttle. The lamp should light as the throttle is partly opened. Failure to operate in this manner requires replacement of the switch.

MAGNETIC SWITCH

The magnetic switch is a solenoid which consists of a plunger and one or two windings so placed and related that, when the windings are magnetically energized, the plunger is sucked into the windings. This motion forces a contact disc across a pair of contacts, so that the battery becomes directly connected to the starting motor. Little attention ordinarily need be given the magnetic switch, except an occasional check to see that the connections and mounting are tight. Many magnetic switches have a small metal cap on one end which may be unscrewed so that the switch contacts can be closed by hand in case the switch does not operate properly.

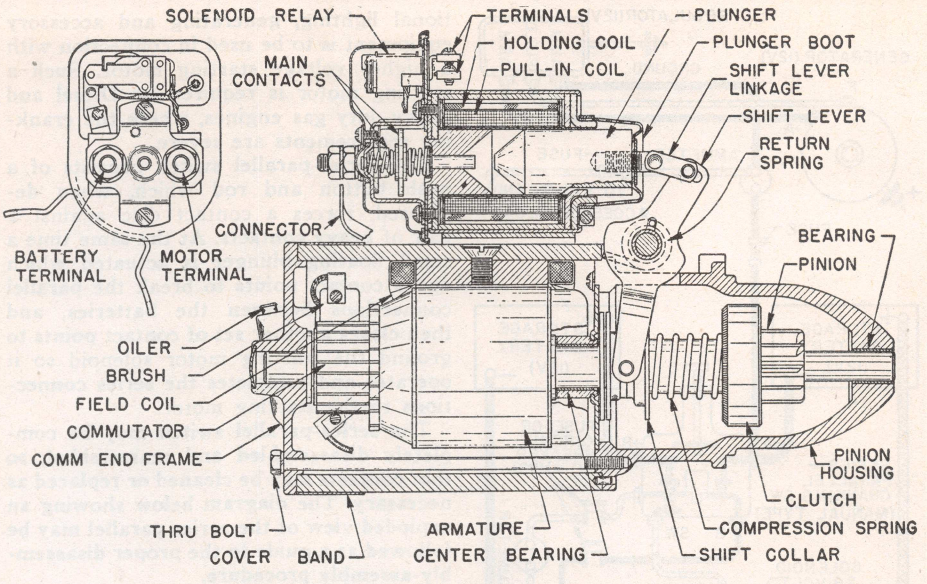
The magnetic switch may be tested by applying varying voltage to the terminals (from a battery and variable resistance or a generator driven by a variable speed motor) to determine the voltage required to operate it. Usually, the switch is assembled by crimping, welding, or brazing parts together, so that it cannot be repaired if it is found to be defective. Consequently, the switch is serviced by complete replacement.

SOLENOID SWITCH WITH RELAY

The solenoid switch with relay is a solenoid of somewhat more powerful construction than the magnetic switch, since it must not only close the circuit between the battery and the starting motor, but it must also operate a shift lever which shifts the starting motor drive pinion into mesh with the engine flywheel teeth. The relay, which mounts on the solenoid, is energized by the operation of the starting motor control device—either a dash push button or an accelerator-linked vacuum switch. When the relay is energized, its points close, so that the solenoid windings become directly connected to the battery. The solenoid becomes energized, pulling in its plunger, so that the drive pinion meshes with the engine flywheel teeth. As the plunger completes its travel, it closes the solenoid switch, directly connecting the starting motor to the battery.

It is possible partly to disassemble the solenoid so that the plunger may be removed and the plunger and plunger chamber cleaned of any grease, dirt, or corrosion which would tend to make the solenoid action sluggish. The contacts and contact disc may be removed so that the contact surfaces can be cleaned by wire brushing or some similar method. The solenoid relay points or air gap, and closing voltage may be checked, and adjustment made as necessary.

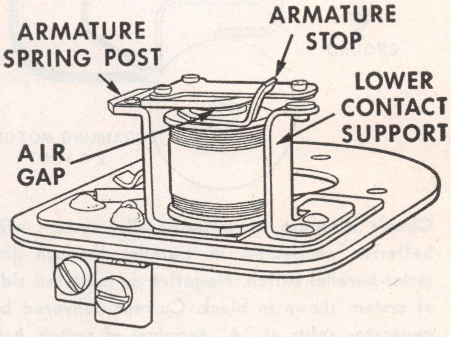
On Auto-Lite solenoid relays, the contact point opening should have .025 to .035 inch gap. Adjustment is made by raising or lowering the upper armature stop. The relay points should close at 3.5 to 4.5 volts on 6-volt units and 7.0 to 9.0 volts on 12-volt units. The relay points should open at 1.5 to 2.5 volts on 6-volt units and 3.0 to 5.0 volts on 12-volt units. The closing and opening voltages may be checked by connecting the relay terminals to a voltmeter and a source of variable voltage (battery and variable resistance or a generator driven by a variable speed motor). Adjust the closing voltage by varying the armature spring tension. Increasing the tension increases the closing voltage. Decreasing the spring tension lowers the closing voltage.


SOLENOID RELAY
MAIN CONTACTS
TERMINALS
HOLDING COIL
PULL-IN COIL
PLUNGER
PLUNGER BOOT
SHIFT LEVER LINKAGE
SHIFT LEVER
RETURN SPRING
CONNECTOR
BATTERY TERMINAL
MOTOR TERMINAL
BEARING
PINION
OILER
BRUSH
FIELD COIL
COMMUTATOR
COMM END FRAME
PINION HOUSING
CLUTCH
THRU BOLT
ARMATURE
COMPRESSION SPRING
COVER BAND
CENTER BEARING
SHIFT COLLAR

Sectional view of solenoid with relay on starting motor.

On late type Delco-Remy solenoid relays, check the point opening and closing voltage. In addition, earlier type solenoid relays, which have the armature mounted to the relay frame by two screws, should have the air gap checked. Air gap is checked by loosening the two armature attaching screws and raising or lowering the armature as required. On all solenoid relays, the point opening is adjusted by bending the upper armature stop. The closing voltage is adjusted by changing the armature spring tension. Increasing the tension increases the relay closing voltage, while reducing the tension lowers the relay closing voltage.

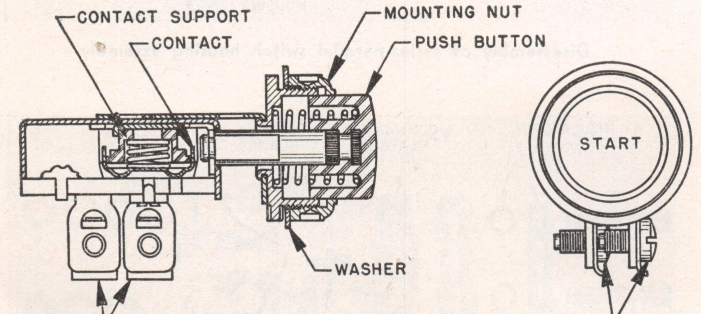
The solenoid may be connected to a source of variable voltage and a voltmeter so that the operating voltage may be checked. Be sure that the plunger is free to move without any restriction or binding, before making this check. The current draw of the shunt or hold-in winding, and the series or pull-in winding of the solenoid may be checked at the specified voltage.


ARMATURE SPRING POST
ARMATURE STOP
LOWER CONTACT SUPPORT
AIR GAP

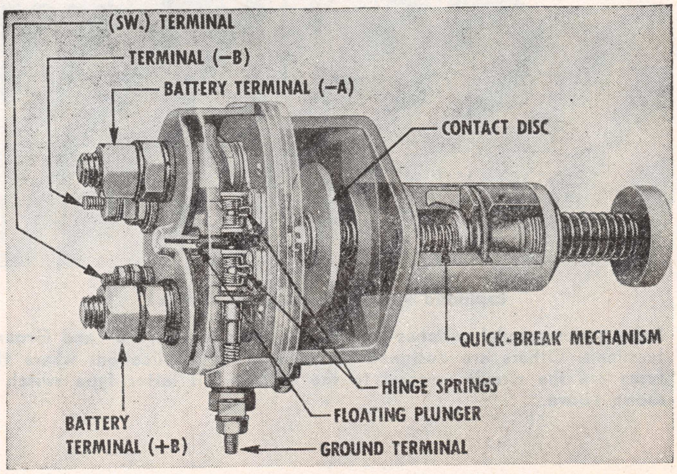
Adjustment of solenoid relay.

SERIES-PARALLEL SWITCH

The series-parallel switch is designed to be used with solenoid operating starting motors, and permits the use of a 24-volt starting motor with a 12-volt system, or a 12-volt motor with a 6-volt system. Such a combination is desirable when conven-

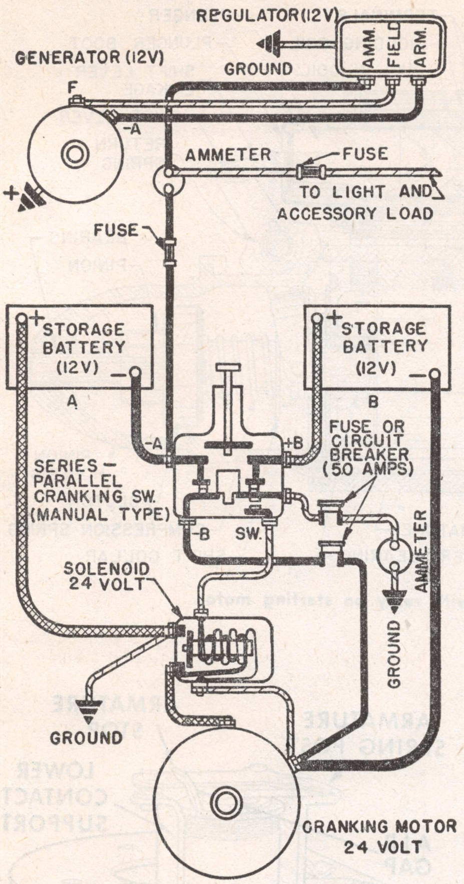

CONTACT SUPPORT
CONTACT
MOUNTING NUT
PUSH BUTTON
WASHER
TERMINALS
START
TERMINAL SCREWS

Dash push button of the type which may be used with solenoid or magnetic switch.


(SW.) TERMINAL
TERMINAL (–B)
BATTERY TERMINAL (–A)
CONTACT DISC
QUICK-BREAK MECHANISM
HINGE SPRINGS
FLOATING PLUNGER
BATTERY TERMINAL (+B)
GROUND TERMINAL

Phantom view of series-parallel switch.

STARTING SWITCHES


REGULATOR (12V)
AMM.
FIELD
ARM.
GENERATOR (12V)
GROUND
F
-A
+
AMMETER
FUSE
TO LIGHT AND ACCESSORY LOAD
FUSE
+ STORAGE BATTERY (12V)
A
—
+ STORAGE BATTERY (12V)
B
—
-A
+B
FUSE OR CIRCUIT BREAKER (50 AMPS)
SERIES-PARALLEL CRANKING SW. (MANUAL TYPE)
-B
SW.
AMMETER
SOLENOID 24 VOLT
GROUND
GROUND
CRANKING MOTOR 24 VOLT

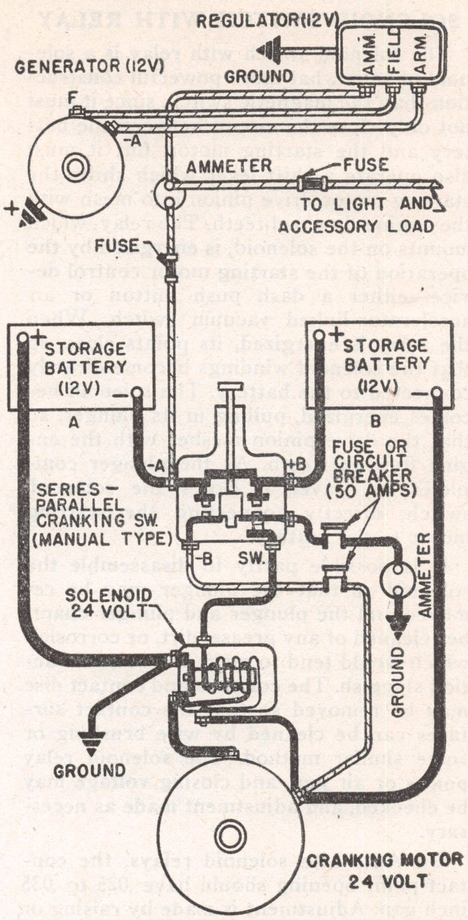
Circuit diagram of series-parallel system with batteries connected in parallel through the series-parallel switch. Negative or insulated side of system shown in black. Current delivered by generator splits at "A" terminal of switch, half going into battery "A," and the other half going into battery "B" through the switch. Fuses may be incorporated in the series-parallel switch, or they may be installed in the external circuit, as shown.

tional lighting, generating and accessory equipment is to be used in connection with a higher voltage starting motor. Such a starting motor is required on Diesel and heavy-duty gas engines, where the cranking requirements are severe.

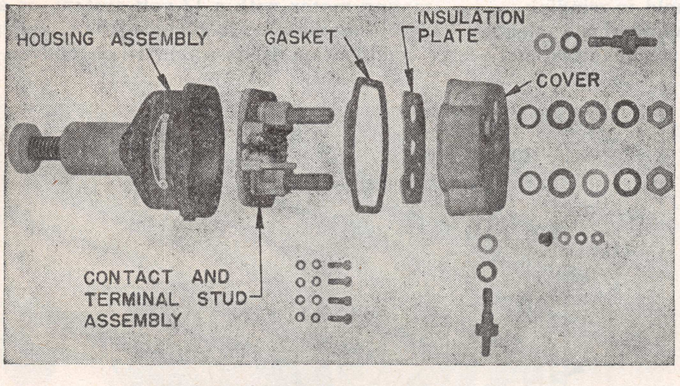
The series-parallel switch consists of a push button and rod which, when depressed, forces a contact disc against a pair of heavy contacts. At the same time a small floating plunger is actuated which opens contact points to break the parallel connections between the batteries, and then closes another set of contact points to ground the starting motor solenoid so it operates and completes the series connections to the starting motor.

The series-parallel switch may be completely disassembled and reassembled, so that contacts may be cleaned or replaced as necessary. The diagram below showing an exploded view of the series parallel may be followed as a guide to the proper disassembly-assembly procedure.

The first step of disassembly is to remove the cover and the contact and terminal stud plate. This is done by unscrewing and removing the nuts and washers from the two main terminal studs and the SW terminals. The "B—" and ground terminals may be unscrewed from the switch cover. The cover, insulating plate, and gasket will now lift off the housing. The housing assembly may be disassembled by pulling the cotter key, unscrewing the castilated nut, and removing the contact disc, washers and spring. If the hex nut which is a part of the push button assembly is now unscrewed from the housing, the push button assembly, push rod, spring and sleeve, may be removed. The triggers and spring which, acting on the push rod, produce the quick-break action, may be removed by lifting out the spring and pushing out the trigger pins. The contact and terminal stud plate may be further disassembled by unscrewing nuts, and removing washers, terminal studs, insulators and supporting plate from the contact plate. Contact blades, with pins

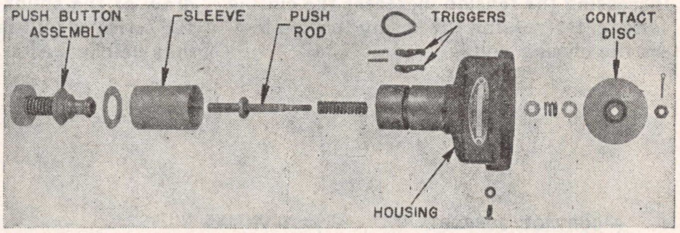

REGULATOR (12V)
AMM.
FIELD
ARM.
GENERATOR (12V)
GROUND
F
-A
+
AMMETER
FUSE
TO LIGHT AND ACCESSORY LOAD
FUSE
+ STORAGE BATTERY (12V)
A
+ STORAGE BATTERY (12V)
B
-A
+B
FUSE OR CIRCUIT BREAKER (50 AMPS)
SERIES-PARALLEL CRANKING SW. (MANUAL TYPE)
-B
SW.
AMMETER
SOLENOID 24 VOLT
GROUND
CRANKING MOTOR 24 VOLT

Circuit diagram of series-parallel system with batteries connected in series through the series-parallel switch. Series-parallel switch has been operated to cause the starting motor to crank the engine. Series connections are made through heavy contacts in switch and through heavy contacts in solenoid. Parallel connections in switch have been broken.

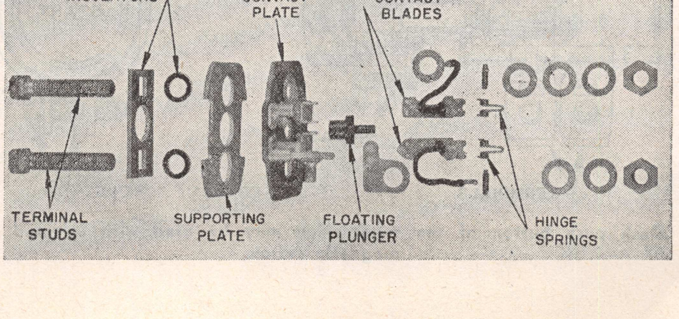

HOUSING ASSEMBLY
GASKET
INSULATION PLATE
COVER
CONTACT AND TERMINAL STUD ASSEMBLY

Exploded view of series-parallel switch.

Some series-parallel switches include two fuses in their "B" and Ground terminals. Others are designed to be used on applications where the fuses are the circuit external to the switch. This latter type switch is shown above.


PUSH BUTTON ASSEMBLY
SLEEVE
PUSH ROD
TRIGGERS
CONTACT DISC
HOUSING

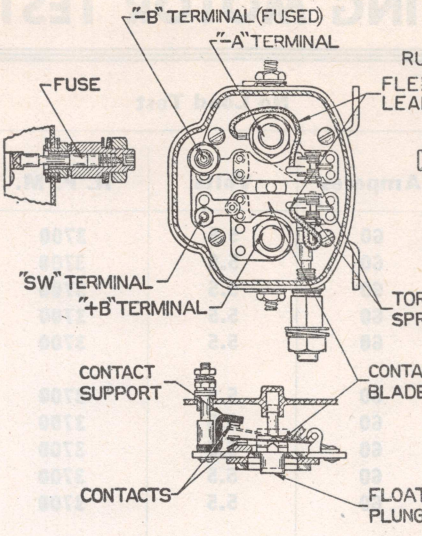
Disassembly of series-parallel switch housing assembly.

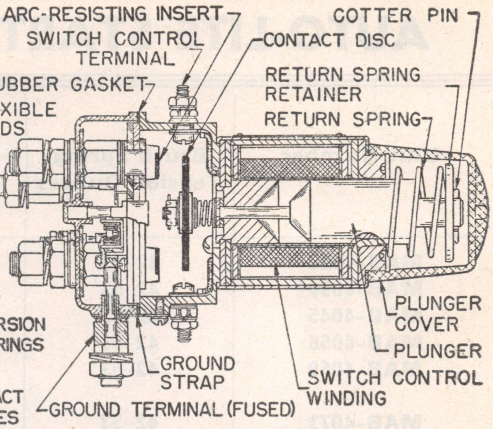

INSULATORS
CONTACT PLATE
CONTACT BLADES
TERMINAL STUDS
SUPPORTING PLATE
FLOATING PLUNGER
HINGE SPRINGS

Disassembly of contact and terminal stud assembly.

and hinge springs, are removed by pushing down on blades at hinge end and sliding from vee slots in support. Assembly is the reverse of the above. Apply a small amount of high melting point grease to the push rod and push button assembly on reassembly. Use Permatex to seal the sleeve and gasket under the push button assembly hex nut. The terminal studs should be reassembled to the contact plate so that the heavy tungsten inserts on the stud heads will be located as near the centerline of the switch as possible. This will permit the maximum area of contact between the tungsten inserts and the contact disc when the switch is operated.

Since series-parallel switches are used on applications where heavy-duty starting motors and higher voltage batteries are installed, it is extremely important to avoid grounding any terminal on the starting motor or switch while the battery or batteries are connected. Due to the low resistance of the circuits, any ground would permit such a high current to flow that fuses would be blown and serious damage might result to the equipment. For this reason, it is strongly recommended that all exposed terminals be protected with friction tape and shellac, rubber tape, or rubber boots. In addition, care should be used to make sure that all leads and terminal slips are adequate to withstand the high current and mechanical shock and vibration on the installation.


"-B" TERMINAL (FUSED)
"-A" TERMINAL
FUSE
FLEXIBLE LEADS
"SW" TERMINAL
"+B" TERMINAL
TORSION SPRINGS
CONTACT SUPPORT
CONTACT BLADES
CONTACTS
FLOATING PLUNGER


ARC-RESISTING INSERT
SWITCH CONTROL TERMINAL
RUBBER GASKET
COTTER PIN
CONTACT DISC
RETURN SPRING RETAINER
RETURN SPRING
PLUNGER COVER
PLUNGER
SWITCH CONTROL WINDING
GROUND STRAP
GROUND TERMINAL (FUSED)

Solenoid operated series-parallel switch. This switch is similar to the manually-operated type except that the switch is operated by a solenoid which is controlled by a push button.

STARTING MOTORS

AUTO-LITE STARTING MOTOR TEST SPECIFICATIONS

Unit Number	Brush Spring Tension Ounces	No Load Test			Lock Test		
		Amperes	Volts	R. P. M.	Amperes	Volts	Torque, Pounds Feet
MAB-4028	42–53	60	5.5	3700	750	4.0	21.5
MAB-4030	42–53	60	5.5	3700	750	4.0	21.5
MAB-4045	42–53	60	5.5	3700	750	4.0	21.5
MAB-4058	42–53	60	5.5	3700	750	4.0	21.5
MAB-4069	42–53	60	5.5	3700	750	4.0	21.5
MAB-4071	42–53	60	5.5	3700	750	4.0	21.5
MAB-4072	42–53	60	5.5	3700	750	4.0	21.5
MAB-4078	42–53	60	5.5	3700	750	4.0	21.5
MAB-4080	42–53	60	5.5	3700	750	4.0	21.5
MAB-4082	42–53	60	5.5	3700	750	4.0	21.5
MAB-4084	42–53	60	5.5	3700	750	4.0	21.5
MAB-4085	42–53	60	5.5	3700	750	4.0	21.5
MAB-4091	42–53	60	5.5	3700	750	4.0	21.5
MAB-4093	42–53	60	5.5	3700	750	4.0	21.5
MAB-4094	42–53	60	5.5	3700	750	4.0	21.5
MAB-4098	42–53	60	5.5	3700	750	4.0	21.5
MAB-4101	42–53	60	5.5	3700	750	4.0	21.5
MAB-4102	42–53	60	5.5	3700	750	4.0	21.5
MAB-4106	42–53	60	5.5	3700	750	4.0	21.5
MAD-4106	42–53	60	5.5	3600	730	4.0	18.5
MAD-4112	42–53	60	5.5	3600	730	4.0	18.5
MAH-4005	42–53	72	11.0	5500	650	4.0	18.0
MAH-4010	42–53	72	11.0	5500	650	4.0	18.0
MAH-4012	42–53	72	11.0	5500	650	4.0	18.0
MAH-4016	42–53	72	11.0	5500	650	4.0	18.0
MAJ-4005	42–53	67	5.5	4100	750	4.0	17.0
MAJ-4006	42–53	67	5.5	4100	750	4.0	17.0
MAJ-4011	42–53	67	5.5	4100	750	4.0	17.0
MAJ-4016	42–53	67	5.5	4100	750	4.0	17.0
MAJ-4024	42–53	67	5.5	4100	750	4.0	17.0
MAJ-4027	42–53	67	5.5	4100	750	4.0	17.0
MAJ-4038	42–53	67	5.5	4100	750	4.0	17.0
MAJ-4040	42–53	67	5.5	4100	750	4.0	17.0
MAJ-4041	42–53	67	5.5	4100	750	4.0	17.0
MAJ-4042	42–53	67	5.5	4100	750	4.0	17.0
MAJ-4045	42–53	67	5.5	4100	750	4.0	17.0
MAJ-4054	42–53	67	5.5	4100	750	4.0	17.0
MAJ-4062	42–53	67	5.5	4100	750	4.0	17.0
MAK-4005	38–61	70	5.5	5000	520	4.0	17.0
MAS-4003	12–16	100	10.0	1720	440	6.0	20.0
MAS-4008	12–16	100	10.0	1720	440	6.0	20.0
MAS-4011	12–16	100	10.0	1720	440	6.0	20.0
MAS-4080	12–16	100	10.0	1720	440	6.0	20.0
MAU-4004	42–53	65	11.0	4800	730	8.0	23.5
MAU-4005	42–53	65	11.0	4800	730	8.0	23.5
MAU-4006	42–53	65	11.0	4800	730	8.0	23.5
MAU-4011	42–53	65	11.0	4800	730	8.0	23.5
MAU-4012	42–53	65	11.0	4800	730	8.0	23.5
MAU-4013	42–53	65	11.0	4800	730	8.0	23.5
MAU-4014	42–53	65	11.0	4800	730	8.0	23.5

Continued on next page

AUTO-LITE STARTING MOTOR TEST SPECIFICATIONS

Continued from previous page

Unit Number	Brush Spring Tension Ounces	No Load Test			Lock Test		
		Amperes	Volts	R. P. M.	Amperes	Volts	Torque, Pounds Feet
MAU-4015	42-53	65	11.0	4800	730	8.0	23.5
MAU-4016	42-53	65	11.0	4800	730	8.0	23.5
MAU-4022	42-53	65	11.0	4800	730	8.0	23.5
MAW-4001	42-53	65	5.5	4900	670	4.0	18.0
MAW-4005	42-53	65	5.5	4900	670	4.0	18.0
MAW-4013	42-53	65	5.5	4900	670	4.0	18.0
MAW-4013A	42-53	65	5.5	4900	670	4.0	18.0
MAW-4013B	42-53	65	5.5	4900	670	4.0	18.0
MAW-4015	42-53	65	5.5	4900	670	4.0	18.0
MAW-4020	42-53	65	5.5	4900	670	4.0	18.0
MAW-4023	42-53	65	5.5	4900	670	4.0	18.0
MAW-4023A	42-53	65	5.5	4900	670	4.0	18.0
MAW-4028	42-53	65	5.5	4900	670	4.0	18.0
MAW-4029	42-53	65	5.5	4900	670	4.0	18.0
MAX-4007	42-53	65	5.5	5300	880	4.0	25.0
MAX-4009	42-53	65	5.5	5300	880	4.0	25.0
MAX-4018	42-53	65	5.5	5300	880	4.0	25.0
MAX-4019	42-53	65	5.5	5300	880	4.0	25.0
MAX-4028	42-53	65	5.5	5300	880	4.0	25.0
MAX-4031	42-53	65	5.5	5300	880	4.0	25.0
MAX-4031A	42-53	65	5.5	5300	880	4.0	25.0
MAX-4031B	42-53	65	5.5	5300	880	4.0	25.0
MAX-4032	42-53	65	5.5	5300	880	4.0	25.0
MAX-4033	42-53	65	5.5	5300	880	4.0	25.0
MAX-4034	42-53	65	5.5	5300	880	4.0	25.0
MAX-4035	42-53	65	5.5	5300	880	4.0	25.0
MAX-4039	42-53	65	5.5	5300	880	4.0	25.0
MAX-4048	42-53	65	5.5	5300	880	4.0	25.0
MAY-4114A	42-53	30	11.0	5300	375	8.0	18.5
MAY-4114B	42-53	30	11.0	5300	375	8.0	18.5
MBD-4003	40-50	70	22.0	5800	590	6.0	35.0
MBG-4004	42-53	50	10.0	6900	520	8.0	14.7
ML-4102	12-16	50	5.5	2980	750	4.0	26.0
ML-4104	12-16	50	5.5	2980	750	4.0	26.0
ML-4111	12-16	50	5.5	2980	750	4.0	26.0
ML-4130	12-16	50	5.5	2980	750	4.0	26.0
ML-4137	12-16	50	5.5	2980	750	4.0	26.0
ML-4144	12-16	50	5.5	2980	750	4.0	26.0
ML-4145	12-16	50	5.5	2980	750	4.0	26.0
ML-4151	12-16	50	5.5	2980	750	4.0	26.0
ML-4154	12-16	50	5.5	2980	750	4.0	26.0
ML-4162	12-16	50	5.5	2980	750	4.0	26.0
ML-4163	12-16	50	5.5	2980	750	4.0	26.0
ML-4166	12-16	50	5.5	2980	750	4.0	26.0
ML-4173	12-16	50	5.5	2980	750	4.0	26.0
ML-4179	12-16	50	5.5	2980	750	4.0	26.0
ML-4180	12-16	50	5.5	2980	750	4.0	26.0
ML-4186	12-16	50	5.5	2980	750	4.0	26.0
ML-4189	12-16	50	5.5	2980	750	4.0	26.0
ML-4191	12-16	50	5.5	2980	750	4.0	26.0

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STARTING MOTORS

AUTO-LITE STARTING MOTOR TEST SPECIFICATIONS

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Unit Number	Brush Spring Tension Ounces	No Load Test			Lock Test		
		Amperes	Volts	R. P. M.	Amperes	Volts	Torque, Pounds, Feet
ML-4192	12–16	50	5.5	2980	750	4.0	26.0
ML-4202	12–16	50	5.5	2980	750	4.0	26.0
ML-4209	12–16	50	5.5	2980	750	4.0	26.0
ML-4211	12–16	50	5.5	2980	750	4.0	26.0
MR-4104	12–16	40	5.5	2800	700	4.0	43.0
MR-4108	12–16	50	11.0	4300	700	4.0	43.0
MR-4111	12–16	50	11.0	4300	700	4.0	43.0
MR-4115	12–16	40	5.5	2800	700	4.0	43.0
MR-4118	12–16	50	11.0	4300	700	4.0	43.0
MR-4119	12–16	50	11.0	4300	700	4.0	43.0
MZ-4019	42–53	70	5.5	4300	560	4.0	11.8
MZ-4025	42–53	70	5.5	4300	560	4.0	11.8
MZ-4027	42–53	70	5.5	4300	560	4.0	11.8
MZ-4028	42–53	70	5.5	4300	560	4.0	11.8
MZ-4031	42–53	70	5.5	4300	560	4.0	11.8
MZ-4031A	42–53	70	5.5	4300	560	4.0	11.8
MZ-4035	42–53	70	5.5	4300	560	4.0	11.8
MZ-4036	42–53	70	5.5	4300	560	4.0	11.8
MZ-4046	42–53	70	5.5	4300	560	4.0	11.8
MZ-4049	42–53	70	5.5	4300	560	4.0	11.8
MZ-4051	42–53	70	5.5	4300	560	4.0	11.8
MZ-4059	42–53	70	5.5	4300	560	4.0	11.8
MZ-4059A	42–53	70	5.5	4300	560	4.0	11.8
MZ-4060	42–53	50	10.0	6900	520	8.0	14.7
MZ-4063	42–53	70	5.5	4300	560	4.0	11.8
MZ-4069	42–53	70	5.5	4300	560	4.0	11.8
MZ-4072	42–53	70	5.5	4300	560	4.0	11.8
MZ-4090	42–53	70	5.5	4300	560	4.0	11.8
MZ-4091	42–58	70	5.5	4300	560	4.0	11.8
MZ-4104	42–53	70	5.5	4300	560	4.0	11.8

DELCO-REMY STARTING MOTOR INDEX

Starting Motor No.	Direction of Rotation	Specification Number	Starting Motor No.	Direction of Rotation	Specification Number	Starting Motor No.	Direction of Rotation	Specification Number	Starting Motor No.	Direction of Rotation	Specification Number
371	C	375	540	C	380	588	C	401	650	C	401
412	C	425	543	C	365	589	C	406	651	C	383
413	C	375	545	C	375	590	C	425	653	C	401
414	C	425	547	C	383	595	C	401	655	C	375
477	C	383	548	C	389	599	C	383	658	C	360
486	C	379	575	C	383	640	C	375	659	C	401
492	C	383	578	C	383	642	C	425	660	C	360
493	C	380	579	C	383	644	C	379	661	C	425
494	C	379	586	C	383	645	C	401	662	C	401
499	C	383	587	C	383	646	C	401	665	C	418

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Starting Motor No.	Direction of Rotation	Specification Number	Starting Motor No.	Direction of Rotation	Specification Number	Starting Motor No.	Direction of Rotation	Specification Number	Starting Motor No.	Direction of Rotation	Specification Number
668	C	401	724-Z	C	370	739-C	CC	400	SM1218	C	375
700	C	375	725-D	C	372	739-D	C	368	SM1219	C	425
704	C	365	725-P	C	410	739-E	C	400	SM1238	C	377
707	C	401	725-U	C	410	739-H	C	368	SM1285	C	368
708	C	401	727	C	379	740	CC	401	SM1307	C	425
709	C	360	727-M	C	395	740-H	C	364	SM1327	C	364
710	C	425	728	C	375	740-J	C	364	SM1336	C	364
711	C	401	728-H	C	384	740-K	C	363	SM1410	C	395
712-E	C	391	728-L	C	373	740-L	C	364	SM1581	C	363
713	C	389	729-D	C	410	740-M	C	363	SM1602	C	377
714-A	C	368	730	C	360	740-N	C	364	SM1625	C	401
714-B	C	368	733	C	360	740-P	C	407	SM1640	C	364
714-G	C	368	734	C	375	741	C	401	SM1664	C	383
714-Q	C	368	734-D	C	368	743	C	360	SM1718	C	377
716-E	C	371	734-H	C	368	743-A	C	364	SM1750	CC	401
717	C	418	734-K	C	368	744	C	389	SM1751	C	401
718-D	C	407	734-S	C	368	751	C	401	SM1763	C	401
718-F	C	363	734-T	C	368	752	C	360	SM1765	C	363
718-H	C	363	734-V	C	400	753	C	383	SM1768	CC	401
718-R	C	407	734-X	C	368	754	C	360	SM1781	C	413
718-S	C	364	734-Y	C	400	757	C	383	SM1805	C	383
718-W	C	363	735	C	401	759	C	383	SM1869	C	383
719	C	360	736	C	360	762	C	401	SM1914	C	364
720-R	C	363	736-B	C	363	763	C	401	SM1917	C	363
720-T	C	363	736-G	C	407	767	C	360	SM1936	C	370
720-V	C	363	736-M	C	363	768	C	401	SM1937	C	364
721-G	C	377	736-N	C	364	769	CC	379	SM1940	C	363
721-K	C	370	736-U	C	364	772	C	401	1107001	C	368
721-L	C	370	736-V	C	363	773	C	360	1107009	C	368
721-M	C	370	736-Y	C	363	774	C	365	1107010	CC	400
721-N	C	377	736-Z	C	364	777	C	401	1107012	C	368
721-P	C	377	737-B	C	363	780	C	360	1107014	C	400
722-D	C	384	737-D	C	363	781	C	425	1107015	C	368
722-E	C	370	737-E	C	363	786	C	401	1107016	C	368
722-L	C	370	737-F	C	364	790	C	389	1107033	C	368
722-N	C	377	737-H	C	364	798	C	379	1107041	C	368
722-T	C	370	737-P	C	364	799	C	360	1107047	C	368
722-U	C	370	737-R	C	363	805	C	419	1107051	C	402
722-Y	C	377	737-T	C	363	806	C	419	1107052	C	368
722-Z	C	370	737-U	C	364	807	CC	419	1107053	C	448
724	C	425	737-W	C	364	808	CC	419	1107054	C	368
724-C	C	370	737-Z	C	363	809	C	419	1107055	C	368
724-D	C	370	738-C	C	368	816	C	419	1107401	C	363
724-K	C	370	738-G	C	368	823	C	433	1107403	C	363
724-L	CC	370	738-H	C	400	833	C	419	1107407	C	363
724-Q	C	370	738-K	C	368	SM1111	C	364	1107408	CC	363
724-R	C	370	738-L	C	368	SM1117	C	363	1107413	C	363
724-U	C	370	738-N	C	368	SM1119	C	363	1107414	C	363
724-X	C	370	739	C	401	SM1170	C	375	1107418	C	363
724-Y	C	377	739-A	C	368	SM1192	C	364	1107420	C	363

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STARTING MOTORS

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Starting Motor No.	Direction of Rotation	Specification Number	Starting Motor No.	Direction of Rotation	Specification Number	Starting Motor No.	Direction of Rotation	Specification Number	Starting Motor No.	Direction of Rotation	Specification Number
1107422	C	363	1108102	C	410	1108454	C	373	1108709	C	429
1107431	C	363	1108103	C	410	1108455	C	373	1108710	C	429
1107437	C	363	1108104	C	410	1108528	C	384	1108711	CC	429
1107443	C	363	1108107	C	410	1108531	C	384	1108712	CC	429
1107803	C	364	1108111	C	410	1108532	C	384	1108715	C	429
1107805	C	364	1108201	C	370	1108533	C	384	1108722	C	429
1107809	C	364	1108205	C	370	1108534	C	384	1108724	C	429
1107811	C	364	1108206	CC	370	1108535	C	384	1108725	C	429
1107813	C	364	1108207	C	370	1108537	C	384	1108900	C	375
1107816	C	364	1108208	C	370	1108557	C	435	1108906	C	375
1107826	C	364	1108209	C	370	1108560	C	368	1108907	C	425
1107829	C	364	1108210	C	370	1108562	C	410	1109100	C	383
1107903	C	372	1108401	C	377	1108676	C	364	1109103	C	383
1107906	C	372	1108404	C	377	1108678	C	364	1109104	C	383
1107915	C	372	1108405	C	377	1108702	C	429	1109303	C	360
1107916	C	372	1108406	C	377	1108704	C	429	1109402	C	360
1107918	C	396	1108407	C	377	1108705	C	429			
1107920	C	396	1108451	C	373	1108706	C	429			
1107936	C	396	1108452	C	373	1108707	C	429			
1108101	C	410	1108453	C	373	1108708	C	429			

C--Clockwise.
CC--Counter-Clockwise.

DELCO-REMY STARTING MOTOR TEST SPECIFICATIONS

Spec. No.	Brush Spring Tension, Ounces	No Load Test			Lock Test		
		Amperes	Volts	R.P.M.	Amperes	Volts	Torque Lbs. Ft.
360	36–40	100	12.0	6000	600	3.0	24
363	24–28	65	5.0	6000	570	3.15	15
364	24–28	65	11.35	6000	450	7.5	15
365	36–40	70	5.7	2200	600	3.0	35
368	24–28	65	5.0	5000	525	3.37	12
370	24–28	70	5.0	3500	600	3.0	22
371	24–28	70	5.0	3000	450	3.7	15
372	24–28	60	5.0	6000	600	3.0	16
373	24–28	70	5.0	2500	600	3.0	28
375	36–40	70	5.0	3000	500	3.0	19
377	24–28	70	10.0	3000	490	6.5	28
379	36–40	75	8.0	2000	500	3.5	45
380	36–40	60	8.0	2000	500	4.5	30
383	36–40	65	12.0	4500	725	4.8	44
384	24–28	70	10.0	2800	530	6.7	33
389	36–40	75	11.25	2400	700	5.0	51
391	24–28	70	5.0	4500	450	3.6	11
395	24–28	65	5.0	5500	600	3.0	15
396	24–28	65	5.0	5500	600	3.0	16
400	24–28	65	5.0	5000	525	3.37	12

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DELCO-REMY STARTING MOTOR TEST SPECIFICATIONS

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Spec. No.	Brush Spring Tension, Ounces	No Load Test			Lock Test		
		Amperes	Volts	R.P.M.	Amperes	Volts	Torque Lbs. Ft.
401	36–40	85	22.0	6000	500	3.0	25
402	24–28	65	5.0	5000	525	3.37	12
406	36–40	77	21.0	6500	340	2.8	23
407	32–36	65	5.0	6000	570	3.15	15
410	24–28	70	10.0	7000	530	6.7	16
413	32–36	30	32.0	8400	200	7.4	28
418	36–40	75	11.25	2250	700	5.0	55
419	36–40	90	23.3	6800	800	4.35	60
425	36–40	80	11.2	4500	670	5.35	32
429	36–40	100	11.6	5000	570	2.3	20
433	36–40	100	30.8	8000	700	5.0	56
435	24–28	40	11.6	5500	260	9.4	15
448	24–28	65	5.0	5000	525	3.37	12

NOTE--Refer to the Delco-Remy numerical index for specification number desired.

LEECE-NEVILLE STARTING MOTOR INDEX

Motor Type Number	Rotation ②	Motor Key Type①	Motor Type Number	Rotation ②	Motor Key Type①	Motor Type Number	Rotation ②	Motor Key Type①
548M	CW	548M	771M	CC	770M	918M	CW	766M
596M	CW	358M	775M	CC	660M	920M	CW	840M
632M	CW	358M	785M	CC	660M	921M	CC	840M
638M	CW	358M	790M	CW	766M	922M	CW	840M
644M	CW	640M	840M	CW	840M	923M	CC	840M
660M	CW	660M	850M	CW	850M	941M	CC	860M
660MA	CW	660M	858M	CW	850M	944M	CW	860M
660MB	CW	660M	860M	CW	860M	945M	CC	860M
661M	CC	660M	870M	CW	870M	960M	CW	766M
662M	CW	660M	870MB	CW	870M	1000M	CW	883M
663M	CC	660M	870MI	CW	870M	1044M	CW	700M
664M	CW	660M	871M	CC	870M	1066M	CW	358M
665M	CC	660M	871MB	CC	870M	1082M	CW	1076M
684M	CW	660M	884M	CW	878M	1084M	CW	1076M
698M	CW	458M	884MB	CW	878M	1112M	CW	850M
702M	CW	700M	884MI	CW	878M	1114M	CW	766M
702MA	CW	700M	885M	CC	878M	1118M	CW	766M
707M	CC	700M	886M	CW	766M	1122M	CW	1076M
734M	CW	728M	888M	CW	766M	1126M	CW	1076M
750M	CW	542M	898M	CW	878M	1127M	CC	1076M
751M	CC	542M	900M	CW	850M	1128M	CW	1076M
751MA	CC	542M	903M	CC	850M	1128MA	CW	1076M
752M	CW	660M	908M	CW	850M	1142M	CW	850M
753M	CC	660M	912M	CW	766M	1172M	CW	850M
766M	CW	766M	914M	CW	842M	1194M	CW	766M

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STARTING MOTORS

LEECE-NEVILLE STARTING MOTOR INDEX

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Motor Type Number	Rotation ②	Motor Key Type①	Motor Type Number	Rotation ②	Motor Key Type①	Motor Type Number	Rotation ②	Motor Key Type①
1236M	CW	850M	1320M	CW	850M	1372M	CW	850M
1254M	CW	1270M	1322M	CW	1004M	1386M	CW	510M
1282M	CW	1076M	1342M	CW	850M	1422M	CW	840M
1288M	CW	766M	1342MA	CW	850M	1440M	CW	1076M
1290M	CW	870M	1343M	CC	850M	1446M	CW	840M
1296M	CW	1076M	1343MA	CC	850M	1546M	CW	1546M
1298M	CW	850M	1346M	CW	850M			
1299M	CC	850M	1366M	CW	850M			

① See "Starting Motor Specifications" for test figures. ②CW—Clockwise. CC—Counter Clockwise.

LEECE-NEVILLE STARTING MOTOR TEST SPECIFICATIONS

Motor Key Type①	Rated Volts	Locked Torque Lbs. Ft.	Terminal Voltage	Amperes	Motor Key Type①	Rated Volts	Locked Torque, Lbs. Ft.	Terminal Voltage	Amperes
358M	12	35– 38	7.2	600	770M	30	90– 95	10.0	1400
458M	6	18– 20	2.5	625	840M	24-32	95–100	10.8	1450
510M	12	35– 40	7.0	645	842M	24-32	89– 90	13.0	1000
542M	12	35– 40	7.2	570	850M	24	85– 90	12.2	1300
548M	6	18– 22	3.1	720	860M	30	210–220	7.6	2000
640M	6	27– 30	4.0	600	870M	24	85– 90	12.2	1300
660M	12	50– 55	6.4	840	878M	24-32	80– 85	13.0	1000
700M	12	60– 65	7.5	795	1004M	12	75– 80	7.0	1900
728M	30	110–120	11.0	1400	1076M	12	60– 65	5.6	2075
766M	24	110–120	15.0	1700	1270M	24	170–180	6.0	2100
					1546M	12	70– 75	5.6	1850

① See "Starting Motor Index" for key type desired.

STARTING MOTORS

Starting motors will be considered herein according to their general type, and not according to their manufacturer. Auto-Lite, Delco-Remy, Ford, and Leece-Neville starting motors using the Bendix-type drive are all much alike in general construction. Likewise, Auto-Lite and Delco-Remy overrunning clutch-type starting motors are similar. A third type of starting motor for heavy-duty applications uses the Dyer drive (Delco-Remy).

Some Bendix drive and overrunning clutch drive starting motors make use of a gear reduction, or a pair of gears between the armature and drive shafts. Service and maintenance on gear reduction starting motors are similar for the comparative types which do not have gear reductions.

Most starting motors are simple in construction, and so similar (except for the drive mechanism) that the procedure of disassembly and assembly is usually easy and obvious. Important features of disassembly, repair and assembly, as well as differences between units, will be pointed out below.

WIRING CIRCUITS

From four to as many as twelve brushes (six sets of two each) may be used. Normally, half the brushes (or brush sets) are grounded to the end frame, while the other half are insulated and are connected to the field coils. Other starting motors have all brushes insulated, with one end of the field circuit grounded. The other end of the field circuit is connected to two (or three on six brush types) of the brushes, while the other two (or three) brushes are connected to the starting motor terminal. On some heavy-duty insulated starting motors, the brushes, instead of being grounded, are connected to a second terminal in the commutator end frame.

It is important to bear in mind these different typical wiring circuits when checking and repairing starting motors, since the checking procedures will differ somewhat for the various types.

COMMUTATOR END FRAMES

Brush holders may be divided into two general classifications, the swivel type, and the box type. The swivel-type brush holder has the brush fastened rigidly to a brush arm which is assembled to and swivels about a pivot pin. In the box type, the brush rides freely in a box, and is kept in contact with the commutator by a spring, or a spring arm.

Pivot pins, and stop pins (swivel-type holder) can be pressed out of the commutator end frame and replaced.

Many box-type brush holders are riveted to the commutator end frame so that the frame, with brush holders, must be serviced as a unit.

Other box-type brush holders are mounted on brush plates, with insulating washers, insulating bushings, lock washers and attaching nuts. On this type, it is very important to note the exact relationship of the parts during disassembly, so that all parts can be replaced in the same relative order.

The brush spring tension on both types of brush holders can be measured by placing the armature in position in the commutator end frame with the brushes resting on the armature in the normal operating position. The pull required to lift the brush arm or brush off the commutator can then be checked with a spring gauge. Improper brush spring tension requires bending or replacement of the brush springs. On Leece-Neville starting motors, a ratchet arrangement on the brush arm assembly permits shifting of the spring end from one notch to another to change the brush spring tension.

New brushes should be installed when necessary. Where the brushes do not have the proper curvature to fit the commutator, they may be seated with fine sandpaper (number 00). Wrap a strip of sandpaper around the commutator with the sanded side out, drop the brushes down on the sandpaper and pull the sandpaper under the brushes. Blow out the dust. Never use emery cloth, since particles of emery may embed and wear the brushes and commutator rapidly.

When taking brushes out of brush holders, do not pull them out against the brush spring pressure by the pigtail leads, since this may loosen the connection in the brush. Pull spring or arm back first, and then remove brush. Do not snap the spring or lever down on brush, as this could crack or break the brush.

NOTE—Some commutator end frames have provision for shifting the brush plate with respect to the end frame. This permits correct relative location at the factory during original assembly. On such starting motors, the brush plate or brush plate attaching screw position should be marked before disassembly, so the parts can be replaced in the same relative positions.

FIELD FRAMES

As mentioned above, starting motors may have two, four, or six field coils. They are connected in various combinations, and may be insulated (connected at one end to the starting motor terminal and at the other end to insulated brushes) or one end may be grounded to the field frame.

On disassembly, the field coil connections to the frame or terminal should be unsoldered or disconnected and a pole shoe screw driver used to remove the pole shoe screws. Use of a hammer and punch is not satisfactory, since this may batter the screw heads so the screws cannot be used again. On reassembly, a pole shoe spreader may be used to bring the pole shoes up tightly against the field frame, and to prevent distortion of the field frame which might otherwise result due to the pressure of the pole shoe screw driver.

Some pole shoes have one long lip and one short lip. The long lip should always be assembled in the direction of normal armature rotation.

On reassembly, reconnect or resolder the field leads as required. Use rosin (not acid) flux in making soldered connections.

BUSHINGS AND BEARINGS

Ball and roller bearings should be checked and serviced in line with the bearing manufacturer's recommendations. This includes washing in clean gasoline, kerosene, or carbon tetrachloride. Swish the bearings in the cleaner and revolve them while submerged. After cleaning, the bearings should be spun slowly in clean, light oil until all solvent has been removed. Repack with ball bearing grease immediately.

Bushings, if worn, may be pressed out in an arbor press and new bushings pressed in. Where the application has grey iron bearings, which have worn, it may be possible to ream the bearings and press in a bushing. Some bushings are pressed in with special arbors which correctly size them. Others must be reamed or burnished to size. Where there is an oil wick assembled through a hole in the side of the bushing so the wick is in contact with the armature shaft, the bushing must be drilled after installation to accommodate the oil wick. This may throw up a burr in the bushing, which must be removed by subsequent burnishing. Bushings should be reamed concentric with the machined registers on the frame or housing so the armature will be centered in the starting motor after reassembly.

FIELD COILS

Field coils should not be cleaned in any degreasing tank or with any solvent, since this may damage the insulation and cause a short or ground when the unit is reassembled.

Field coils with insulation which is chafed, worn, burned or otherwise defective may often be reinsulated by rewrapping them with insulating tape and painting them with shellac or insulating compound. This job must be neatly done, so that the rewrapped coils will fit properly under the pole shoes on reassembly. Soldered connections between coils should be made with rosin (not acid) flux.

ARMATURE

The armature should not be cleaned in any solvent or degreasing compound since this might damage the insulation. If the commutator is worn, out of round, burned, dirty or gummed, or has high mica, it may be turned down in a lathe. While all manufacturers do not specify undercutting the mica on starting motor commutators, the mica may be undercut if high mica is found, since this is an indication that the mica is hard. Be sure to remove any slight burrs which exist after the mica is undercut. This can be done with a strip of fine sandpaper.

CAUTION—Never use emery cloth on commutators, since particles of emery may embed and cause rapid brush wear.

If the armature shaft is worn at the bearing surfaces, it may be possible to save the armature by grinding the shaft down and then installing undersized bushings in the frame or housing.

Burned commutator bars are usually an indication of open-circuited armature windings. Such a condition usually results from excessive overloading of the starting motor, or excessively long cranking periods. Thirty seconds is the maximum length of time a starting motor should be used at any one time without a pause of several minutes to allow the motor to cool. Otherwise, overheating results, solder is thrown from the lead connections at the commutator riser bars, and open circuits develop. Further operation causes arcing at the bars which are open, and the bars burn. It is sometimes possible to save an armature when the bars are not too badly burned by resoldering the leads in the riser bars (using rosin flux) and then turning the commutator down and undercutting the mica, if necessary.

Thrown armature windings indicate the armature has been spun at excessive speeds. This sort of failure usually occurs only on the overrunning clutch type starting motor, and is a result of overrunning clutch failure. The details of overrunning clutch failures are covered in the section below on the overrunning clutch. Usually, little can be done to an armature which has failed in this manner. Even though windings which have been thrown are replaced, the other windings have probably loosened in their slots, and may throw out the next time the starting motor is operated.

The armature may be checked for grounds with a test lamp and test points. Check with test points from the commutator to the shaft or core. If the lamp lights, a ground exists. Grounds which are apparent (winding touching the core, broken or burned insulation) may often be repaired. Otherwise, the armature may have to be replaced.

With a "growler," the armature may be checked for short circuits. Short circuits which are apparent (filled commutator slots, shorts between lead cross-overs) may be repaired. Do not discard an armature as shorted without first checking to see whether the commutator slots are clean. Slots filled with copper or brush dust may cause shorts between adjacent commutator bars which can be eliminated by cleaning out the slots.

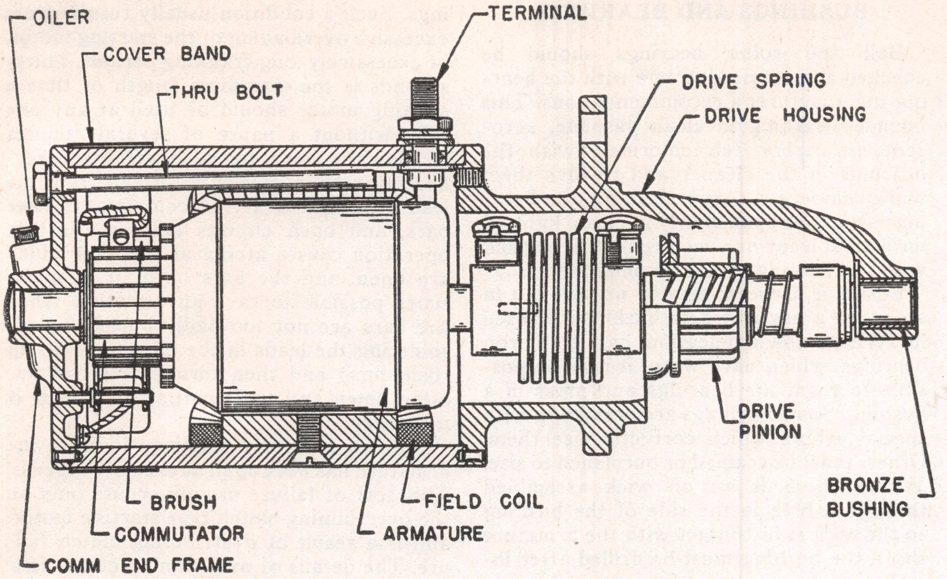
BENDIX DRIVES

There are a number of different types of Bendix drives. The servicing procedures will vary somewhat according to the type.

The standard type Bendix drives and their modifications employ an externally threaded hollow sleeve on which is mounted the drive pinion. The pinion has internal threads which match the threads on the sleeve. The sleeve is connected to the armature shaft through the drive spring and drive head. Disassembly is accomplished by removing the drive spring attaching screws and slipping the sleeve and pinion assembly, drive spring, and drive head off the armature shaft. Parts should be thoroughly cleaned (use kerosene) and on reassembly, the threaded portion of the sleeve may be lubricated with a small amount of light engine oil.

The Bendix drive sleeve is assembled under the drive spring and it prevents wrapping down of the spring. To install a

STARTING MOTORS



Bendix drive type starting motor.

new sleeve, slip the sleeve over the hollow shaft and drive the two divided portions down into the groove on the end of the shaft with a blunt chisel and hammer. It is not necessary to swedge the material down into the groove—merely drive it down enough to hold the sleeve, and yet permit it to turn freely on the hollow shaft.

Before reassembling the drive on the armature shaft, clean the shaft of rust, burrs or scoring and lubricate it with a trace of graphite grease or oil. Be sure to use the proper shaft spring and head spring screws. A screw which is too short or too long will not attach the drive spring properly, and failure will occur. Lock washers should be properly assembled under the screws, with the bent lip in the corresponding gap in the spring eye, and the other lip bent tightly up against a flat side of the screw head after the screw is tightened. Always use new lock washers.

After assembly is complete, check to see that there is free longitudinal movement of the Bendix along the armature shaft. It should be possible to compress the Bendix spring so the threaded sleeve moves freely about ¼ inch with respect to the shaft. Without this free movement, drive operation will be impaired. Damaged or distorted parts, rough shaft, long spring screw, and improper assembly are causes of restricted longitudinal movement.

The barreltype Bendix drive has the drive spring either attached with spring screws, as on the standard type, or the drive spring is anchored by means of anchor plates, as shown. To remove from armature shaft, turn pinion and barrel back to drive spring and then push end anchor plate against drive spring. This uncovers the pilot pin or screw which, when removed, permits removal of the drive assembly. Barrel and pinion assembly may be detached from the remainder of the drive by removing the retainer wire from the groove on the inside of the barrel.

After cleaning, the threads on the hollow sleeve may be lubricated with a small amount of kerosene. Heavy oil or grease should not be used, since this would cause sluggish action, particularly in cold weather. The armature shaft should be free of rust, gum, rough spots, etc. Lubricate shaft with a small amount of graphite grease or oil.

On reassembly, make certain that the pilot pin is fully covered by the anchor plate.

The compression springtype Bendix drive depends upon the compression of the drive spring to take up the shock of meshing whereas the standard types depend upon the twisting of the drive spring to accomplish this purpose. The compression spring-type Bendix drive parts are assembled together on the armature shaft and the drive spring is held between two thrust washers (or washer and cup). When the pinion goes into mesh, the screw sleeve, which has longitudinal splines matching shaft splines, moves longitudinally along the armature shaft, compressing the drive spring to take up the shock of meshing.

Disassembly is accomplished by removing the shaft nut from the end of the shaft and sliding the parts from the shaft. All parts should be cleaned. The threaded portion of the screw sleeve may be lubricated with light engine oil. In addition, the longitudinal splines on the armature shaft may be lubricated with a small quantity of graphite grease or heavy oil.

The friction clutchtype Bendix drives are used on heavy duty internal combustion engines and employ a series of spring-loaded clutch discs which slip to take up the shock of engagement, and then take hold to transmit the cranking torque. No attempt should be made to adjust the clutch, since special instructions and tools are required to test and set correctly the spring tension. The drive is removed from the armature shaft by realeasing the lock ring and removing the head screw. Clutch drives from different models of starting motors may be mechanically interchangable, but it is a dangerous practice to so interchange them, since the clutch adjustments may be different for different models of starting motors. Bendix recommends returning the complete drive to their factory for any necessary service, should trouble occur with this type drive. Application information, including the make and type starting motor and engine, should accompany the drive when it is returned, so the correct clutch setting can be made.

Bendix Housing and Spring Breakage: Breakage of Bendix housings and springs, and wrapping up of Bendix springs, can often be traced to improper starting. If the driver attempts to re-engage the drive pinion by closing the starter switch after a false start while the engine is still in motion, it is possible to mesh the pinion while the engine is on a "rock-back." With the flywheel rotating in one direction, and the drive pinion going into mesh rotating in the opposite direction, the resulting force causes the drive spring or housing to break. Drivers should be cautioned always to make sure the engine has come completely to rest before attempting another start. If the timing is off so that the engine backfires on cranking, similar damage to the housing or spring may result. Here, the remedy is to retime the engine.

B & S STARTING MOTOR DRIVE

The B & S drive is somewhat similar to the Bendix, except that a resilient rubber cushion has been substituted for the spiral spring. The rubber cushion takes up the shock of meshing. This type drive has been used on some late model Fords and on a number of other applications.

The drive is serviced as a unit, and no disassembly is possible. The drive is removed from the armature shaft by straightening the tang of the lock washer and removing the drive attaching bolt. The drive may then be pushed away from the shaft and to expose the Woodruff key which, when removed, allows the complete shaft to be slipped off the armature shaft.

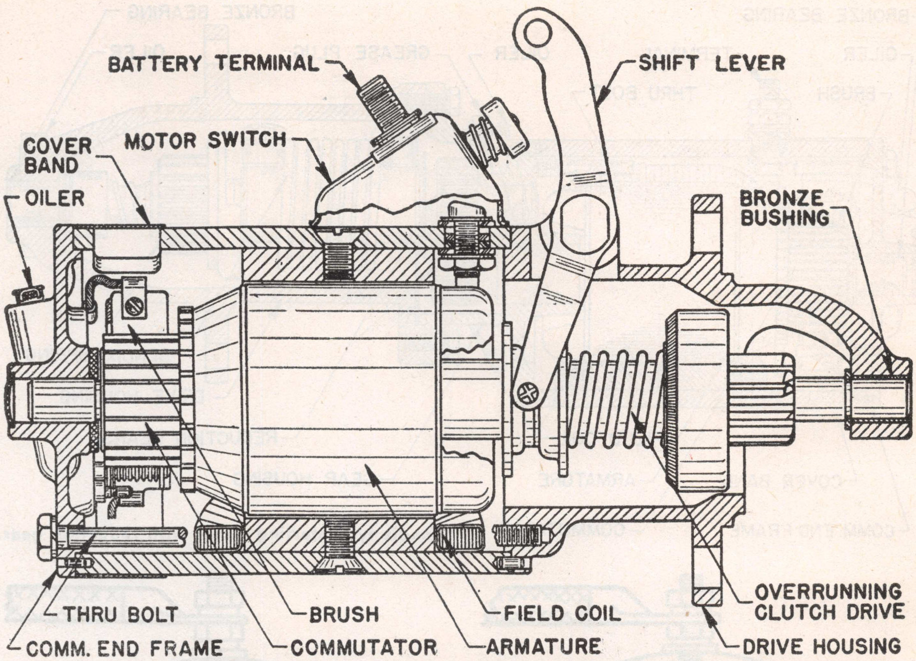
NOTE—The drive must never be cleaned by dipping it in any type of cleaning fluid. Clean the threads only by holding the drive with the rubber cushion up, and squirt kerosene from an oil can on the threads and tube at the base of the threads. Move pinion up and down several times to distribute kerosene over the threads. Blow kerosene off and wipe tube. By following this procedure, kerosene will be prevented from getting on the rubber cushion.

Lubricate threads with light (10W) oil. Squirt oil on threads and on tube and washer at base of threads. Move pinion back and forth to distribute oil. Do not get oil on the rubber cushion.

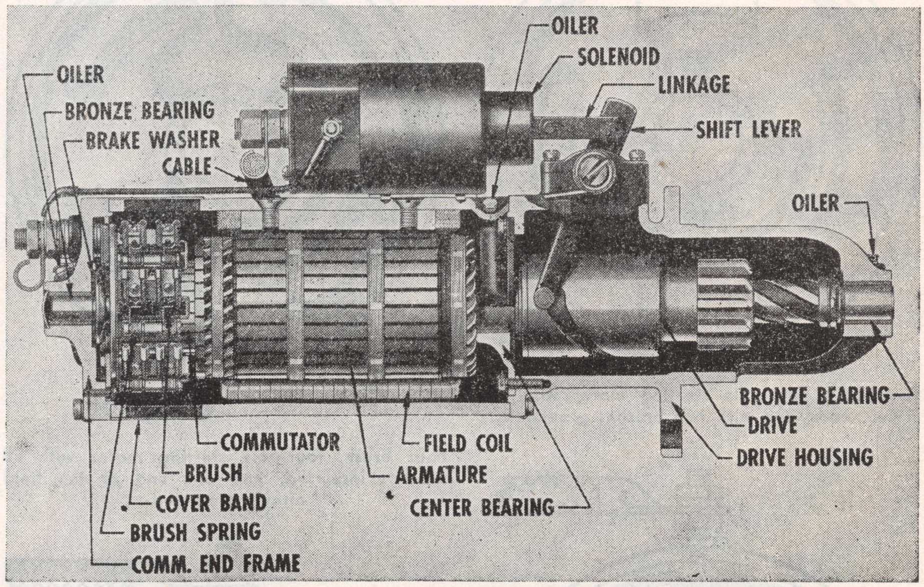
OVERRUNNING CLUTCH

The overrunning clutch should not be cleaned in any degreasing tank or by any degreasing process, since the clutch is packed with lubricant and this would dissolve the lubricant and cause the overrunning clutch eventually to fail.

The overrunning clutch may be tested by submitting it to a torque test. Place the



Typical overrunning clutch drive starting motor.



Dyer drive starting motor.

clutch on an old armature clamped in a vise, and with a torque wrench or a clamp and spring scale (such as may be used to torque-test starting motors) apply about 25 to 50 pounds-feet torque (according to type of clutch). The clutch should not slip. Remove torque wrench or clamp and spring scale, and turn the pinion in the overrunning direction. The pinion should turn freely and smoothly. If the pinion slips in the driving direction, or if it rolls roughly in the overrunning direction, it should be replaced. Never attempt to relubricate or repair a defective overrunning clutch.

If the clutch is defective, it may spin the starting motor armature at such high speeds on initial start that the armature windings will be thrown out of the armature slots Such clutch failures are often found to be caused by improper adjustment of the throttle-opening linkage to the starter pedal or to improper starting practice. Failure to remove the foot from the starter pedal immediately after the engine starts, or opening the throttle wide during cranking so that the engine immediately increases to a high speed after starting, put an undue stress on the clutch. The clutch overheats, lubricant escapes, and the clutch ultimately seizes and spins the armature at high speed, causing the armature windings to throw out. Evidence of excessive overrunning is a blued or bronzed armature shaft (due to the excessive heat which develops) where the pinion overruns.

On some manually-operated, and on all solenoid-operated overrunning clutch starting motors, the clearance between the drive pinion and housing (pinion in cranking position) can be adjusted by adjusting the starting motor switch button or the solenoid plunger stud. The clearance on Auto-Lite starting motors between the thrust washer and pinion should be 5/64 inch. On Delco-Remy starting motors, the clearance between the pinion and housing should be 3/16 inch. Take measurement with pinion in the cranking position.

DYER DRIVE

The Dyer drive provides positive meshing of the drive pinion with the flywheel teeth before the starting motor switch closes and the armature begins to rotate. The construction of the Dyer drive is somewhat more complex than other types of drives, and extreme care must be used in the disassembly-assembly procedure to make sure all parts are returned to their proper relative positions.

Disassembly is accomplished by removing the pinion stop (held in place either by a cotter pin or by a "W" lock wire) and then sliding the pinion, pinion spring. pinion guide, shift sleeve and thrust washers off the shaft. After cleaning all parts. including the splined portion of the shaft (avoid getting any cleaning fluid on the armature windings or insulation), parts may be lubricated with light oil and reassembled in the reverse order of disassembly. Note that the lugs on the pinion guide are toward the pinion. If the pinion guide is accidentally assembled backwards, failure of the drive may result. Assembly is accomplished by placing thrust washers and shift sleeve all the way on shaft, and pinion guide only about one third of the way on spiral splines. Hold guide steady, put pinion spring on shaft, and then start pinion. Align slots in pinion with lugs on pinion guide, force pinion back until it is on splines. Then release pinion guide and force pinion back toward shift sleeve. Put pinion stop on shaft and secure with a new cotter pin or "W" lock wire (according to type).

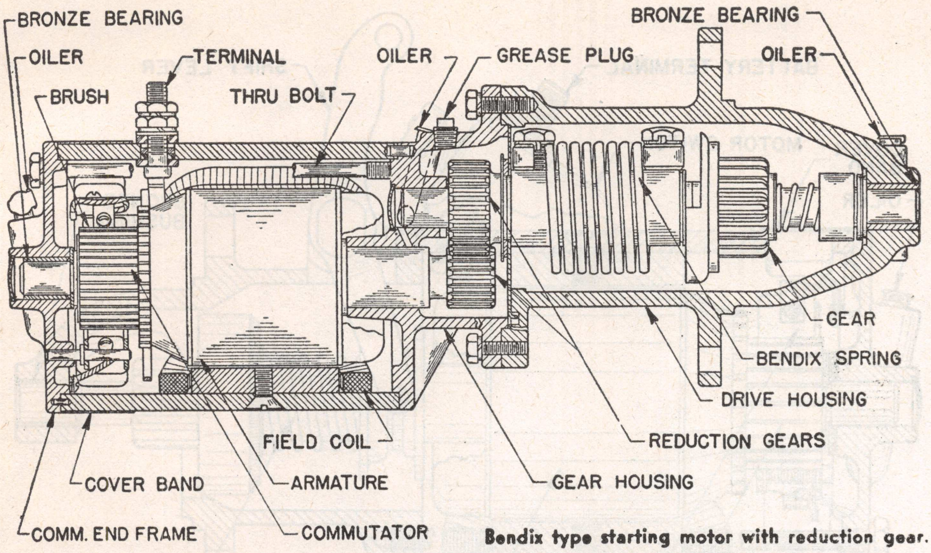
The drive should be adjusted so that when the shift lever is in the cranking position, the pinion can move back against the pinion spring ⅛ to 3/16 inch. This adjustment is accomplished on manually-operated starting motors by means of a screw and lock nut on the shift lever. On solenoid-operated types, it is adjusted by turning the solenoid plunger stud in or out as required.

Be sure to replace safety wire, and use new tang lock washers on reassembly of the starting motor. If the old tang lock washers are used again, the tangs may break off and allow screws to back out.

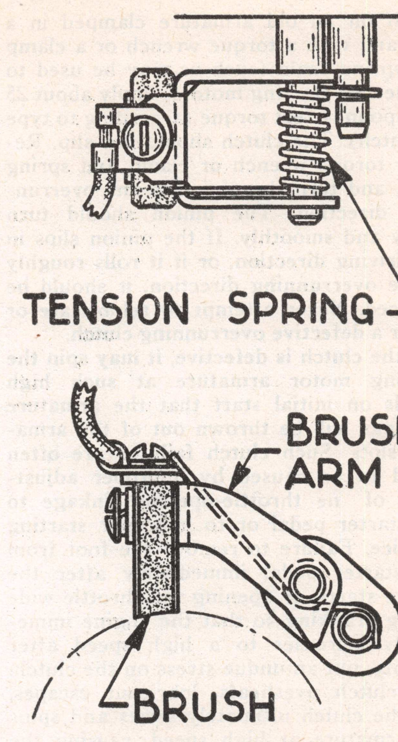
NO-LOAD AND TORQUE TESTS

After a starting motor has been disassembled and reassembled, it should be submitted to no load and torque tests, to make sure it can develop rated torque at

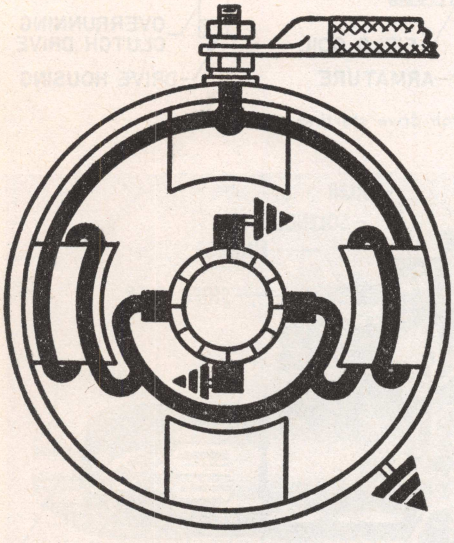
STARTING MOTORS


BRONZE BEARING
OILER
TERMINAL
BRUSH
THRU BOLT
OILER
GREASE PLUG
BRONZE BEARING
OILER
GEAR
BENDIX SPRING
DRIVE HOUSING
REDUCTION GEARS
GEAR HOUSING
FIELD COIL
COVER BAND
ARMATURE
COMM. END FRAME
COMMUTATOR

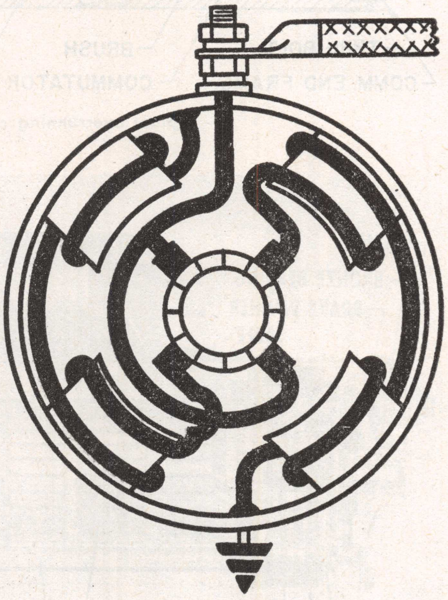
Bendix type starting motor with reduction gear.


TENSION SPRING
BRUSH ARM
BRUSH

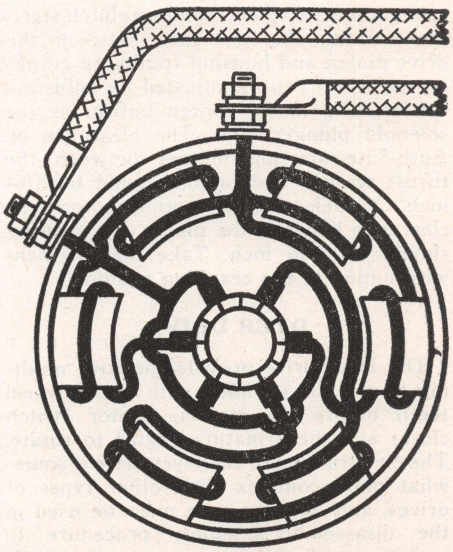
Swivel-type brush holder.



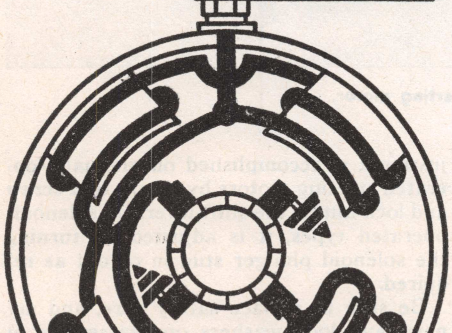
Four-brush, four-pole starting motor with two field coils, and with two brushes grounded.



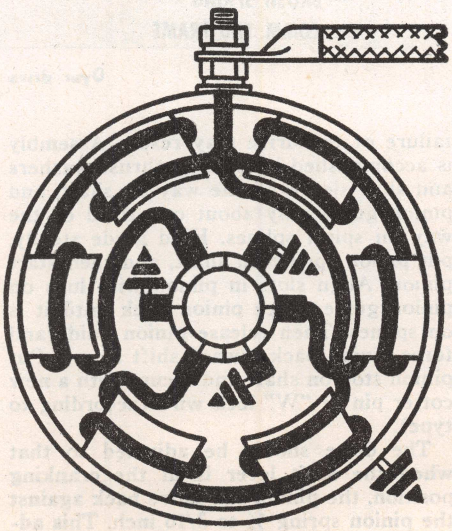
Four brush, four-pole starting motor with all brushes insulated, and one end of the field circuit grounded.



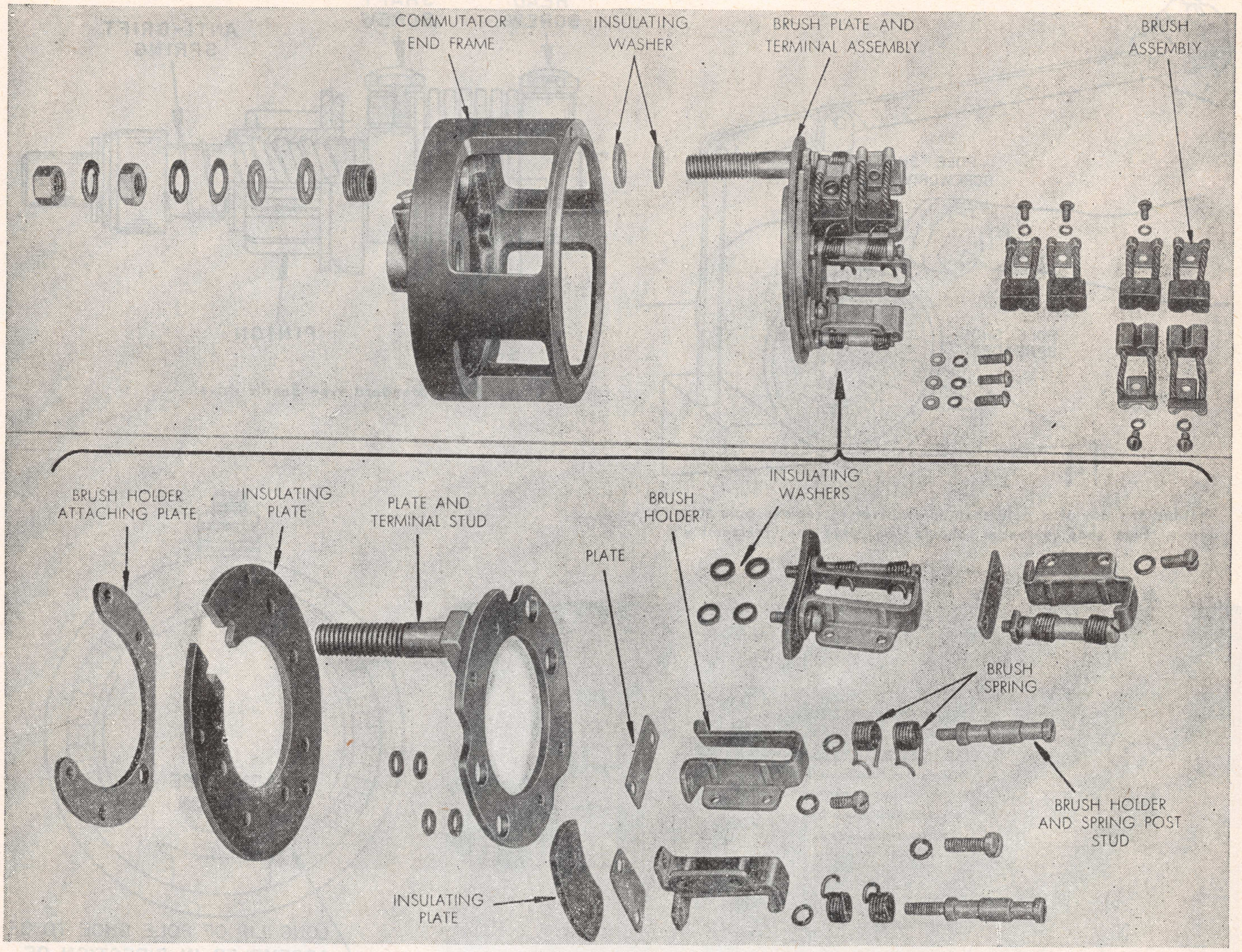
Six-brush, six-pole insulated type starting motor with three brushes connected to the field coils and the other three brushes connected to a second starting motor terminal.



Four-brush, four-pole starting motor with four field coils, and with two brushes grounded.



Six-brush, six-pole starting motor with three brushes grounded.


COMMUTATOR END FRAME
INSULATING WASHER
BRUSH PLATE AND TERMINAL ASSEMBLY
BRUSH ASSEMBLY
BRUSH HOLDER ATTACHING PLATE
INSULATING PLATE
PLATE AND TERMINAL STUD
PLATE
BRUSH HOLDER
INSULATING WASHERS
BRUSH SPRING
BRUSH HOLDER AND SPRING POST STUD
INSULATING PLATE

Showing disassembly of one type of starting motor commutator end frame in which brush plates, brush holders and arms, are detachable.

the specified voltages. It is also possible to no-load and torque-test a defective starting motor and determine the location of the defect. Thus, the following routine may be valuable as a trouble-shooting procedure.

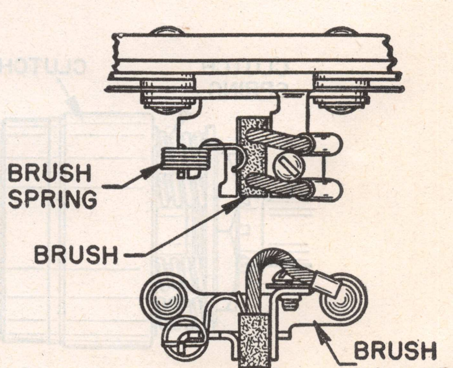
No-load test is made by connecting the starting motor in series with a battery of the proper voltage and a high reading ammeter. The ampere draw and armature speed should be checked and compared with the specifications for the unit.

Torque-testing equipment is necessary to conduct a torque test of the starting motor. It may be a simple testing set-up such as is shown, or more elaborate commercial equipment which indicates the results on a dial. Most starting motors are tested on stall torque, but some units must be given a running torque test, and this requires special prony brake apparatus.

A heavy variable resistance should be inserted into the circuit between the battery and starting motor so that the specified voltage may be applied to the starting motor. A small change in voltage causes a marked change in the torque developed.

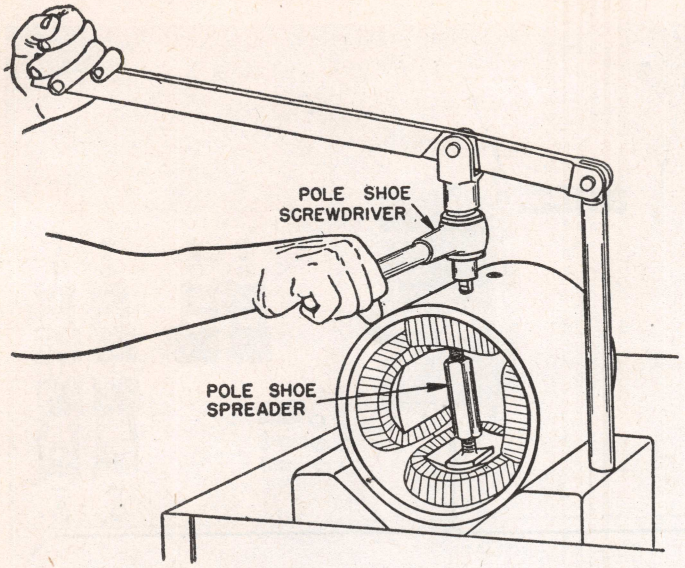
Interpreting No-Load and Torque Test Results: If a test lamp and test points are used in conjunction with the above starting motor tests, the location of trouble in the starting motor can often be determined. This aids the service repair man in quickly detecting the source of trouble in a defective starting motor so that corrections can be more rapidly made. Note the conditions listed below.

1. Rated torque, current draw and no-load speed indicates normal starting motor operation.
2. Low free speed and high current draw with low developed torque may result from:
   a. Tight, dirty, or worn bearings, bent armature shaft, or loose field pole shoe screws which allow the armature to drag on the pole shoes.
   b. Grounded armature or field. Where the starting motor is of the type with

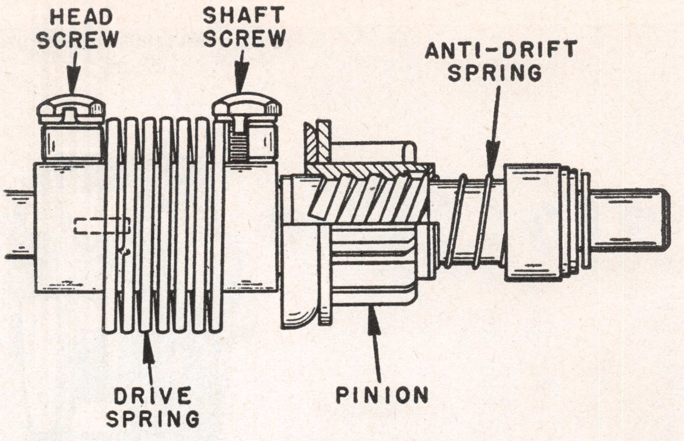

BRUSH SPRING
BRUSH
BRUSH HOLDER
COMMUTATOR

Showing a typical box-type brush holder.

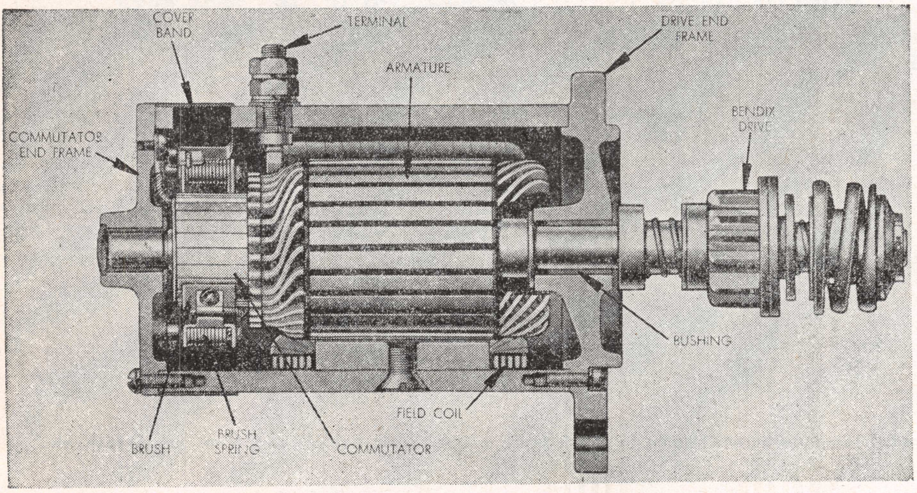
STARTING MOTORS


POLE SHOE SCREWDRIVER
POLE SHOE SPREADER

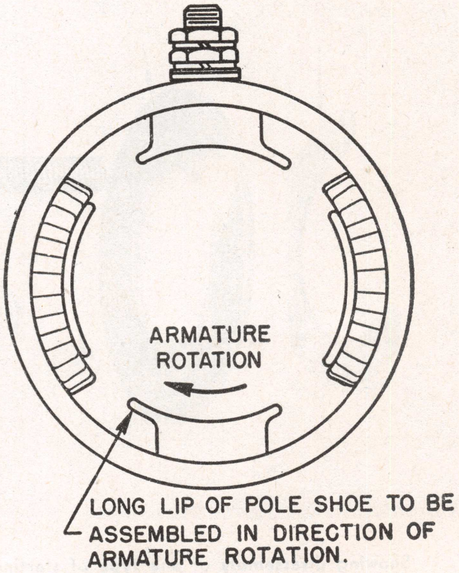
Showing the use of a pole shoe screwdriver to remove pole shoe screws. Pole shoe spreader should be used on reassembly


HEAD SCREW
SHAFT SCREW
ANTI-DRIFT SPRING
DRIVE SPRING
PINION

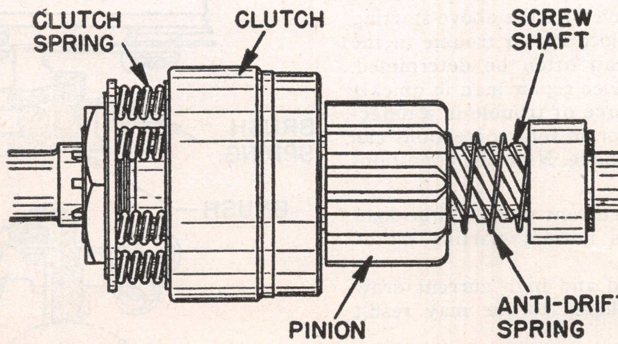
Standard type Bendix drive.


COVER BAND
TERMINAL
DRIVE END FRAME
ARMATURE
COMMUTATOR END FRAME
BENDIX DRIVE
BUSHING
FIELD COIL
BRUSH
BRUSH SPRING
COMMUTATOR

Showing compression-type Bendix drive assembled on armature shaft.


ARMATURE ROTATION
LONG LIP OF POLE SHOE TO BE ASSEMBLED IN DIRECTION OF ARMATURE ROTATION.

Showing the direction of assembly for pole shoe with one long and one short lip


CLUTCH SPRING
CLUTCH
SCREW SHAFT
PINION
ANTI-DRIFT SPRING

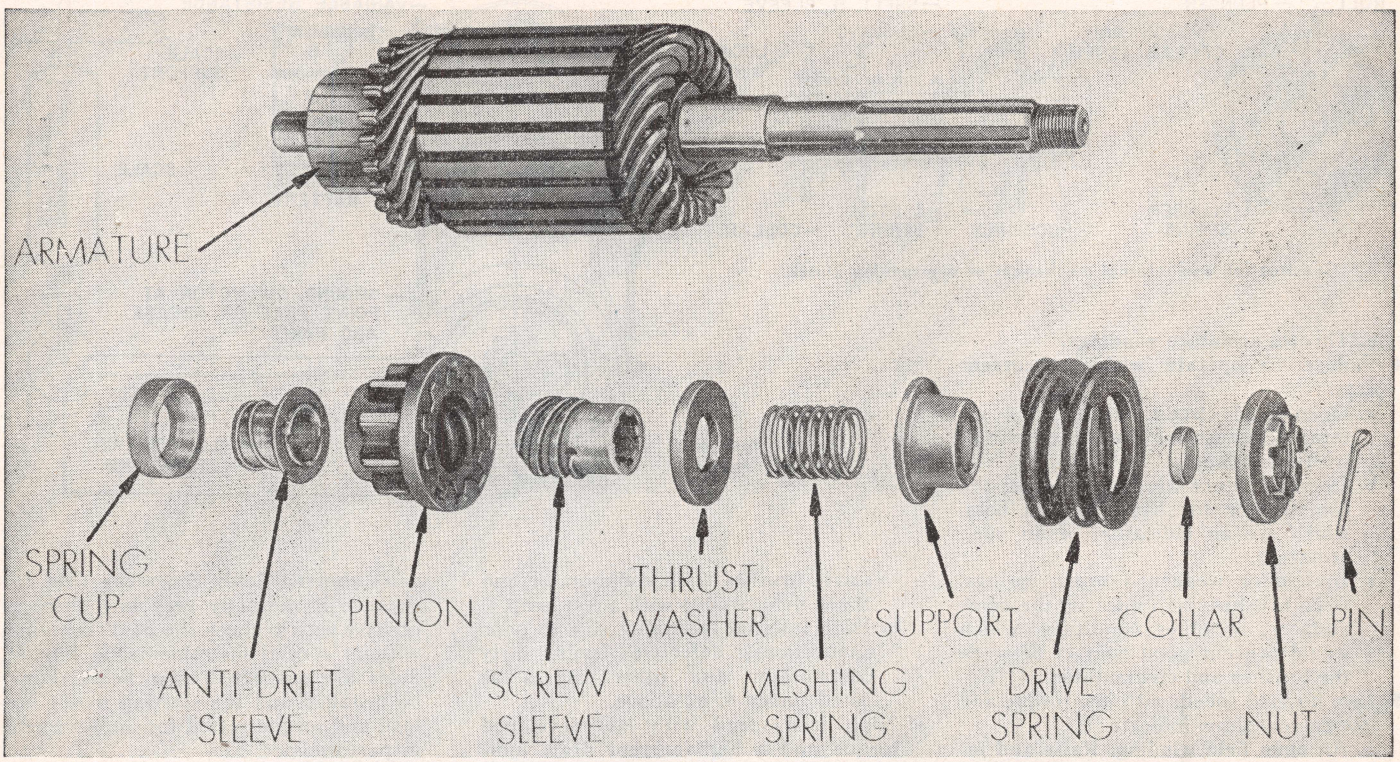
Friction clutch-type Bendix drive.

normally grounded brushes, raise and insulate grounded brushes from the commutator and check with test lamp from the starting motor terminal and the frame. If the lamp lights, the starting motor is grounded. Raise other brushes and check the fields and commutator separately for grounds.

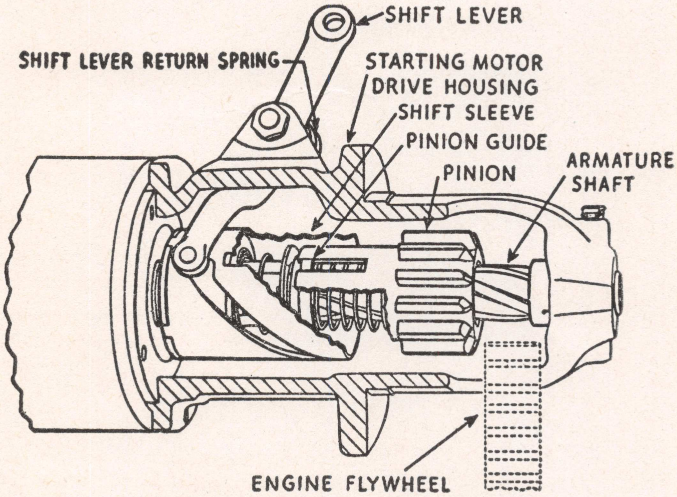
If the starting motor is of the type with normally grounded fields, and with all brushes insulated, then the fields must be disconnected from ground before the unit can be tested for ground. The armature can be tested separately for ground by raising the brushes from the commutator. If the starting motor is of the insulated type, it may be tested for ground by checking from either terminal to the frame with the test points.

c. Shorted armature. Check armature on "growler."

3. Failure to operate with a high current draw:
   a. Direct ground in the switch, at the starting motor terminal, fields or brushes.
   b. Frozen shaft bearings, which prevent armature rotation

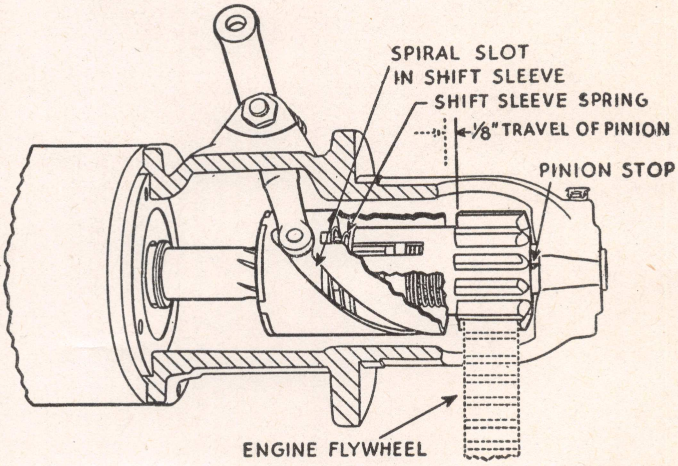

ARMATURE
SPRING CUP
ANTI-DRIFT SLEEVE
PINION
SCREW SLEEVE
THRUST WASHER
MESHING SPRING
SUPPORT
DRIVE SPRING
COLLAR
NUT
PIN

Exploded view of compression-type Bendix drive.


SHIFT LEVER
SHIFT LEVER RETURN SPRING
STARTING MOTOR DRIVE HOUSING
SHIFT SLEEVE
PINION GUIDE
PINION
ARMATURE SHAFT
ENGINE FLYWHEEL

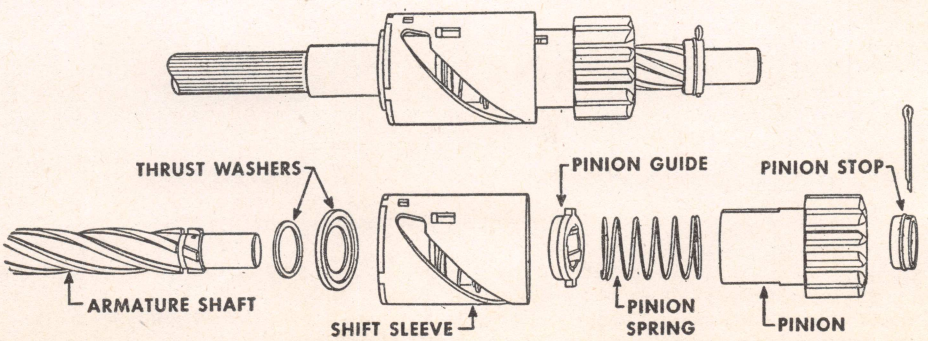
"AT REST" POSITION

Dyer drive assembled in position in housing—showing relationship of shift lever to the drive.

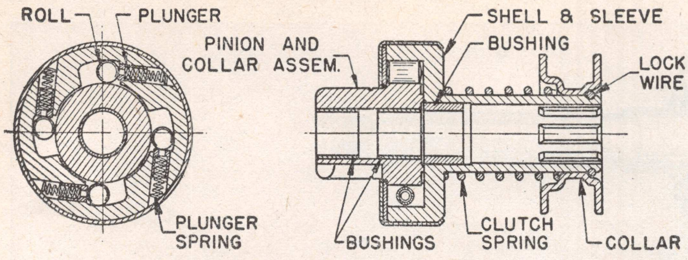

SPIRAL SLOT IN SHIFT SLEEVE
SHIFT SLEEVE SPRING
1/8" TRAVEL OF PINION
PINION STOP
ENGINE FLYWHEEL

ENGAGEMENT ACTION COMPLETED

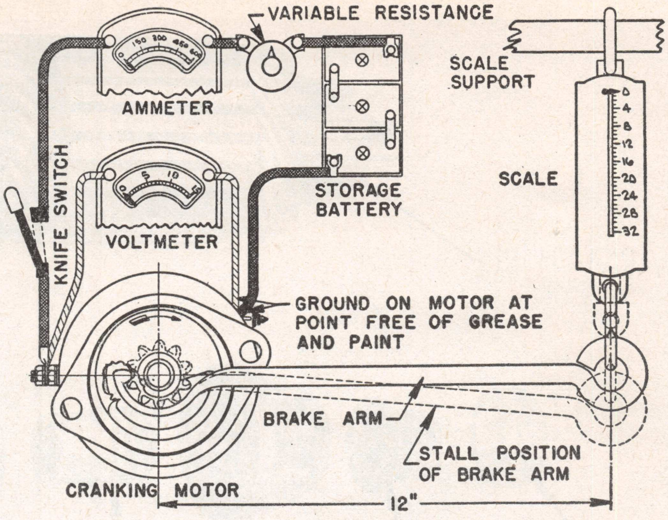
Adjustment of Dyer drive pinion travel.


THRUST WASHERS
PINION GUIDE
PINION STOP
ARMATURE SHAFT
SHIFT SLEEVE
PINION SPRING
PINION

A complete Dyer drive and its component parts in their correct relative position for proper assembly. Note particularly that the lugs on the pinion guide are toward the pinion.


ROLL
PLUNGER
PINION AND COLLAR ASSEM.
SHELL & SLEEVE
BUSHING
LOCK WIRE
PLUNGER SPRING
BUSHINGS
CLUTCH SPRING
COLLAR

Construction and internal mechanism of overrunning clutch.


VARIABLE RESISTANCE
AMMETER
SCALE SUPPORT
KNIFE SWITCH
STORAGE BATTERY
SCALE
VOLTMETER
GROUND ON MOTOR AT POINT FREE OF GREASE AND PAINT
BRAKE ARM
STALL POSITION OF BRAKE ARM
CRANKING MOTOR
12"

Torque test of starting motor.

c. Thrown armature windings.

4. Failure to operate with no current draw:
   a. Open field circuit. Inspect the internal connections and trace circuit with a test lamp.
   b. Open armature windings. Inspect the commutator for badly burned bars, which are an indication of an open armature.
   c. Broken or weakened brush springs, worn brushes, high mica on the commutator, or other conditions which would prevent good contact between the brushes and commutator.

5. Low no-load speed, with low torque and low current draw indicate:
   a. An open field winding. Raise and insulate brushes from commutator and check field circuits with a test lamp.
   b. High internal resistance due to poor connections, defective leads, dirty commutator and other causes as listed under 4. c., above.

6. High free speed with low developed torque and a high current draw indicates shorted fields. Since the field resistance is normally very low, there is no easy way to check the field resistance without special instruments. If shorted fields are suspected, new fields should be installed and the starting motor no-load and torque-tested for improvement in performance.

AUTO–LITE GENERATOR TEST SPECIFICATIONS

THIRD BRUSH CONTROL TYPE

Unit Number	Direction of Rotation	Field Current at 6 Volts Amperes	Brush Spring Tension		Low Output Test			Maximum Output ①	
			Main, Ounces	Third, Ounces	Amperes	Maximum R. P. M. at Volts	Maximum R. P. M. at Volts	Amperes at Volts	Amperes at Volts
GAE-4004	C	1.9 –2.1②	20–26	20–26	4	835@13.	860@15.	8.3–10.3@12.2	10.5–12.5@15.
GAE-4029	C	1.9 –2.1②	20–26	20–26	4	835@13.	860@15.	8.3–10.3@12.2	10.5–12.5@15.
GAE-4031	C	1.9 –2.1②	20–26	20–26	4	835@13.	860@15.	8.3–10.3@12.2	10.5–12.5@15.
GAE-4041	C	1.9 –2.1②	20–26	20–26	4	835@13.	860@15.	8.3–10.3@12.2	10.5–12.5@15.
GAG-4111	C	4.08–5.52	22–27	22–27	8	825@ 7.0	835@ 7.6	15.9–13.9@ 7.4	17.0–15.0@ 8.0
GAL-4130	C	3.51–3.89	22–25	22–25	8	1015@ 6.6	1040@ 8.0	12.8–14.8@ 6.6	16.0–18.0@ 8.0
GAL-4330	C	3.51–3.89	17–22	17–22	8	1015@ 6.6	1040@ 8.0	12.8–14.8@ 6.6	16.0–18.0@ 8.0
GAP-4101	C	2.85–3.15	22–27	22–27	8	980@ 6.6	990@ 8.0	11.5–13.5@ 6.0	15.0–17.0@ 8.0
GAP-4104	C	2.85–3.15	22–27	22–27	8	980@ 6.6	990@ 8.0	11.5–13.5@ 6.0	15.0–17.0@ 8.0
GAP-4105	C	2.85–3.15	22–27	22–27	8	980@ 6.6	990@ 8.0	11.5–13.5@ 6.0	15.0–17.0@ 8.0
GAP-4112	CC	2.85–3.15	22–27	22–27	8	980@ 6.6	990@ 8.0	11.5–13.5@ 6.0	15.0–17.0@ 8.0
GAP-4114	C	2.85–3.15	22–27	22–27	8	980@ 6.6	990@ 8.0	11.5–13.5@ 6.0	15.0–17.0@ 8.0
GAP-4124	CC	2.85–3.15	22–27	22–27	8	980@ 6.6	990@ 8.0	11.5–13.5@ 6.0	15.0–17.0@ 8.0
GAP-4125	C	2.85–3.15	22–27	22–27	8	980@ 6.6	990@ 8.0	11.5–13.5@ 6.0	15.0–17.0@ 8.0
GAP-4130	C	2.85–3.15	22–27	22–27	8	980@ 6.6	990@ 8.0	11.5–13.5@ 6.0	15.0–17.0@ 8.0
GAP-4135	C	2.85–3.15	22–27	22–27	8	980@ 6.6	990@ 8.0	11.5–13.5@ 6.0	15.0–17.0@ 8.0
GAP-4140	C	2.85–3.15	22–27	22–27	8	980@ 6.6	990@ 8.0	11.5–13.5@ 6.0	15.0–17.0@ 8.0
GAP-4146	C	2.85–3.15	22–27	22–27	8	980@ 6.6	990@ 8.0	11.5–13.5@ 6.0	15.0–17.0@ 8.0
GAR-4112	C	3.51–4.89	22–25	22–25	8	1135@ 6.6	....	15.5–13.5@ 7.4	17.0–15.0@ 8.0
GAR-4312	C	3.51–3.89	17–22	17–22	8	1130@ 6.0	1165@ 8.0	11.0–13.0@ 6.0	15.0–17.0@ 8.0
GAR-4315	C	3.51–3.89	17–22	17–22	8	1130@ 6.0	1165@ 8.0	11.0–13.0@ 6.0	15.0–17.0@ 8.0
GAR-4502	C	3.51–3.89	18–22	18–22	8	1130@ 6.0	1165@ 8.0	11.0–13.0@ 6.0	15.0–17.0@ 8.0
GAR-4512	C	3.51–3.89	18–22	18–22	8	1130@ 6.0	1165@ 8.0	11.0–13.0@ 6.0	15.0–17.0@ 8.0
GAR-4515	C	3.51–3.89	18–22	18–22	8	1130@ 6.0	1165@ 8.0	11.0–13.0@ 6.0	15.0–17.0@ 8.0
GAR-4522	C	3.51–3.89	18–22	18–22	8	1130@ 6.0	1165@ 8.0	11.0–13.0@ 6.0	15.0–17.0@ 8.0
GAR-4524	C	3.51–3.89	18–22	18–22	8	1130@ 6.0	1165@ 8.0	11.0–13.0@ 6.0	15.0–17.0@ 8.0
GAR-4525	C	3.51–3.89	18–22	18–22	8	1130@ 6.0	1165@ 8.0	11.0–13.0@ 6.0	15.0–17.0@ 8.0
GAR-4528	C	3.51–3.89	18–22	18–22	8	1130@ 6.0	1165@ 8.0	11.0–13.0@ 6.0	15.0–17.0@ 8.0
GAR-4534	C	3.51–3.89	18–22	18–22	8	1130@ 6.0	1165@ 8.0	11.0–13.0@ 6.0	15.0–17.0@ 8.0
GAR-4535	C	3.51–3.89	18–22	18–22	8	1130@ 6.0	1165@ 8.0	11.0–13.0@ 6.0	15.0–17.0@ 8.0
GAR-4537	C	3.51–3.89	18–22	18–22	8	1130@ 6.0	1165@ 8.0	11.0–13.0@ 6.0	15.0–17.0@ 8.0
GAR-4538	C	3.51–3.89	18–22	18–22	8	1130@ 6.0	1165@ 8.0	11.0–13.0@ 6.0	15.0–17.0@ 8.0
GAR-4543	C	3.51–3.89	18–22	18–22	8	1130@ 6.0	1165@ 8.0	11.0–13.0@ 6.0	15.0–17.0@ 8.0
GAR-4545	C	3.51–3.89	18–22	18–22	8	1130@ 6.0	1165@ 8.0	11.0–13.0@ 6.0	15.0–17.0@ 8.0
GAR-4546	CC	3.51–3.89	17–22	17–22	8	1130@ 6.0	1165@ 8.0	11.0–13.0@ 6.0	15.0–17.0@ 8.0
GAR-4547	C	3.51–3.89	18–22	18–22	8	1130@ 6.0	1165@ 8.0	11.0–13.0@ 6.0	15.0–17.0@ 8.0
GAR-4551	CC	3.51–3.89	18–22	18–22	8	1130@ 6.0	1165@ 8.0	11.0–13.0@ 6.0	15.0–17.0@ 8.0
GAR-4555	C	3.51–3.89	18–22	18–22	8	1130@ 6.0	1165@ 8.0	11.0–13.0@ 6.0	15.0–17.0@ 8.0
GAR-4607-3	C	3.70–4.10	50–60	50–60	8	1080@ 6.0	1115@ 8.0	14.6–16.6@ 6.0	19.0–21.0@ 8.0
GAR-4608C-5	C	3.51–3.89	50–60	50–60	8	1065@ 6.0	1100@ 8.0	15.7–17.7@ 6.2	20.4–22.4@ 8.0
GAR-4608E-5	C	3.51–3.89	50–60	50–60	8	1065@ 6.0	1100@ 8.0	15.7–17.7@ 6.2	20.4–22.4@ 8.0
GAR-4614	C	3.75–4.15	50–60	50–60	8	1065@ 6.0	1100@ 8.0	15.7–17.7@ 6.2	20.4–22.4@ 8.0
GAR-4614-5	C	3.75–4.15	50–60	50–60	8	1065@ 6.0	1100@ 8.0	15.7–17.7@ 6.2	20.4–22.4@ 8.0
GAR-4619-3	C	3.70–4.10	50–60	50–60	8	1080@ 6.0	1115@ 8.0	14.6–16.6@ 6.0	19.0–21.0@ 8.0
GAR-4622-3	C	3.70–4.10	50–60	50–60	8	1080@ 6.0	1115@ 8.0	14.6–16.6@ 6.0	19.0–21.0@ 8.0

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THIRD BRUSH CONTROL TYPE

Unit Number	Direction of Rotation	Field Current at 6 Volts Amperes	Brush Spring Tension		Low Output Test			Maximum Output ①	
			Main, Ounces	Third, Ounces	Amperes	Maximum R. P. M. at Volts	Maximum R. P. M. at Volts	Amperes at Volts	Amperes at Volts
GAR-4623-4	C	3.75–4.15	50–60	50–60	8	1015@ 6.0	1075@ 8.0	17.9–19.9@ 6.0	24.0–26.0@ 8.5
GAR-4624-5	C	3.51–3.89	50–60	50–60	8	1065@ 6.0	1100@ 8.0	15.7–17.7@ 6.2	20.4–22.4@ 8.0
GAR-4625-5	C	3.51–3.89	50–60	50–60	8	1065@ 6.0	1100@ 8.0	15.7–17.7@ 6.2	20.4–22.4@ 8.0
GAR-4631-5	C	3.51 3.89	50–60	50–60	8	1065@ 6.0	1100@ 8.0	15.7–17.7@ 6.2	20.4–22.4@ 8.0
GAR-4635-5	C	3.51–3.89	50–60	50–60	8	1065@ 6.0	1100@ 8.0	15.7–17.7@ 6.2	20.4–22.4@ 8.0
GAS-4107	C	3.80–4.20	15–20	15–20	8	1440@ 7.0	1445@ 7.6	14.2–12.2@ 7.4	15.3–13.3@ 8.0
GAS-4110	C	3.80–4.20	15–20	15–20	8	1440@ 7.0	1445@ 7.6	14.2–12.2@ 7.4	15.3–13.3@ 8.0
GAS-4119	C	3.80–4.20	15–20	15–20	8	1440@ 7.0	1445@ 7.6	14.2–12.2@ 7.4	15.3–13.3@ 8.0
GAS-4120	C	3.80–4.18	15–20	15–20	8	1440@ 7.0	1445@ 7.6	14.2–12.2@ 7.4	15.3–13.3@ 8.0
GAS-4123	C	3.80–4.20	15–20	15–20	8	1440@ 7.0	1445@ 7.6	14.2–12.2@ 7.4	15.3–13.3@ 8.0
GAS-4125	C	3.80–4.20	15–20	15–20	8	1440@ 7.0	1445@ 7.6	14.2–12.2@ 7.4	15.3–13.3@ 8.0
GAS-4127	C	3.80–4.20	15–20	15–20	8	1440@ 7.0	1445@ 7.6	14.2–12.2@ 7.4	15.3–13.3@ 8.0
GAS-4128	C	3.80–4.20	15–20	15–20	8	1440@ 7.0	1445@ 7.6	14.2–12.2@ 7.4	15.3–13.3@ 8.0
GBB-4201	C	3.32–3.68②	22–27	22–27	8	720@13.0	750@15.0	12.2–14.2@12.2	16.0–18.0@15.0
GBB-4203	C	3.32–3.68②	22–27	22–27	8	720@13.0	750@15.0	12.2–14.2@12.2	16.0–18.0@15.0
GBB-4303	C	3.32–3.68②	22–27	22–27	8	720@13.0	750@15.0	12.2–14.2@12.2	16.0–18.0@15.0
GBB-4304	C	3.32–3.68②	22–27	22–27	8	720@13.0	750@15.0	12.2–14.2@12.2	16.0–18.0@15.0
GBE-4301	C	2.75–3.05②	17–22	17–22	4	1200@13.0	1275@15.0	10.7–12.7@12.2	14.0–16.0@15.0
GBM-4601	C	3.80–4.20	50–60	50–60	8	1190@ 7.6	----------	20.1–18.1@ 7.6	21.0–19.0@ 8.0
GBM-4602	C	3.80–4.20	50–60	50–60	8	1190@ 7.6	----------	20.1–18.1@ 7.6	21.0–19.0@ 8.0
GBM-4604A-2	C	3.80–4.20	50–60	50–60	8	1240@ 7.6	----------	17.8–15.8@ 7.6	19.0–17.0@ 8.0
GBM-4604B-2	C	3.80–4.20	50–60	50–60	8	1240@ 7.6	----------	17.8–15.8@ 7.6	19.0–17.0@ 8.0
GBM-4606	C	3.80–4.20	50–60	50–60	8	1240@ 7.6	----------	17.8–15.8@ 7.6	19.0–17.0@ 8.0
GBM-4606-1	C	3.80–4.20	50–60	50–60	8	1240@ 7.6	----------	17.8–15.8@ 7.6	19.0–17.0@ 8.0
GBM-4606-B	C	3.80–4.20	50–60	50–60	8	1240@ 7.6	----------	17.8–15.8@ 7.6	19.0–17.0@ 8.0
GBM-4606B-1	C	3.80–4.20	50–60	50–60	8	1240@ 7.6	----------	17.8–15.8@ 7.6	19.0–17.0@ 8.0
GBM-4607A-2	C	3.80–4.20	50–60	50–60	8	1240@ 7.6	----------	17.8–15.8@ 7.6	19.0–17.0@ 8.0
GBM-4607B	C	3.80–4.20	50–60	50–60	8	1240@ 7.6	----------	17.8–15.8@ 7.6	19.0–17.0@ 8.0
GBM-4607B-2	C	3.80–4.20	50–60	50–60	8	1240@ 7.6	----------	17.8–15.8@ 7.6	19.0–17.0@ 8.0
GBM-4608A	C	3.80–4.20	50–60	50–60	8	1240@ 7.6	----------	17.8–15.8@ 7.6	19.0–17.0@ 8.0
GBM-4608B	C	3.80–4.20	50–60	50–60	8	1190@ 7.6	----------	20.1–18.1@ 7.6	21.0–19.0@ 8.0
GBM-4608D	C	3.80–4.20	50–60	50–60	8	1240@ 7.6	----------	17.8–15.8@ 7.6	19.0–17.0@ 8.0
GBM-4610A-5	C	3.80–4.20	50–60	50–60	8	1250@ 7.6	----------	15.2–13.1@ 7.6	16.0–14.0@ 8.0
GBM-4612A	C	3.80–4.20	50–60	50–60	8	1190@ 7.6	----------	20.1–18.1@ 7.6	21.0–19.0@ 8.0
GBM-4614A-1	C	3.80–4.20	50–60	50–60	8	1240@ 7.6	----------	17.8–15.8@ 7.6	19.0–17.0@ 8.0
GBM-4615A	C	3.80–4.20	50–60	50–60	8	1190@ 7.6	----------	20.1–18.1@ 7.6	21.0–19.0@ 8.0
GBM-4616A-1	C	3.80–4.20	50–60	50–60	8	1240@ 7.6	----------	17.8–15.8@ 7.6	19.0–17.0@ 8.0
GBM-4620A-1	C	3.80–4.20	50–60	50–60	8	1240@ 7.6	----------	17.8–15.8@ 7.6	19.0–17.0@ 8.0
GBM-4804C	C	3.80–4.20	37–44	50–60	8	1250@ 7.6	----------	15.2–13.1@ 7.6	16.0–14.0@ 8.0
GBM-4807-1	C	3.80–4.20	37–44	50–60	8	1240@ 7.6	----------	17.8–15.8@ 7.6	19.0–17.0@ 8.0
GBM-4807A-1	C	3.80–4.20	37–44	50–60	8	1240@ 7.6	----------	17.8–15.8@ 7.6	19.0–17.0@ 8.0
GBO-4301	C	3.32–3.68②	22–27	22–27	4	1025@13.8	----------	19.7–17.7@14.2	21.0–19.0@15.0
GBO-4302	C	3.32–3.68②	22–27	22–27	4	1025@13.8	----------	19.7–17.7@14.2	21.0–19.0@15.0
GBR-4605	C	4.18–4.62	50–60	50–60	8	965@ 7.0	----------	22.0–20.0@ 7.6	23.0–21.0@ 8.0
GBR-4605-5	C	4.18–4.62	50–60	50–60	8	965@ 7.0	----------	22.0–20.0@ 7.6	23.0–21.0@ 8.0

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THIRD BRUSH CONTROL TYPE

Unit Number	Direction of Rotation	Field Current at 6 Volts Amperes	Brush Spring Tension		Low Output Test			Maximum Output ①	
			Main, Ounces	Third, Ounces	Amperes	Maximum R. P. M. at Volts	Maximum R. P. M. at Volts	Amperes at Volts	Amperes at Volts
GBR-4607-5	C	4.18–4.62	50–60	50–60	8	965@ 7.0	----------	22.0–20.0@ 7.6	23.0–21.0@ 8.0
GBR-4608-5	C	4.18–4.62	50–60	50–60	8	965@ 7.0	----------	22.0–20.0@ 7.6	23.0–21.0@ 8.0
GBR-4609-5	C	4.18–4.62	50–60	50–60	8	965@ 7.0	----------	22.0–20.0@ 7.6	23.0–21.0@ 8.0
GBR-4611-5	C	4.18–4.62	50–60	50–60	8	965@ 7.0	----------	22.0–20.0@ 7.6	23.0–21.0@ 8.0
GBS-4608	C	3.23–3.57②	50–60	50–60	4	1040@13.0	1060@15.0	7.7– 9.7@12.2	10.0–12.0@15.0
GBU-4201	C	3.51–3.89	50–60	50–60	5	910@ 7.0	915@ 7.6	11.1– 9.1@ 7.6	11.7– 9.7@ 8.0
GBU-4207	C	3.51–3.89	17–22	17–22	5	910@ 7.0	915@ 7.6	11.1– 9.1@ 7.6	11.7– 9.7@ 8.0
GBU-4209	C	3.51–3.89	50–60	50–60	5	910@ 7.0	915@ 7.6	11.1– 9.1@ 7.6	11.7– 9.7@ 8.0
GBU-4209A	C	3.51–3.89	50–60	50–60	5	910@ 7.0	915@ 7.6	11.1– 9.1@ 7.6	11.7– 9.7@ 8.0
GBU-4210	C	3.51–3.89	50–60	50–60	5	910@ 7.0	915@ 7.6	11.1– 9.1@ 7.6	11.7– 9.7@ 8.0
GBU-4212	C	3.51–3.89	50–60	50–60	5	910@ 7.0	915@ 7.6	11.1– 9.1@ 7.6	11.7– 9.7@ 8.0
GBU-4213A	C	3.51–3.89	50–60	50–60	5	910@ 7.0	915@ 7.6	11.1– 9.1@ 7.6	11.7– 9.7@ 8.0
GBU-4214	C	3.51–3.89	50–60	50–60	8	910@ 7.0	915@ 7.6	11.1– 9.1@ 7.6	11.7– 9.7@ 8.0
GBU-4216	C	3.51–3.89	50–60	50–60	5	910@ 7.0	915@ 7.6	11.1– 9.1@ 7.6	11.7– 9.7@ 8.0
GBX-4601-5	C	2.85–3.15	41–52	41–52	5	895@ 7.0	----------	26.7–24.7@ 7.0	30.8–28.8@ 8.0
GBX-4601A-5	C	2.85–3.15	41–52	41–52	8	895@ 7.0	----------	26.7–24.7@ 7.0	30.8–28.8@ 8.0
GBX-4602-5	C	2.85–3.15	41–52	41–52	8	895@ 7.0	----------	26.7–24.7@ 7.0	30.8–28.8@ 8.0
GCJ-4802B	C	1.9 –2.1	53 Max.	53 Max.	8	1075@ 6.0	1135@ 8.0	17.7–20.1@ 6.0	24.0–26.0@ 8.0
GCJ-4802C	C	1.9 –2.1	53 Max.	53 Max.	8	1075@ 6.0	1135@ 8.0	17.7–20.1@ 6.0	24.0–26.0@ 8.0
GCJ-4805A	C	1.9 –2.1	53 Max.	53 Max.	8	1075@ 6.0	1135@ 8.0	17.7–20.1@ 6.0	24.0–26.0@ 8.0
GCJ-4805B	C	1.9 –2.1	53 Max.	53 Max.	8	1075@ 6.0	1135@ 8.0	17.7–20.1@ 6.0	24.0–26.0@ 8.0
GCJ-4806	C	1.9 –2.1	53 Max.	53 Max.	8	1075@ 6.0	1135@ 8.0	17.7–20.1@ 6.0	24.0–26.0@ 8.0
GCJ-4808A	C	1.9 –2.1	53 Max.	53 Max.	8	1075@ 6.0	1135@ 8.0	17.7–20.1@ 6.0	24.0–26.0@ 8.0
GCM-4802A-4	C	3.50–3.89	53 Max.	53 Max.	8	1075@ 7.0	1090@ 7.6	22.1–20.1@ 7.6	23.0–21.0@ 8.0
GCM-4804	C	3.50–3.89	53 Max.	53 Max.	8	1075@ 7.0	1090@ 7.6	22.1–20.1@ 7.6	23.0–21.0@ 8.0
GCM-4804-4	C	3.50–3.89	53 Max.	53 Max.	8	1075@ 7.0	1090@ 7.6	22.1–20.1@ 7.6	23.0–21.0@ 8.0
GCM-4805-4	CC	3.50–3.89	53 Max.	53 Max.	8	1075@ 7.0	1090@ 7.6	22.1–20.1@ 7.6	23.0–21.0@ 8.0
GCM-4806-4	C	3.50–3.89	53 Max.	53 Max.	8	1075@ 7.0	1090@ 7.6	22.1–20.1@ 7.6	23.0–21.0@ 8.0
GCM-4808-4	C	3.50–3.89	53 Max.	53 Max.	8	1075@ 7.0	1090@ 7.6	22.1–20.1@ 7.6	23.0–21.0@ 8.0
GCM-4809A-4	C	3.50–3.89	53 Max.	53 Max.	8	1075@ 7.0	1090@ 7.6	22.1–20.1@ 7.6	23.0–21.0@ 8.0
GCM-4810-4	C	3.50–3.89	53 Max.	53 Max.	8	1075@ 7.0	1090@ 7.6	22.1–20.1@ 7.6	23.0–21.0@ 8.0
GCM-4811-4	C	3.50–3.89	53 Max.	53 Max.	8	1075@ 7.0	1090@ 7.6	22.1–20.1@ 7.6	23.0–21.0@ 8.0
GCM-4815A	C	3.50–3.89	53 Max.	53 Max.	8	1075@ 7.0	1090@ 7.6	22.1–20.1@ 7.6	23.0–21.0@ 8.0
GCM-4815A-4	C	3.50–3.89	53 Max.	53 Max.	8	1075@ 7.0	1090@ 7.6	22.1–20.1@ 7.6	23.0–21.0@ 8.0
GCM-4816A	C	3.50–3.89	53 Max.	53 Max.	8	1075@ 7.0	1090@ 7.6	22.1–20.1@ 7.6	23.0–21.0@ 8.0
GCM-4816A-4	C	3.50–3.89	53 Max.	53 Max.	8	1075@ 7.0	1090@ 7.6	22.1–20.1@ 7.6	23.0–21.0@ 8.0
GCM-4817-4	C	3.50–3.89	53 Max.	53 Max.	8	1075@ 7.0	1090@ 7.6	22.1–20.1@ 7.6	23.0–21.0@ 8.0
GCM-4818	C	3.51–3.89	53 Max.	50–60	8	1145@ 7.0	1160@ 7.6	16.0–14.0@ 7.6	17.0–15.0@ 8.0
GCM-4819-4	C	3.50–3.89	53 Max.	53 Max.	8	1075@ 7.0	1090@ 7.6	22.1–20.1@ 7.6	23.0–21.0@ 8.0
GCM-4822-4	C	3.50–3.89	53 Max.	53 Max.	8	1075@ 7.0	1090@ 7.6	22.1–20.1@ 7.6	23.0–21.0@ 8.0
GCM-4823-4	C	3.50–3.89	53 Max.	53 Max.	8	1075@ 7.0	1090@ 7.6	22.1–20.1@ 7.6	23.0–21.0@ 8.0
GCM-4824-4	C	3.50–3.89	53 Max.	53 Max.	8	1075@ 7.0	1090@ 7.6	22.1–20.1@ 7.6	23.0–21.0@ 8.0
GCM-4829A	C	3.50–3.89	53 Max.	53 Max.	8	1075@ 7.0	1090@ 7.6	22.1–20.1@ 7.6	23.0–21.0@ 8.0
GCS-4801-5	C	3.56–3.94	53 Max.	53 Max.	8	800@ 7.0	----------	20.0–18.0@ 7.6	21.0–19.0@ 8.0
GCS-4802	C	3.56–3.94	53 Max.	53 Max.	8	800@ 7.0	----------	20.0–18.0@ 7.6	21.0–19.0@ 8.0

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AUTO-LITE GENERATOR TEST SPECIFICATIONS

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THIRD BRUSH CONTROL TYPE

Unit Number	Direction of Rotation	Field Current at 6 Volts Amperes	Brush Spring Tension		Low Output Test			Maximum Output①	
			Main, Ounces	Third, Ounces	Amperes	Maximum R. P. M. at Volts	Maximum R. P. M. at Volts	Amperes at Volts	Amperes at Volts
GCS-4802-5	C	3.56–3.94	53 Max.	53 Max.	8	800@ 7.0	----------	20.0–18.0@ 7.6	21.0–19.0@ 8.0
GCS-4803A	C	3.56–3.94	53 Max.	53 Max.	8	800@ 7.0	----------	20.0–18.0@ 7.6	21.0–19.0@ 8.0
GCS-4803A-5	C	3.56–3.94	53 Max.	53 Max.	8	800@ 7.0	----------	20.0–18.0@ 7.6	21.0–19.0@ 8.0
GCS-4803B-5	C	3.56–3.94	53 Max.	53 Max.	8	800@ 7.0	----------	20.0–18.0@ 7.6	21.0–19.0@ 8.0
GCS-4804A-5	C	3.56–3.94	53 Max.	53 Max.	8	800@ 7.0	----------	20.0–18.0@ 7.6	21.0–19.0@ 8.0
GCS-4804B-5	C	3.56–3.94	53 Max.	53 Max.	8	800@ 7.0	----------	20.0–18.0@ 7.6	21.0–19.0@ 8.0
GCS-4804D-5	C	3.56–3.94	53 Max.	53 Max.	8	800@ 7.0	----------	20.0–18.0@ 7.6	21.0–19.0@ 8.0
GCS-4804DA-5	C	3.56–3.94	53 Max.	53 Max.	8	800@ 7.0	----------	20.0–18.0@ 7.6	21.0–19.0@ 8.0
GCS-4805A-5	C	3.56–3.94	53 Max.	53 Max.	8	800@ 7.0	----------	20.0–18.0@ 7.6	21.0–19.0@ 8.0
GCS-4806A-5	C	3.56–3.94	53 Max.	53 Max.	8	800@ 7.0	----------	20.0–18.0@ 7.6	21.0–19.0@ 8.0
GCS-4808	C	3.56–3.94	53 Max.	53 Max.	8	800@ 7.0	----------	20.0–18.0@ 7.6	21.0–19.0@ 8.0
GCS-4810-5	C	3.56–3.94	53 Max.	53 Max.	8	800@ 7.0	----------	20.0–18.0@ 7.6	21.0–19.0@ 8.0
GCS-4811A	C	3.56–3.94	53 Max.	53 Max.	8	800@ 7.0	----------	20.0–18.0@ 7.6	21.0–19.0@ 8.0
GCS-4811A-5	C	3.56–3.94	53 Max.	53 Max.	8	800@ 7.0	----------	20.0–18.0@ 7.6	21.0–19.0@ 8.0
GCS-4811B-5	C	3.56–3.94	53 Max.	53 Max.	8	800@ 7.0	----------	20.0–18.0@ 7.6	21.0–19.0@ 8.0
GCS-4812-5	C	3.56–3.94	53 Max.	53 Max.	8	800@ 7.0	----------	20.0–18.0@ 7.6	21.0–19.0@ 8.0
GCS-4814-5	C	3.56–3.94	53 Max.	53 Max.	8	800@ 7.0	----------	20.0–18.0@ 7.6	21.0–19.0@ 8.0
GCS-4815-5	C	3.56–3.94	53 Max.	53 Max.	8	800@ 7.0	----------	20.0–18.0@ 7.6	21.0–19.0@ 8.0
GDB-4801A-1	C	3.23–3.57②	53 Max.	53 Max.	4	1050@13.8	1055@14.6	11.5– 9.5@14.6	12.0–10.0@15.0
GDF-4801	C	1.90–2.10	53 Max.	53 Max.	8	1445@ 7.0	1460@ 7.6	18.0–16.0@ 7.6	19.0–17.0@ 8.0
GDF-4801C	C	1.90–2.10	53 Max.	53 Max.	8	1445@ 7.0	1460@ 7.6	18.0–16.0@ 7.6	19.0–17.0@ 8.0
GDF-4804B	C	1.90–2.10	53 Max.	53 Max.	8	1245@ 7.0	1270@ 7.6	30.5–27.5@ 7.6	32. –29. @ 8.0
GDF-4811A	CC	1.90–2.10	53 Max.	53 Max.	8	1335@ 7.0	1360@ 7.6	19.6–17.6@ 7.6	21.0–19.0@ 8.0
GDF-4815A	CC	1.90–2.10	53 Max.	53 Max.	8	1245@ 7.0	1270@ 7.6	30.5–27.5@ 7.6	32. –29. @ 8.0
GDY-4101	C	2.23–2.47②	15–20	15–20	2	1215@13.4	1235@14.2	6.7– 5.8@14.6	7.0– 6.0@15.0
GFA-4801-3	C	1.65–1.82	53 Max.	53 Max.	8	1030@ 7.0	1030@ 7.4	16.4–14.4@ 7.6	17.0–15.0@ 8.0
GFA-4801A	C	1.65–1.82	53 Max.	53 Max.	8	1030@ 7.0	1030@ 7.4	16.4–14.4@ 7.6	17.0–15.0@ 8.0
GFB-4804-3	C	1.80–1.99②	53 Max.	53 Max.	4	1155@14.2	----------	15.2–13.2@14.6	16.0–14.0@15.0
GFB-4805-3	C	1.80–1.99②	53 Max.	53 Max.	4	1155@14.2	----------	15.2–13.2@14.6	16.0–14.0@15.0
GRC-4201	C	3.61–3.99	18–21	22–26	8	845@ 7.0	----------	13.9–11.9@ 6.6	17.0–15.0@ 8.0
GRC-4204	C	3.61–3.99	18–21	22–26	8	845@ 7.0	----------	13.9–11.9@ 6.6	17.0–15.0@ 8.0
GRC-4210	C	3.61–3.99	18–21	22–26	8	845@ 7.0	----------	13.9–11.9@ 6.6	17.0–15.0@ 8.0
GRC-4217	C	3.61–3.99	18–21	22–26	8	845@ 7.0	----------	13.9–11.9@ 6.6	17.0–15.0@ 8.0
GRC-4221	C	3.61–3.99	18–21	22–26	8	845@ 7.0	----------	13.9–11.9@ 6.6	17.0–15.0@ 8.0

① Maximum output readings taken at 70 degrees F. For each 15 degree change of temperature, add 1 ampere if below 70 degrees and subtract 1 ampere if above 70 degrees.

C—Clockwise. CC—Counter-clockwise.

② Field Current at 13.0 Volts.

AUTO–LITE GENERATOR TEST SPECIFICATIONS

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CURRENT–VOLTAGE REGULATOR CONTROL TYPE

Unit Number	Direction of Rotation	Field Current at 6 Volts Amperes	Brush Spring Tension Ounces	Ground Polarity	Low Output Test Amperes	Low Output Test Maximum R. P. M. at Volts	Low Output Test Maximum R. P. M. at Volts	Maximum Output Test① Amperes	Maximum Output Test① Maximum R. P. M. at Volts	Maximum Output Test① Maximum R. P. M. at Volts
GBG-4601	C	1.38–1.52②	23–26	P	8	835@14.2	850@14.6	40	1060@14.6	1065@15.0
GBG-4602	C	1.38–1.52②	23–26	P	8	835@14.2	850@14.6	40	1060@14.6	1065@15.0
GBG-4603	C	1.38–1.52②	23–26	P	8	835@14.2	850@14.6	40	1060@14.6	1065@15.0
GBG-4604	C	1.38–1.52②	23–26	P	8	835@14.2	850@14.6	40	1060@14.6	1065@15.0
GBG-4606	C	1.38–1.52②	23–26	P	8	835@14.2	850@14.6	40	1060@14.6	1065@15.0
GBG-4607B	C	1.38–1.52②	23–26	P	8	835@14.2	850@14.6	40	1060@14.6	1065@15.0
GBW-4803D	C	1.66–1.84	53 max.	P	8	1125@ 7.0	----------	22	1830@ 7.6	1800@ 8.0
GBW-4804A	C	1.66–1.84	53 max.	P	8	1125@ 7.0	----------	22	1830@ 7.6	1800@ 8.0
GBW-4808	C	1.66–1.84	53 max.	P	8	1125@ 7.0	----------	22	1830@ 7.6	1800@ 8.0
GCB-4601	C	1.5 –1.7	64–68	P	8	615@ 6.0	660@ 8.0	20	925@ 6.0	925@ 8.0
GCB-4602	C	1.5 –1.7	64–68	P	8	615@ 6.0	660@ 8.0	20	925@ 6.0	925@ 8.0
GCB-4803A	C	1.5– 1.7	64–68	P	8	615@ 6.0	660@ 8.0	20	925@ 6.0	925@ 8.0
GCB-4803B	C	1.5 –1.7	64–68	P	8	615@ 6.0	660@ 8.0	20	925@ 6.0	925@ 8.0
GCB-4804	C	1.5 –1.7	64–68	P	8	615@ 6.0	660@ 8.0	20	925@ 6.0	925@ 8.0
GCB-4805	C	1.5 –1.7	64–68	P	8	615@ 6.0	660@ 8.0	20	925@ 6.0	925@ 8.0
GCB-4808	C	1.5 –1.7	64–68	P	8	615@ 6.0	660@ 8.0	20	925@ 6.0	925@ 8.0
GCB-4810A	C	1.5 –1.7	64–68	P	8	615@ 6.0	660@ 8.0	20	925@ 6.0	925@ 8.0
GCB-4813A	C	1.5 –1.7	64–68	P	8	615@ 6.0	660@ 8.0	20	925@ 6.0	925@ 8.0
GCB-4814A	C	1.5 –1.7	64–68	P	8	615@ 6.0	660@ 8.0	20	925@ 6.0	925@ 8.0
GCB-4815A	C	1.5 –1.7	64–68	P	8	615@ 6.0	660@ 8.0	20	925@ 6.0	925@ 8.0
GCB-4816	C	1.5 –1.7	64–68	P	8	615@ 6.0	660@ 8.0	20	925@ 6.0	925@ 8.0
GCB-4817A	C	1.5 –1.7	64–68	P	8	615@ 6.0	660@ 8.0	20	925@ 6.0	925@ 8.0
GCB-4820	C	1.5 –1.7	64–68	P	8	615@ 6.0	660@ 8.0	20	925@ 6.0	925@ 8.0
GCD-4801	C	1.37–1.52②	55–65	P	4	660@13.0	710@15.0	20	1110@13.0	1110@15.0
GCD-4802	C	1.37–1.52②	55–65	P	4	660@13.0	710@15.0	20	1110@13.0	1110@15.0
GCD-4803A	C	1.37–1.52②	55–65	P	4	660@13.0	710@15.0	20	1110@13.0	1110@15.0
GCD-4804	C	1.37–1.52②	55–65	P	4	660@13.0	710@15.0	20	1110@13.0	1110@15.0
GCE-4806	C	1.66–1.84	64–68	P	8	910@ 6.0	1000@ 8.0	30	1500@ 6.0	1500@ 8.0
GCE-4807A	C	1.66–1.84	64–68	P	8	910@ 6.0	1000@ 8.0	30	1500@ 6.0	1500@ 8.0
GCE-4807B	C	1.66–1.84	64–68	P	8	910@ 6.0	1000@ 8.0	30	1500@ 6.0	1500@ 8.0
GCE-4808	C	1.66–1.84	64–68	P	8	910@ 6.0	1000@ 8.0	30	1500@ 6.0	1500@ 8.0
GCE-4809	C	1.66–1.84	64–68	P	8	910@ 6.0	1000@ 8.0	30	1500@ 6.0	1500@ 8.0
GCE-4810	C	1.66–1.84	64–68	P	8	910@ 6.0	1000@ 8.0	30	1500@ 6.0	1500@ 8.0
GCE-4812	C	1.66–1.84	64–68	N	8	910@ 6.0	1000@ 8.0	30	1500@ 6.0	1500@ 8.0
GCE-4814A	C	1.66–1.84	64–68	P	8	910@ 6.0	1000@ 8.0	30	1500@ 6.0	1500@ 8.0
GCE-4815A	C	1.66–1.84	64–68	P	8	910@ 6.0	1000@ 8.0	30	1500@ 6.0	1500@ 8.0
GCE-4816A	C	1.66–1.84	64–68	P	8	910@ 6.0	1000@ 8.0	30	1500@ 6.0	1500@ 8.0
GCE-4817	C	1.66–1.84	64–68	P	8	910@ 6.0	1000@ 8.0	30	1500@ 6.0	1500@ 8.0
GCE-4820A	C	1.66–1.84	64–68	P	8	910@ 6.0	1000@ 8.0	32	1600@ 6.0	1600@ 8.0
GCE-4822A	C	1.66–1.84	64–68	P	8	910@ 6.0	1000@ 8.0	32	1600@ 6.0	1600@ 8.0
GCH-4601	C	1.17–1.29	23–26	P	8	680@ 7.0	710@ 7.6	40	975@ 7.6	975@ 8.0
GCH-4602	C	1.17–1.29	23–26	P	8	680@ 7.0	710@ 7.6	40	975@ 7.6	975@ 8.0
GCH-4603	C	1.17–1.29	23–26	P	8	680@ 7.0	710@ 7.6	40	975@ 7.6	975@ 8.0
GCH-4604	C	1.17–1.20	23–26	P	8	680@ 7.0	710@ 7.6	40	975@ 7.6	975@ 8.0
GCH-4605	C	1.17–1.29	23–26	P	8	680@ 7.0	710@ 7.6	40	975@ 7.6	975@ 8.0

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AUTO–LITE GENERATOR TEST SPECIFICATIONS

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CURRENT–VOLTAGE REGULATOR CONTROL TYPE

Unit Number	Direction of Rotation	Field Current at 6 Volts Amperes	Brush Spring Tension Ounces	Ground Polarity	Low Output Test			Maximum Output Test ①		
					Amperes	Maximum R. P. M. at Volts	Maximum R. P. M. at Volts	Amperes	Maximum R. P. M. at Volts	Maximum R. P. M. at Volts
GCH-4606	C	1.17–1.29	23–26	P	8	680@ 7.0	710@ 7.6	40	975@ 7.6	975@ 8.0
GCH-4607A	C	1.17–1.29	23–26	P	8	680@ 7.0	710@ 7.6	50	1020@ 7.6	1025@ 8.0
GCH-4608	C	1.17–1.29	23–26	P	8	680@ 7.0	710@ 7.6	50	1020@ 7.6	1025@ 8.0
GCH-4608-1	C	1.17–1.29	23–26	P	8	680@ 7.0	710@ 7.6	40	975@ 7.6	975@ 8.0
GCH-4609A	C	1.17–1.29	23–26	P	8	680@ 7.0	710@ 7.6	40	975@ 7.6	975@ 8.0
GCH-4610B	C	1.17–1.29	23–26	P	8	680@ 7.0	710@ 7.6	40	975@ 7.6	975@ 8.0
GCR-4802	C	1.47–1.63②	53 max.	P	4	980@14.2	----------	15	1575@14.2	1565@15.0
GCW-4804A	C	1.40–1.55②	64–68	P	4	790@13.4	830@15.0	17	1140@13.4	1170@15.0
GDA-4801	C	1.66–1.84	53 max.	P	8	1175@ 7.0	1195@ 7.6	28	2055@ 7.6	2025@ 8.0
GDA-4801C	C	1.66–1.84	53 max.	P	8	1175@ 7.0	1195@ 7.6	28	2055@ 7.6	2025@ 8.0
GDA-4801D	C	1.66–1.84	53 max.	P	8	1175@ 7.0	1195@ 7.6	28	2055@ 7.6	2025@ 8.0
GDA-4801E	C	1.66–1.84	53 max.	P	8	1175@ 7.0	1195@ 7.6	28	2055@ 7.6	2025@ 8.0
GDA-4803A	C	1.66–1.84	53 max.	P	8	1175@ 7.0	1195@ 7.6	28	2055@ 7.6	2025@ 8.0
GDA-4804A	C	1.66–1.84	53 max.	P	8	1175@ 7.0	1195@ 7.6	28	2055@ 7.6	2025@ 8.0
GDA-4808A	C	1.66–1.84	53 max.	P	8	1175@ 7.0	1195@ 7.6	28	2055@ 7.6	2025@ 8.0
GDJ-4803A	C	1.48–1.64②	71–76	P	8	805@13.8	825@14.6	55	1080@14.6	1080@15.0
GDJ-4804A	C	1.48–1.64②	71–76	N	8	805@13.8	825@14.6	55	1080@14.6	1080@15.0
GDJ-4808A	C	1.48–1.64②	71–76	N	8	805@13.8	825@14.6	55	1080@14.6	1080@15.0
GDM-4803-1	C	1.41–1.56②	55–65	N	4	880@13.8	900@14.6	30	1270@14.6	1275@15.0
GDO-4601A-1	C	1.10–1.30	23–26	P	8	510@ 7.0	530@ 7.6	30	840@ 7.6	840@ 8.0
GDT-4802	C	1.58–1.79	55–65	P	8	815@ 7.0	----------	40	1350@ 7.0	1350@ 8.0
GDW-4601A	C	.91–1.01③	23–26	P	2	780@26.0	----------	10	890@27.2	925@30.0
GDZ-4801B	C	1.60–1.78	53 max.	P	8	1125@ 6.8	----------	30.0–36.7	8.0①	----------
GDZ-4801C	C	1.60–1.78	53 max.	P	8	1125@ 6.8	----------	30.0–36.7	8.0①	----------
GDZ-4801D	C	1.60–1.78	53 max.	P	8	1125@ 6.8	----------	30.0–36.7	8.0①	----------
GDZ-4802A	C	1.60–1.78	53 max.	P	8	1125@ 6.8	----------	30.0–36.7	8.0①	----------
GDZ-4804A	C	1.60–1.78	53 max.	P	8	1125@ 6.8	----------	30.0–36.7	8.0①	----------
GDZ-4805A	C	1.60–1.78	53 max.	P	8	1125@ 6.8	----------	30.0–36.7	8.0①	----------
GDZ-4807A	CC	1.60–1.78	53 max.	P	8	1125@ 6.8	----------	30.0–36.7	8.0①	----------
GDZ-4809	C	1.60–1.78	53 max.	P	8	1125@ 6.8	----------	30.0–36.7	8.0①	----------
GDZ-4810A	C	1.60–1.78	53 max.	P	8	1125@ 6.8	----------	30.0–36.7	8.0①	----------
GDZ-4811A	C	1.60–1.78	53 max.	P	8	1125@ 6.8	----------	30.0–36.7	8.0①	----------
GEB-4801A	C	1.60–1.78	64–68	P	8	725@ 7.0	740@ 7.6	32	1160@ 7.6	1165@ 8.0
GEB-4801B	C	1.60–1.78	64–68	P	8	725@ 7.0	740@ 7.6	32	1160@ 7.6	1165@ 8.0
GEB-4804A	C	1.60–1.78	64–68	P	8	725@ 7.0	740@ 7.6	32	1160@ 7.6	1165@ 8.0
GEB-4805A	C	1.60–1.78	64–68	P	8	725@ 7.0	740@ 7.6	32	1160@ 7.6	1165@ 8.0
GEB-4806B	C	1.60–1.78	64–68	P	8	725@ 7.0	740@ 7.6	32	1160@ 7.6	1165@ 8.0
GEB-4806C	C	1.60–1.78	64–68	P	8	725@ 7.0	740@ 7.6	32	1160@ 7.6	1165@ 8.0
GEB-4806D	C	1.60–1.78	64–68	P	8	725@ 7.0	740@ 7.6	32	1160@ 7.6	1165@ 8.0
GEB-4806E	C	1.60–1.78	64–68	P	8	725@ 7.0	740@ 7.6	32	1160@ 7.6	1165@ 8.0
GEB-4807	C	1.60–1.78	64–68	P	8	725@ 7.0	740@ 7.6	32	1160@ 7.6	1165@ 8.0
GEB-4809	C	1.60–1.78	64–68	P	8	725@ 7.0	740@ 7.6	32	1160@ 7.6	1165@ 8.0
GEB-4810	C	1.60–1.78	64–68	P	8	725@ 7.0	740@ 7.6	32	1160@ 7.6	1165@ 8.0
GEB-4811A	C	1.60–1.78	64–68	P	8	725@ 7.0	740@ 7.6	32	1160@ 7.6	1165@ 8.0
GEB-4813	C	1.60–1.78	64–68	P	8	725@ 7.0	740@ 7.6	32	1160@ 7.6	1165@ 8.0

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AUTO–LITE GENERATOR TEST SPECIFICATIONS

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CURRENT–VOLTAGE REGULATOR CONTROL TYPE

Unit Number	Direction of Rota-tion	Field Current at 6 Volts Amperes	Brush Spring Tension Ounces	Ground Polarity	Low Output Test			Maximum Output Test①		
					Am-peres	Maximum R. P. M. at Volts	Maximum R. P. M. at Volts	Am-peres	Maximum R. P. M. at Volts	Maximum R. P. M. at Volts
GEB-4814	C	1.60–1.78	64–68	P	8	725@ 7.0	740@ 7.6	32	1160@ 7.6	1165@ 8.0
GEB-4815A	C	1.60–1.78	64–68	P	8	725@ 7.0	740@ 7.6	32	1160@ 7.6	1165@ 8.0
GEB-4816A	C	1.60–1.78	64–68	P	8	725@ 7.0	740@ 7.6	32	1160@ 7.6	1165@ 8.0
GEB-4820–1	C	1.60–1.78	64–68	P	8	725@ 7.0	740@ 7.6	16	875@ 7.6	885@ 8.0
GEB-4821A	C	1.60–1.78	64–68	P	8	725@ 7.0	740@ 7.6	32	1160@ 7.6	1165@ 8.0
GEB-4822A	C	1.60–1.78	64–68	P	8	725@ 7.0	740@ 7.6	32	1160@ 7.6	1165@ 8.0
GEB-4823	CC	1.60–1.78	64–68	P	8	725@ 7.0	740@ 7.6	32	1160@ 7.6	1165@ 8.0
GEB-4824–1	C	1.60–1.78	64–68	P	8	725@ 7.0	740@ 7.6	32	1160@ 7.6	1165@ 8.0
GEB-4826A	C	1.60–1.78	64–68	P	3	630@ 7.0	----------	25	1094@ 7.6	1100@ 8.0
GEB-4827	C	1.60–1.78	64–68	P	8	725@ 7.0	740@ 7.6	32	1160@ 7.6	1165@ 8.0
GEB-4828A	C	1.60–1.78	64–68	P	8	725@ 7.0	740@ 7.6	32	1160@ 7.6	1165@ 8.0
GEB-4829A	C	1.60–1.78	64–68	P	8	725@ 7.0	740@ 7.6	32	1160@ 7.6	1165@ 8.0
GEG-4811A	C	1.60–1.78	64–68	P	8	930@ 7.0	955@ 7.6	40	1460@ 7.6	1465@ 8.0
GEG-4813	C	1.60–1.78	64–68	P	8	930@ 7.0	955@ 7.6	40	1460@ 7.6	1465@ 8.0
GEG-4814	C	1.60–1.78	64–68	P	8	930@ 7.0	955@ 7.6	40	1460@ 7.6	1465@ 8.0
GEH-4802	C	1.38–1.53③	64–68	P	4	855@13.8	875@14.6	17	1120@14.6	1125@15.0
GEH-4806	C	1.38–1.53③	64–68	P	4	855@13.8	875@14.6	17	1120@14.6	1125@15.0
GEW-4801	CC	1.60–1.78	64–68	P	8	600@ 7.6	----------	25	970@ 7.6	960@ 8.0
GEW-4802	C	1.60–1.78	64–68	P	8	600@ 7.6	----------	25	970@ 7.6	960@ 8.0
GEW-4803A	C	1.60–1.78	64–68	P	8	600@ 7.6	----------	25	970@ 7.6	960@ 8.0
GEW-4804	C	1.60–1.78	64–68	P	8	600@ 7.6	----------	25	970@ 7.6	960@ 8.0
GEW-4805	CC	1.60–1.78	64–68	P	8	600@ 7.6	----------	25	970@ 7.6	960@ 8.0
GEW-4806A	C	1.60–1.78	64–68	P	8	600@ 7.6	----------	25	970@ 7.6	960@ 8.0

① Do not run generator in excess of the maximum test figures given above for any length of time as to do so may result in burnt armature and fields. Maximum output readings taken at 70 degrees F. For each 15 degree change of temperature, add 1 ampere if below 70 degrees and subtract 1 ampere if above 70 degrees.

C—Clockwise. CC—Counter-clockwise. P—Positive.
N—Negative.
② Field Current at 13.0 Volts.
③ Field Current at 25.4 Volts.

DELCO–REMY GENERATOR INDEX

Generator Number	Specification Number	Direction of Rotation	Brush Spring Tension, Oz.	Generator Number	Specification Number	Direction of Rotation	Brush Spring Tension, Oz.	Generator Number	Specification Number	Direction of Rotation	Brush Spring Tension, Oz.
405	333	C	25	525	333	C	25	555	332	C	25
417	332	C	25	527	333	C	25	556	332	C	25
419	332	C	25	530	280	CC	25	557	1238	C	25
434	281	C	25	534	333	C	25	560	1245	CC	25
440	335	CC	25	535	333	C	25	561	335	CC	25
469	333	C	25	538	333	C	25	563	1277	C	25
504	1272	C	25	539	333	CC	25	564	1278	C	25
518	1612	C	25	550	332	C	25	567	1218	C	25
519	1272	CC	25	552	1209	CC	25	568	332	C	25
522	333	C	25	553	332	C	25	600	1266	C	20

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DELCO-REMY GENERATOR INDEX

Generator Number	Specification Number	Direction of Rotation	Brush Spring Tension, Oz.
601	1261	C	25
602	1279	C	20
603	1640	C	25
604	1278	C	25
605	1640	C	25
606	1625	C	25
607	1648	C	25
608	1277	C	25
609	1277	C	25
610	280	C	25
611	333	C	25
613	333	CC	25
614	1251	C	25
616	1278	CC	25
622	333	C	25
625	333	C	25
630	333	C	25
633	333	CC	25
634	333	CC	25
637	333	C	25
639	333	C	25
670	1277	CC	25
671	1277	C	25
672	1621	C	25
673	1277	C	25
674	1278	C	25
676	332	C	25
677	335	CC	25
678	1621	C	25
679	1277	C	25
680	1277	C	25
682	1625	C	25
683	1625	C	25
687	332	C	25
688	1277	C	25
689	1277	C	25
690	1625	C	25
691	1621	C	25
692	1648	C	25
693	1648	C	25
694	1625	C	25
695	332	C	25
696	1625	C	25
697	1621	C	25
698	1621	C	25
699	1648	C	25
916-A	1603	C	25
916-B	1604	C	25
916-D	1603	C	25
916-F	1610	C	25
916-G	1604	C	25
916-H	1610	C	25
916-J	1604	C	25
916-K	1610	C	25
925-F	1608	C	25
925-G	1608	CC	25
925-H	1608	C	25
927-X	1220	C	25
928-B	1616	C	25
930-C	1616	CC	25
930-D	1619	C	25
930-E	1616	C	25
930-G	1631	C	25
930-H	1619	C	25
931-J	286	C	25
931-M	1241	C	25
931-R	286	C	25
931-T	286	C	25
931-X	1270	C	25
932-A	1274	C	25
932-B	286	C	25
932-D	286	C	25
933-D	1249	C	25
934-A	1603	C	25
934-B	1604	C	25
934-C	1603	CC	25
934-D	1604	CC	25
934-E	1603	C	25
934-F	1610	C	25
934-G	1604	C	25
934-H	1603	C	25
934-J	1604	C	25
934-M	1603	C	25
934-N	1604	C	25
934-P	1603	C	25
934-R	1604	C	25
934-S	1603	C	25
934-T	1604	C	25
934-U	1603	C	25
934-V	1604	C	25
934-W	1603	C	25
934-X	1604	C	25
934-Y	1603	C	25
934-Z	1610	C	25
935-D	1250	C	25
935-P	1250	C	25
935-V	1254	C	25
935-Z	1243	C	25
936-A	1254	C	25
936-B	1254	CC	25
936-H	1254	C	25
936-M	1254	C	25
936-U	1271	C	25
936-Y	1254	C	25
936-Z	1254	C	25
937-G	1236	C	25
937-H	278	C	25
937-P	1244	C	25
937-R	268	C	16
937-V	1234	C	25
937-Y	278	C	25
937-Z	278	C	25
938-B	302	C	16
938-E	304	C	16
939-H	270	C	16
939-J	1624	C	25
939-M	270	C	16
939-U	1222	C	16
939-V	270	C	16
939-Y	270	C	16
940-Z	302	C	16
941-F	302	C	16
941-H	302	CC	16
941-J	295	C	16
941-N	302	C	16
941-S	302	C	16
941-W	302	C	16
941-Z	348	C	16
942-H	268	C	16
943-J	268	C	16
943-R	274	C	25
943-V	268	C	16
943-Z	308	C	17
945-D	307	C	16
945-L	305	C	16
945-N	305	C	16
945-S	307	C	16
945-T	307	C	16
945-V	305	CC	16
946-B	278	C	25
946-C	268	C	16

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DELCO-REMY GENERATOR INDEX

Generator Number	Specification Number	Direction of Rotation	Brush Spring Tension, Oz.
946-D	268	C	16
946-G	278	C	25
946-H	1244	C	25
946-J	268	C	16
946-N	268	C	16
946-P	268	C	16
946-S	268	C	16
948-C	1254	C	25
948-F	1243	C	25
948-G	1271	C	25
948-H	1271	C	25
948-K	1243	C	25
948-M	1243	C	25
948-N	1254	C	25
948-P	1254	CC	25
948-R	1254	C	25
948-V	1243	C	25
952	1635	C	25
953-D	302	C	16
953-G	302	C	16
953-Y	302	C	16
955	1635	CC	25
955-E	302	C	17
956-C	1224	C	16
956-D	1224	C	16
956-E	1224	C	16
956-F	1205	C	16
956-H	1215	C	25
956-J	1205	C	16
956-K	1205	C	16
956-P	285	CC	16
957-B	307	C	16
957-M	322	C	16
957-T	307	C	16
957-W	345	C	16
957-X	322	C	16
957-Y	1213	C	25
957-Z	305	CC	16
958-A	1611	C	25
958-C	1611	C	25
958-D	1611	C	25
958-E	1611	C	25
959-B	270	CC	16
959-L	302	C	16
959-N	302	CC	16
959-P	302	C	16
959-Q	302	CC	16
959-X	302	C	16
959-Y	304	C	16
960	1635	C	25
960-A	1271	C	25
960-B	1254	CC	25
960-C	1254	C	25
960-D	1254	C	25
960-E	1606	C	25
960-F	278	C	25
960-G	1271	C	25
960-H	1254	C	25
960-J	1254	CC	25
961	1635	CC	25
962	1656	CC	25
963	333	C	25
964	1635	C	25
965-A	322	CC	16
965-F	285	C	25
965-J	305	C	16
965-L	307	C	16
965-R	344	C	25
965-S	307	C	16
965-U	307	C	16
965-W	305	C	16
965-Z	1214	C	16
966	1635	C	25
967-G	1205	C	16
967-R	307	C	25
967-S	1258	CC	25
967-V	307	C	16
967-W	322	C	16
967-Y	305	C	16
967-Z	1224	C	25
968-A	322	C	16
968-B	1275	CC	25
968-D	285	C	25
968-E	1258	CC	25
968-G	1258	C	25
968-H	1611	C	25
968-J	1611	C	25
968-K	1611	C	25
968-P	1611	C	25
968-T	1611	C	25
968-V	307	CC	16
969	1635	CC	25
970-E	1211	C	25
970-F	1237	C	25
970-G	1208	C	25
973-E	1221	C	25
973-G	1233	C	25
973-J	1207	C	25
973-L	1221	C	25
974	1635	C	25
975-F	1657	C	25
975-G	1657	C	25
975-H	1208	C	25
975-J	1208	CC	25
975-S	1646	C	25
975-T	1208	C	25
975-U	1211	C	25
975-V	1211	C	25
975-W	1211	C	25
975-X	1208	C	25
976	1635	C	25
977	1635	C	25
977-E	1265	C	25
977-F	1269	C	25
977-J	1211	C	25
977-K	1237	C	25
977-L	1211	C	25
977-M	1276	C	25
977-N	1211	C	25
977-P	1211	C	25
977-R	1211	CC	25
977-S	1605	C	25
977-U	1276	CC	25
977-V	1605	CC	25
977-W	1265	C	25
977-X	1265	C	25
977-Y	1618	CC	25
977-Z	1208	C	25
978-A	1237	C	25
978-B	1208	C	25
978-E	1641	CC	25
983	1635	C	25
984	1635	C	25
985	1635	C	25
988	1635	C	25
SM1168	270	C	16
SM1193	322	C	16
SM1212	265	C	25
SM1214	1214	C	25
SM1249	265	C	16
SM1277	1229	C	25
SM1278	1218	C	25
SM1298	280	C	25
SM1315	1218	CC	25
SM1322	1217	C	25
SM1324	333	CC	25
SM1326	1208	C	25

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DELCO—REMY GENERATOR INDEX

Generator Number	Specification Number	Direction of Rotation	Brush Spring Tension, Oz.
SM1328	333	C	25
SM1334	1657	C	25
SM1335	270	C	16
SM1353	305	C	16
SM1374	1237	C	25
SM1378	349	C	16
SM1491	307	C	16
SM1505	1218	C	25
SM1518	322	C	16
SM1569	1217	C	16
SM1591	1263	C	25
SM1597	1208	CC	25
SM1615	1208	C	25
SM1616	1208	C	25
SM1627	1241	C	25
SM1643	308	C	17
SM1644	270	C	16
SM1656	1263	CC	25
SM1660	1211	CC	25
SM1676	280	C	16
SM1680	1245	C	25
SM1684	333	C	25
SM1685	322	C	16
SM1687	280	C	25
SM1704	322	C	16
SM1717	322	CC	25
SM1730	1224	C	16
SM1752	1265	CC	25
SM1778	1607	CC	25
SM1779	1616	CC	25
SM1795	1243	C	25
SM1799	1620	CC	25
SM1806	270	C	16
SM1819	1208	C	25
SM1858	1277	C	25
SM1862	1245	C	25
SM1866	1277	C	25
SM1868	1604	C	25
SM1873	1280	C	25
SM1876	1604	C	25
SM1884	335	CC	25
SM1909	1254	C	25
SM1933	1625	C	25
SM1945	268	C	16
1100001	1645	C	25
1100004	1645	C	25
1100006	1645	C	25
1100008	1645	C	25
1100451	1254	CC	25

Generator Number	Specification Number	Direction of Rotation	Brush Spring Tension, Oz.
1100452	1243	C	25
1100456	1254	C	25
1100458	1271	C	25
1100459	1250	C	25
1100463	1271	CC	25
1100468	1254	C	25
1101358	1651	C	16
1101360	268	C	16
1101702	1647	C	25
1101705	270	C	16
1101708	1647	C	16
1101710	270	C	16
1101714	1653	C	25
1101716	270	C	25
1101729	1673	C	25
1101730	1673	C	25
1101731	1673	CC	25
1101734	1673	C	25
1101736	1653	C	25
1101742	1673	C	25
1101744	1653	C	25
1102402	1611	C	25
1102403	1611	C	25
1102404	1224	C	25
1102405	1205	C	16
1102407	1611	C	25
1102408	1611	C	25
1102413	1611	C	25
1102419	1611	C	25
1102501	322	C	16
1102514	322	C	16
1102520	322	C	16
1102660	1671	C	25
1102667	1671	C	25
1102670	1671	C	25
1102671	1671	C	25
1102673	1671	C	25
1102674	1671	C	25
1102675	1671	C	25
1102676	1671	CC	25
1102677	1683	C	25
1102678	1671	C	25
1102685	1671	C	25
1102689	1671	C	25
1102690	1671	C	25
1102691	1671	C	25
1102953	1676	C	25
1102954	1676	C	25
1102955	1676	C	25

Generator Number	Specification Number	Direction of Rotation	Brush Spring Tension, Oz.
1102957	1676	CC	25
1102961	1676	C	25
1105201	1616	C	25
1105501	1604	C	25
1105527	1610	C	25
1105529	1603	C	25
1105532	1603	C	25
1105726	1604	C	25
1105727	1604	C	25
1105728	1604	C	25
1105731	1604	C	25
1105732	1604	C	25
1105733	1604	C	25
1105734	1604	C	25
1105735	1604	C	25
1105740	1604	C	25
1105741	1604	C	25
1105742	1604	CC	25
1105744	1604	C	25
1105747	1604	C	25
1105752	1610	C	25
1105753	1649	C	25
1105756	1649	C	25
1105757	1649	CC	25
1105758	1649	C	25
1105759	1649	CC	25
1105760	1649	C	25
1105778	1604	CC	25
1105780	1604	C	25
1105854	1688	C	25
1105855	1688	C	25
1105856	1681	C	25
1105859	1688	C	25
1106252	1237	C	25
1106253	1276	CC	25
1106254	1237	C	25
1106255	1237	C	25
1106403	1680	C	25
1106408	1693	C	25
1106451	1641	CC	25
1106452	1662	CC	25
1106455	1641	C	25
1106576	1654	C	25
1106577	1654	CC	25
1106578	1654	C	25
1106579	1654	C	25
1106580	1654	C	25
1106581	1654	C	25

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DELCO—REMY GENERATOR INDEX

Generator Number	Specification Number	Direction of Rotation	Brush, Spring Tension, Oz.
1106582	1675	C	25
1106584	1675	C	25
1106585	1675	CC	25
1106586	1675	C	25
1106587	1687	C	25
1106588	1675	CC	25
1106589	1210	C	25
1106590	1687	CC	25
1106591	1700	C	25
1106593	1654	C	25
1106626	1650	C	25
1106627	1650	CC	25
1106628	1650	C	25
1106629	1650	C	25
1106630	1650	C	25
1106631	1650	C	25
1106632	1650	C	25
1106633	1650	C	25

Generator Number	Specification Number	Direction of Rotation	Brush Spring, Tension, Oz.
1106635	1650	CC	25
1106636	1650	C	25
1106637	1650	C	25
1106638	1650	C	25
1106639	1650	C	25
1106640	1650	C	25
1106641	1650	CC	25
1106642	1650	CC	25
1106643	1650	C	25
1106648	1690	CC	25
1106650	1695	C	25
1106651	1650	C	25
1106653	1701	C	25
1106654	1650	C	25
1117001	1648	CC	25
1117002	332	CC	25
1117004	1648	C	25
1117005	1648	C	25

Generator Number	Specification Number	Direction of Rotation	Brush Spring Tension, Oz.
1117006	1277	C	25
1117008	1277	C	25
1117009	1277	C	25
1117011	1278	C	25
1117012	1648	C	25
1117013	1277	C	25
1117014	1238	C	25
1117015	1648	C	25
1117017	1245	C	25
1117018	332	C	25
1117020	332	C	25
1117022	343	CC	25
1117025	1668	CC	25
1117027	1668	C	25
1117028	1648	C	25

C—Clockwise. CC—Counterclockwise. Third Brush spring tension 17 ounces unless otherwise indicated.

DELCO—REMY GENERATOR TEST SPECIFICATIONS

Spec. No.	Field Current at 6 Volts (Amperes)	Maximum Cold Output			Maximum Hot Output		
		Amperes	Volts	Approximate R.P.M.	Amperes	Volts	Approximate R.P.M.
265	1.5–1.8	24–26	8.8–9.2	1800	14–18	7.8–8.25	2300
268	3.5–4.5	15–17	7.9–8.2	1700	10–12	7.4–7.7	1800
270	2.5–3.2①	8–10	14.4–14.6	1500	6–8	14.2–14.4	1800–2000
274	3.5–4.5	15–17	8–8.2	2300	11–14	7.3–7.6	2400
278	3.5–4.5	15–18	7.9–8.3	2000	13–15	7.7–8.0	2400
280	1.09–1.20①	50	13.0	1700	②	②	②
281	1.3–1.4③	10	7.45	....	④	④	④
285	2.5–3.0①	11–13	15–15.5	1700	7–10	14.1–14.9	2000
286	3.5–4.0	22–24	8.6–9.0	1300	13.5–16.5	7.7–8.1	1600–1800
295	4.0–5.9	13–15	7.75–7.95	1300	5.5–7.5	6.9–7.1	1400–1500
302	4.0–6.1	19–22	8.3–8.7	1550	9–12	7.3–7.7	1800–2000
304	4.0–6.1	15–17	7.9–8.15	1400	11–14	7.5–7.85	1700–1800
305	2.8–3.5	23–26	8.8–9.2	1900	13–16	7.7–8.1	2200
307	4.0–5.9	18–20	8.3–8.5	1300	9–12	7.3–7.6	1300–1500
308	4.0–5.9	15–17	7.95–8.05	1600	11–13	7.5–7.85	1750–1850
322	2.5–3.0①	11–13	15.1–15.5	1700	7–9.5	14.2–14.8	2000
332	1.35–1.48①	24–26	13.0	1600	18	13.0	3000
333	1.09–1.20①	40	13.0	1100	②	②	②
335	1.39–1.47①	24–26	13.0	1100	18	13.0	3000
343	1.46–1.49①	18	13.0	1100	②	②	②
344	1.75–2.25	17–19	8.2–8.4	1700	13–15	7.7–8.0	1800–2000
345	2.8–3.5	19–21	8.4–8.6	1800	11–14	7.5–7.6	1900–2100

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DELCO-REMY GENERATOR TEST SPECIFICATIONS

Spec. No.	Field Current at 6 Volts (Amperes)	Maximum Cold Output			Maximum Hot Output		
		Amperes	Volts	Approximate R.P.M.	Amperes	Volts	Approximate R.P.M.
348	4.0–6.1	17–19	8.1–8.3	1450	7–10	7.1–7.4	1800–2000
349	4.0–5.9	13–15	7.7–8.0	1600	10–12	7.5–7.7	1750–1850
1205	1.75–2.25	17–19	7.9–8.1	1700	13–15	7.7–8.0	1800–2000
1207	1.76–1.88	26–28	9.15–9.4	1800	16–18	8.1–8.4	2100
1208	1.2–1.27①	22–24	13.0	2000	15–17	13.0	2100
1209	1.3	10	7.45	2100	④	④	④
1210	1.77–2.0	30	8.0	960	②	②	③
1211	1.53–1.67	26–28	7.0	1400	21–23	7.0	1600
1213	1.75–2.25	17–20	8.2–8.5	1900	13–15	7.7–8.0	1900
1214	2.5–3.0①	8–10	14.5–15.5	1700	5–7	14.1–14.9	2000
1215	2.1–2.5	19–22	8.3–8.7	2000	11–14	7.5–7.9	2200–2600
1217	1.35–1.55①	16–18	16.1–16.5	2400	11–13	15.1–15.5	2600
1218	3.5–3.75	38–40	7.0	1500	30–32	7.0	1700
1220	2.0–2.5①	16–18	13.0	2200	13–15	13.0	2500
1221	1.76–1.88	24–26	7.0	1600	19–21	7.0	1800
1224	4.0–6.1	20–22	8.4–8.6	1500–1600	10–12	7.4–7.6	1600–1800
1229	1.5–2.0	22–24	8.6–9.0	1800	12–16	7.6–8.05	2300
1233	0.83–0.89①	21–23	13.0	2400	16–18	13.0	2800
1234	3.5–4.5	16–18	8.05–8.25	2000	11–13	7.5–7.8	2000–2100
1236	3.5–4.5	15–17	7.95–8.15	1900	10–13	7.45–7.75	2100
1237	1.53–1.67	17–19	7.0	1200	13–15	7.0	1200
1238	1.39–1.47①	13–15	13.0	1200	10	13.0	3000
1241	1.5–1.8	23–26	8.8–9.1	2300	17–20	8.1–8.5	2500
1243	2.3–2.6	17–20	8.2–8.5	2400	13–15	7.7–8.0	3000
1244	3.5–4.5	19–22	8.3–8.7	2400	12–15	7.6–8.0	2600
1245	1.12–1.23⑤	14	26.0	1000	②	②	②
1249	1.7–2.0	10.5	7.4–7.5	5000	10.5	7.4–7.5	5000
1250	2.3–2.6	18–21	8.2–8.5	2400	15–18	7.9–8.3	2900
1251	1.58–1.71	50	7.5	800	②	②	②
1254	2.3–2.6	19–23	8.4–8.8	2800	16–20	8.1–8.5	3100
1258	2.8–3.5	22–25	8.7–9.0	1800	13–16	7.8 8.1	2000
1261	1.9–2.1①	19–21	13.00	1600	16	13.0	1600
1263	0.96–1.05⑤	25	24.0	1300	②	②	②
1265	0.58–0.63⑤	10	26.0	1200	②	②	②
1266	1.9–2.1①	9–11	14.7–15.1	1200	7.0–8.5	14.2–14.6	1300
1269	.57–.62⑤	11	26.0	1800	8.5	24.0	3000
1270	.95–1.2	15–20	8.0–8.5	1700	-----	---	----
1271	2.3–2.6	23–27	8.8–9.0	3000	18–23	8.2–8.7	3200
1272	1.78–1.92①	80	13.0	800	②	②	②
1274	2.7–3.0	25–28	9.0–9.4	1900	20–24	8.5–8.9	2100
1276	1.53–1.67	30–31	7.0	2000	28–30	7.0	2100
1277	3.53–3.75	40	7.0	950	②	②	②
1278	3.53–3.75	28–30	7.0	1000	22–24	7.0	1200
1279	1.5–1.6①	9–11	14.7–15.1	1400	8.0–10.5	14.5–15.0	1400
1280	1.7–2.0	22	8.0	1200	②	②	②
1603	1.7–2.0	25⑥	8.1–8.3	1250	②	②	②
1604	1.25–1.45①	17	14.5–14.75	1250	②	②	②
1605	1.20–1.27①	25–28	13.0	2600	23–26	13.0	3000
1606	2.3–2.6	22–25	8.7–9.1	3000	17–20	8.1–8.5	3200

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DELCO—REMY GENERATOR TEST SPECIFICATIONS

Spec. No.	Field Current at 6 Volts (Amperes)	Maximum Cold Output			Maximum Hot Output		
		Amperes	Volts	Approximate R.P.M.	Amperes	Volts	Approximate R.P.M.
1607	1.8–2.3	22	8.0	1100	②	②	②
1608	2.7–3.0	30	8.0	1800	28	8.0	1900
1610	1.7–2.0	26	8.1–8.3	1325	②	②	②
1611	2.8–3.5	18–20	8.2–8.5	2000	15–17	7.9–8.2	2200
1612	1.78–1.92①	57	13.0	650	②	②	②
1616	1.08–1.15①	17	14.5–14.75	1650	②	②	②
1618	1.20–1.27①	17–20	13.0	1500	13–16	13.0	1500
1619	1.8–2.3	26	8.1–8.3	1450	②	②	②
1620	1.25–1.4①	19–21	16.8–17.2	2100	15–17	15.9–16.4	2200
1621	1.39–1.47①	40	13.0	1400	②	②	②
1624	3.3–4.0①	15–18	15.9–16.6	2600	13–15	15.5–16.0	2800
1625	1.26–1.33①	33	13.00	950	②	②	②
1631	1.8–2.3	28	8.0	1450	②	②	②
1635	1.54–1.71①	55	13.0	950	②	②	②
1640	1.26–1.33①	20	13.0	950	②	②	②
1641	1.20–1.27①	8	13.0	640	②	②	②
1645	2.3–2.6	26–30	8.0	3400	25–28	8.0	3600
1646	1.53–1.67	28–30	9.3–9.6	2000	21–23	8.6–8.9	2000
1647	2.6–3.1①	11–13	15.0	2400	9–12	14.7–15.0	2600
1648	1.26–1.33①	40	13.0	1250	②	②	②
1649	0.63–0.69⑤	5–7	26.0	2000	4.5–6.5	26.0	2000
1650	1.20–1.27①	25	13.0	1300	②	②	②
1651	3.5–4.5	13–16	7.7–8.1	1800	9–11	7.3–7.6	1900
1653	1.5–1.65①	18–21	15.00	3400	15–18	15.0	3500
1654	0.91–0.98	35	8.0	1400	②	②	②
1656	1.58–1.71	40	7.5	675	②	②	②
1657	2.3–2.5	25–27	9.0–9.3	1200	22–24	8.7–9.0	1500
1661	0.78–0.84⑦	25	35.0	1550	②	②	②
1662	1.20–1.26①	16	15.0	1050	②	②	②
1668	1.26–1.33①	18	13.0	800	②	②	②
1671	1.67–1.82	30⑥	8.0	1750	②	②	②
1673	1.5–1.67①	8–10	14.4–14.9	2200	6–8	14.1–14.5	2400
1675	1.54–1.67	40	7.5	1080	②	②	②
1676	1.6–1.7①	18⑥	15.0	1480	②	②	②
1680	1.77–2.0	35	8.0	1040	②	②	②
1681	1.82–1.94	40	8.0	1850	②	②	②
1683	1.76–1.88	26⑥	8.0	1450	②	②	②
1687	1.54–1.67	40	7.5	1380	②	②	②
1688	1.70–1.90	25⑥	8.0	1150	②	②	②
1689	1.26–1.33①	18	13.0	800	②	②	②
1690	1.2–1.27①	25	13.0	1300	②	②	②
1693	1.77–2.0	35	8.0	1040	②	②	②
1695	1.2–1.27①	30	13.0	1400	②	②	②
1700	1.54–1.67	50	7.5	1400	②	②	②
1701	1.2–1.27①	40	13.0	2300	②	②	②

Note—Refer to the Delco-Remy numerical index for specification number desired. Generators equipped with thermostats should not be adjusted to the specified maximum hot output unless the thermostat points are open.

① Field current at 12 volts.

② Maximum output controlled by current regulator.

③ Shunt coils.

④ Lamp load 20 amperes.

⑤ Field current at 24 volts.

⑥ Output at given speed—not necessarily maximum output.

⑦ Field current at 32 volts.

LEECE—NEVILLE GENERATOR SPECIFICATIONS

Setting Key Type①	Generator Resistance Load⑨				Open Circuit Balance				
	Amperes	Volts	R. P. M.	Field Amperes	Volts	R. P. M.	Field Amperes	Temperature Setting	Remarks
528G	5	12.0	850	1.1–1.2	12	720	1.2–1.3	Hot	⑦
528G	9	12.0	1300	.85–.95	12	660	1.3–1.4	Cold	⑦
528G	7	12.0	3500⑧	.30–.40	--	---	------	-----	--
868G	15	12.5	650	1.65–1.75	12	575	1.4–1.5	Hot	④
868G	30	13.0	900	1.5–1.6	12	525	1.6–1.7	Cold	④
868G	30	13.0	3000⑧	.45–.55	--	---	------	-----	--
997G	5	24.0	900	.3–.4	24	600	.70–.75	Hot	⑦
997G	8	24.0	1250	.5–.6	24	550	------	Cold	⑦
997G	6	24.0	3000⑧	.2–.3	--	---	------	-----	--
1010G	5	11.9	950	1.5–1.6	12	775	1.6–1.7	Hot	⑦
1010G	15	11.9	1800	1.0–1.1	12	750	1.5–1.7	Cold	⑦
1010G	11	11.8	3500⑧	.60–.65	--	---	------	-----	--
1042G	5	30	800	.8–.9	30	700	.80–.90	Hot	②
1042G	8	31	1000	.7–.8	30	650	.85–.95	Cold	②
1042G	7	31	3000⑧	.2–.3	32	700	.80–.90	Hot	③
1042G	5	32	800	.80–.90	32	650	.85–.95	Cold	③
1042G	10	34	1300	.50–.60	--	---	------	-----	--
1042G	7	34	3500⑧	.20–.30	--	---	------	-----	--
1063G	10	6.0	900	1.90–2.00	--	---	------	-----	--
1063G	23	6.5	1500	1.60–1.70	--	---	------	-----	--
1063G	18	6.5	4000⑧	.60–.70	--	---	------	-----	--
1079G	10	12	1200	1.0–1.1	12	1000	1.0–1.1	Hot	⑦
1079G	25	12	2000	.8–.9	--	---	------	-----	--
1079G	19	14	4000⑧	.4–.5	--	---	------	-----	--
1217G	20	31	950	2.15–2.20	30	850	2.1–2.3	Hot	②
1217G	50	31	1200	1.90–2.00	30	800	2.3–2.4	Cold	②
1217G	50	35	2800	.95–1.05	30	850	2.1–2.3	Hot	③
1217G	50	32	3500⑧	.90–1.0	30	800	2.3–2.4	Cold	③
1217G	30	34	1000	2.45–2.55	--	---	------	-----	--
1217G	50	34	2000	1.05–1.15	--	---	------	-----	--
1217G	50	34	3000⑧	.80–.90	--	---	------	-----	--
1221G	25	12	500	1.8–2.0	12	400	1.6–1.7	Hot	④
1221G	50	12.5	650	1.6–1.65	12	375	1.7–1.8	Cold	④
1221G	50	14.4	2750⑧	.40–.45	--	--	------	-----	--
1238G	5	6	500	1.3–1.35	6	350	1.3–1.35	Hot	⑦
1238G	7.5	6.3	3000⑧	.65–.70	6	350	1.4–1.45	Cold	⑦
1246G	10	12.5	950	1.70–1.80	12	700	1.70–1.80	Hot	⑦
1246G	20	13.0	2000	1.30–1.40	--	---	------	-----	--
1246G	17	13.0	3500⑧	.90–1.00	--	---	------	-----	--
1250G	10	12	1100	2.6–2.8	12	925	2.2–2.3	Hot	⑦
1250G	25	12	1700	1.6–1.8	12	900	2.7–2.8	Cold	⑦
1250G	15	12	4000⑧	.8–1.0	--	--	------	-----	--
1262G	10	24.5	1100	.6–.7	24	875	.70–.80	Hot	⑦
1262G	15	24.5	2000	.4–.5	24	850	None	Cold	⑦
1262G	12	24.5	3000⑧	.2–.3	--	---	------	-----	--
1273G	10	32	900	1.30–1.40	30	750	1.4–1.5	Hot	②
1273G	25	32	1350	1.10–1.20	30	700	1.6–1.7	Cold	②
1273G	21	32	3000	.60–.70	30	750	1.3–1.4	Hot	③

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LEECE–NEVILLE GENERATOR SPECIFICATIONS

Setting Key Type①	Generator Resistance Load⑨				Open Circuit Balance				
	Amperes	Volts	R. P. M.	Field Amperes	Volts	R. P. M.	Field Amperes	Temperature Setting	Remarks
1273G	10	32	890	1.32	30	700	1.6–1.7	Cold	⑧
1273G	25	32	1400	1.00	--	---	------	-----	--
1273G	17	32	3000⑧	.40	--	---	------	-----	--
1300G	20	12	1200	1.6–1.7	12	1050	1.5–1.6	Hot	④
1300G	40	12	1500	1.6–1.7	12	950	1.6–1.7	Cold	④
1300G	40	14	4000⑧	.50–.60	--	---	------	-----	--
1315G	25	12	1250	1.6–1.7	12	900	1.5–1.6	Hot	⑦
1315G	50	13.5	1800	1.6–1.7	12	850	1.7–1.8	Cold	⑦
1315G	45	13.5	3500⑧	1.0–1.1	--	---	------	-----	--
1320G	5	31	900	.73–.75	30	700	.8–.9	Hot	⑦
1320G	6	32.5	3000⑧	.25–.27	30	650	.9–1.0	Cold	⑦
1342G	2	26.5	1300	.50–.55	--	---	------	-- --	--
1342G	4.5	28.5	2000	.35–.40	--	--	------	-- --	--
1342G	5	29	3000⑧	.20–.25	--	--	------	-- --	--
1406G	2	26.5	1300	.50–.55	--	--	------	-- --	--
1406G	4.5	28.6	2000	.35–.40	--	--	------	-----	--
1406G	5.0	29	3000⑧	.20–.25	--	--	------	-- --	--
1412G	5	24	1100	.60–.65	24	950	.60–.70	Hot	⑦
1412G	10	24	1500	.50–.55	24	900	.70–.80	Cold	⑦
1412G	10	24	2000	.40–.45	--	--	------	-- --	--
1412G	8	24	3000⑧	.25–.30	--	--	------	-- --	--
1419G	20	12	665	1.7–1.8	12	580	1.7–1.8	Hot	④
1419G	40	12.8	1000	1.5–1.6	12	500	1.9–2.0	Cold	④
1419G	40	13.7	2750⑧	.6–.7	--	--	------	-- --	--
1422G	20	13	1100	1.4–1.6	12	950	1.4–1.5	Hot	④
1422G	35	12.0	2500	.7–.8	12	900	1.6–1.7	Cold	④
1422G	35	14.0	4000⑧	.4–.5	--	--	------	-- --	--
1424G	15	6.5	1000	2.0–2.1	6	675	2.0–2.2	Hot	⑦
1424G	25	6	2000	2.0–2.1	--	---	------	-- --	--
1424G	25	6	4000⑧	1.4–1.5	--	--	------	-----	--
1429G	20	13	1100	1.4–1.6	12	950	1.6	Hot	④
1429G	40	14	2500	.7–.8	12	925	1.8	Cold	④
1429G	40	14	4000⑧	.4–.5	--	---	------	-----	--
1430G	20	12.0	1100	2.0–2.10	12	800	2.0–2.1	Hot	④
1430G	40	12.0	1400	1.6–1.65	12	720	2.2–2.3	Cold	④
1430G	40	14.5	4000⑧	.60–.65	--	---	------	-- --	--
1444G	20	12	750	2.1–2.2	12	550	2.1–2.2	Hot	④
1444G	40	12	1000	2.1–2.2	12	525	2.3–2.4	Cold	④
1444G	40	14	4000⑧	.4–.5	--	---	------	-----	--
1452G	20	6	825	1.00–1.10	6	620	1.0–1.1	Hot	④
1452G	50	6	1700	1.00–1.10	6	610	1.15–1.25	Cold	④
1452G	50	6	4000⑧	.50–.55	--	---	------	-----	--
1462G	10	12	950	1.5–1.6	12	800	1.5–1.6	Hot	④
1462G	25	12	1200	1.5–1.6	12	700	1.6–1.7	Cold	④
1462G	25	14	4000⑧	.4–.5	--	---	------	-----	--
1486G	10	12	1100	2.0–2.10	12	800	2.0–2.1	Hot	④
1486G	40	12	1400	1.6–1.65	12	720	2.2–2.3	Cold	④

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LEECE–NEVILLE GENERATOR SPECIFICATIONS

Setting Key Type①	Generator Resistance Load⑨				Open Circuit Balance				
	Amperes	Volts	R. P. M.	Field Amperes	Volts	R. P. M.	Field Amperes	Temperature Setting	Remarks
1486G	40	14.5	4000⑧	.60–.65	--	---	------	-----	--
1490G	15	12	825	1.9–2.0	12	650	1.9–2.0	Hot	④
1490G	30	12	1175	1.8–1.9	12	600	2.1–2.2	Cold	④
1490G	30	12	3500⑧	1.0–1.1	--	---	------	-----	--
1504G	20	6	825	1.0–1.10	6	620	1.0–1.1	Hot	④
1504G	50	6	1700	1.0–1.10	6	610	1.15–1.25	Cold	④
1504G	50	6	4000⑧	.50–.55	--	---	------	-----	--
1506G	20	12	750	2.1–2.2	12	550	2.1–2.2	Hot	④
1506G	40	12	1000	2.1–2.2	12	525	2.3–2.4	Cold	④
1506G	40	14	4000⑧	.4–.5	--	---	------	-----	--
1510G	15	12.2	800	1.7–1.8	12	600	1.6–1.7	Hot	④
1510G	30	12.5	1000	1.7–1.8	12	580	1.7–1.8	Cold	④
1510G	30	14.2	3000⑧	.6–.7	--	---	------	-----	--
1528G	10	30	900	1.0–1.05	30	825	1.00–1.05	Hot	⑤
1528G	25	30	1200	.90–1.0	30	775	1.00–1.10	Cold	⑤
1528G	25	30	2500⑧	.60–.70	30	750	.85–.95	Hot	⑥
1528G	10	32	1080	0.9	30	700	1.0–1.1	Cold	⑥
1528G	25	32	1400	0.9	32	910	.9–1.0	Hot	⑥
1528G	25	35.3	2500⑧	0.6	--	---	------	-----	--
1534G	10	12	950	1.9–2.0	12	900	2.0–2.1	Hot	④
1534G	30	12	1400	1.35–1.4	12	860	2.1–2.2	Cold	④
1534G	30	13.5	3500⑧	.5–.6	--	---	------	-----	--
1553G	10	24	975	.55–.60	24	600	1.1–1.3	Hot	④
1553G	25	24	1800	.52–.55	24	550	1.0–1.2	Cold	④
1553G	25	26	3000⑧	.25–.30	--	--	------	-- --	--
1579G	10	12	1050	2.1–2.2	12	900	2.0–2.1	Hot	④
1579G	25	12	1400	2.1–2.2	12	860	2.1–2.2	Cold	④
1579G	25	14	4000⑧	.4–.5	--	--	------	-----	--
1582G	10	12	1050	2.1–2.2	12	900	2.0–2.1	Hot	④
1582G	25	12	1400	2.1–2.2	12	860	2.1–2.2	Cold	④
1582G	25	14	4000⑧	.4–.5	--	---	------	-----	--
1602G	20	12	950	2.2–2.3	12	800	2.1–2.2	Hot	④
1602G	50	12	1200	2.2–2.3	12	775	2.3–2.5	Cold	④
1602G	50	14	4000⑧	.5–.6	--	---	------	-----	--
1630G	20	12	1100	1.4–1.5	12	950	1.4–1.5	Hot	④
1630G	50	12	1300	1.4–1.5	12	900	1.6–1.7	Cold	④
1630G	50	14	4000⑧	.4–.5	--	---	------	-----	--
1641G	5	12	525	1.7–1.8	12	450	1.6–1.7	Hot	④
1641G	15	12	700	1.7–1.8	12	425	1.9–2.0	Cold	④
1641G	15	14	3500⑧	.4–.5	--	---	------	-----	--
1656G	20	12	1100	2.4–2.50	12	950	2.2–2.3	Hot	④
1656G	40	12	1500	1.6–1.65	12	900	2.4–2.5	Cold	④
1656G	40	14.5	4000⑧	.60–.65	--	---	------	-----	--
1691G	20	12	700	2.2–2.3	12	500	2.2–2.4	Hot	④
1691G	40	12	1000	2.1–2.2	--	---	------	-----	
1691G	40	14	4000⑧	.6–.8	--	---	------	-----	--
1693G	30	12	1000	2.2–2.3	12	800	2.1–2.2	Hot	④
1693G	60	12	1350	2.2–2.3	12	775	2.3–2.5	Cold	④
1693G	60	14.2	4000⑧	1.10–1.20	--	---	------	-----	--

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LEECE–NEVILLE GENERATOR SPECIFICATIONS

Setting Key Type①	Generator Resistance Load⑨				Open Circuit Balance				
	Amperes	Volts	R. P. M.	Field Amperes	Volts	R. P. M.	Field Amperes	Temperature Setting	Remarks
1703G	10	12	800	1.80–1.90	12	650	1.9–2.0	Hot	④
1703G	20	12	1000	1.80–1.90	12	600	2.1–2.2	Cold	④
1703G	20	14	3500⑧	.50–.60	--	---	------	-----	--
1740G	7	12.5	950	1.70–1.80	12	700	1.6–1.7	Hot	⑦
1740G	15	13	1800	1.20–1.30	--	---	------	-----	
1740G	11	13	3500⑧	.60–.70	--	---	------	-----	--
1750G	10	12	800	1.80–1.90	12	650	1.9–2.0	Hot	④
1750G	20	12	1000	1.80–1.90	12	600	2.1–2.2	Cold	④
1750G	20	14	3500⑧	.50–.60					
1888G	30	12	400	3.45–3.55	12	320	3.5–3.6	Hot	④
1888G	70	12	900	2.8–2.9	12	310	3.6–3.7	Cold	④
1888G	70	12	3500⑧	1.3–1.5	--	---	------	-----	--
1953G	5	12	1000	2.5–2.6	12	950	2.6–2.7	Hot	⑦
1953G	24	12	1500	1.8–1.7	--	---	------	-- --	--
1953G	17	13.6	3000⑧	.30–.40	--	---	------	-----	--
1962G	10	12	1070	1.70–1.80	12	925	1.90–2.00	Hot	⑦
1962G	25	12	1750	1.30–1.40	12	900	2.00–2.10	Cold	⑦
1962G	23	12	3500	.70–.75	--	---	------	-----	--
1962G	21	12	4000⑧	.65–.70	--	---	------	-----	--

① See the "Generator Index" table on page 697 for setting key type number desired.

② Third brush type for 15 cells of battery.

③ Third brush type for 16 cells of battery.

④ Current and voltage regulator—3-element type.

⑤ Current and voltage regulator for 15 cells of battery—3-element type.

⑥ Current and voltage regulator for 16 cells of battery—3-element type.

⑦ Third brush type—2-element regulator.

⑧ Maximum.

⑨ Hot.

LEECE–NEVILLE THIRD BRUSH TYPE

Setting Key Type①	Battery Gravity	Temperature Setting	Maximum Amperes	Volts	R. P. M.	Field Amperes	Remarks
397G	Below 1.180	Hot	9–10	14.0	1000	2.95	None
397G	Above 1.250	Hot	10–11	14.7	1000	2.70	None
528G	Above 1.250	Hot	10–11	12.6–12.8	1500	.80–.90	②
997G	Above 1.225	Hot	10	25	1500	.4–.5	③
1010G	Above 1.225	Hot	18	13.5	1800	1.2–1.3	②
1042G	Above 1.225	Hot	11	31	1500	.6–.7	③
1042G	Above 1.225	Hot	11	34	1500	.45–.55	④
1079G	Above 1.225	Hot	27	13.5	2000	0.9	None
1238G	Above 1.250	Hot	11.5	7.5	1000	1.25	②
1238G	Above 1.250	Cold	10.5	7.5	1000	1.15	③
1246G	Above 1.250	Hot	20	13	2000	1.4	③
1250G	Above 1.225	Hot	27	14.6	2000	1.5	②
1250G	Above 1.225	Cold	35	14.6	2000	1.7	②
1262G	Above 1.225	Hot	16	24.5	2000	.30–.35	②
1273G	Above 1.225	Hot	27	36	1500	1.1–1.2	③

Continued on next page

GENERATORS

Continued from previous page

LEECE–NEVILLE THIRD BRUSH TYPE

Setting Key Type①	Battery Gravity	Temperature Setting	Maximum Amperes	Volts	R. P. M.	Field Amperes	Remarks
1273G	Above 1.225	Hot	27	38.5	1500	1.1–1.2	④
1315G	Above 1.225	Hot	55	12	2000	1.5–1.6	②
1315G	Above 1.225	Cold	60	12	2000	1.6–1.7	②
1320G	Below 1.180	Hot	10.5	36	1500	.48–.50	③
1320G	Above 1.250	Hot	12	36	1500	.65–.68	②
1412G	Above 1.225	Hot	11	26	2000	.40–.45	③
1424G	Above 1.250	Hot	30	7	2000	2–2.1	②
1740G	Above 1.250	Hot	16	13	1800	1.2–1.3	②
1953G	Above 1.250	Hot	26	14	1500	2.4–2.5	②
1962G	Above 1.225	Hot	25	13	2000	1.4–1.5	②

① See "Generator Index" on page 697 for setting key type desired.

② Regulator contact points held closed.

③ Set for 15 cells of battery. Regulator contact points held closed.

④ Set for 16 cells of battery. Regulator contact points held closed.

LEECE–NEVILLE CUTOUT RELAY GENERATOR

Setting Key Type ①	Battery Gravity	Balance①		Generator Output at R. P. M.								
		R. P. M.	Volts	R. P. M.	Amperes	Volts	R. P. M.	Amperes	Volts	R. P. M.	Amperes	Volts
397G	1.150③	600	13.2	750	5	13.7	1000	9.2	14.2	3500	5	14.0
397G	1.250④	600	14.2	700	5	14.4	1000	11.0	14.8	3500	5	14.3
1089G	1.150③	250	6	400	5	6	800	8–9	6	2500	4½–5	6
1089G	1.250④	275	6	450	5	6	800	10–11	6	2500	6–7	6
1275G	1.150③	925	24	1100	5	24	1700	9	24	3500	5.5	24
1275G	1.250④	975	28	1175	5	28	1700	11	28	3500	7.5	28
1342G	1.150③	220	12	240	5	12	600	14–15	12	3000	4	12
1342G	1.250④	250	13	300	5	13	600	15–16	13	3000	5	13
1406G	1.150③	1300	25.2	1300	2	25.2	2000	4	25.5	3000	4.5	25.8
1406G	1.250④	1300	26.5	1300	2	26.5	2000	4.5	28.6	3000	5	29
1439G	1.150③	600	21	700	2	21	1500	4	21	3000	3	21
1439G	1.250④	650	27	725	2	27	1500	5.5	27	3000	4	27
1479G	1.250④	575②	24	700	5	24	1500	11–12	24	3000	6	24
1479G	1.250④	600	24	750	5	24	1500	10–11	24	3000	5.5	24
1732G	1.150③	670	28.5	800	2	29.2	1500	4	30.4	3000	3	30.5
1732G	1.250④	670	34.8	840	2	35	1500	5	36.2	3000	3.75	35.8

① Set hot unless otherwise noted.

② Cold.

③ Below specific gravity shown.

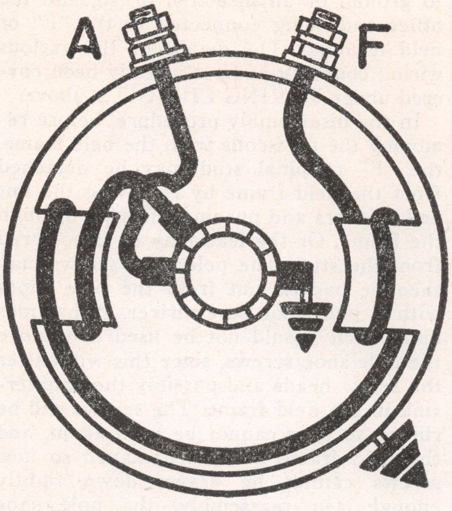
④ Above specific gravity shown.

GENERATORS

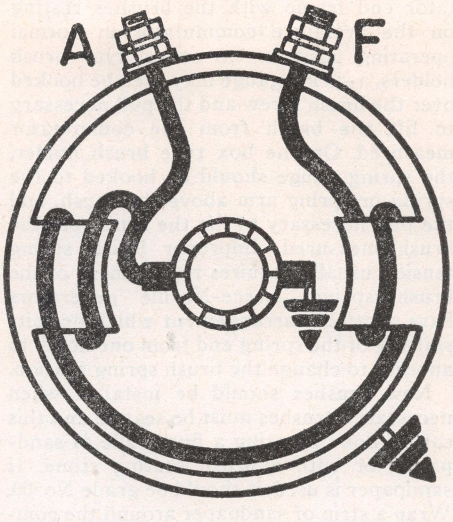
Generators are much alike in general construction, regardless of make and, broadly speaking, are serviced, disassembled, repaired, and reassembled in a similar manner. There are certain variations in detail however, between the different models and makes of generators, and special attention should be paid to these variations, since they make some difference in the servicing procedures. These, as well as the important features of disassembly, repair, and assembly, will be discussed in the following paragraphs.

WIRING CIRCUITS

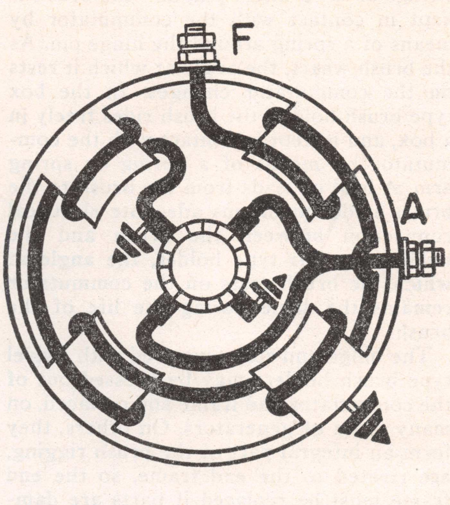
Two, three, or four brushes may be used in automotive type generators, with either two or four field coils. Normally, one main brush (two in four brush units) is grounded, while the other is connected to an insulated terminal in the field frame or commutator



Wiring circuit of third brush generator.



Wiring circuit of two-brush shunt generator.



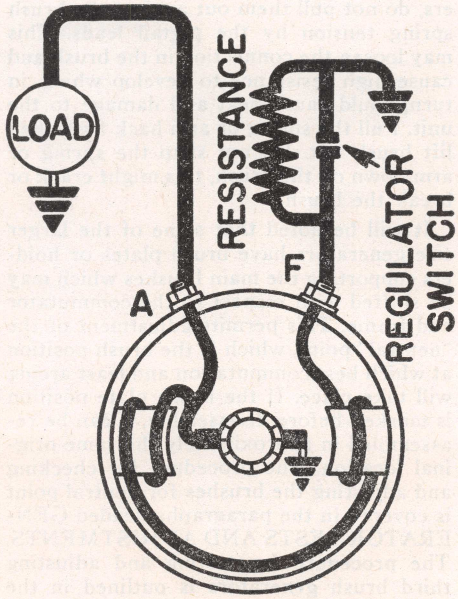
Wiring circuit of four-brush, four-pole, shunt generator.

end frame. Generators are usually classified into two groups, **third brush, and shunt.** In third brush generators, the field circuit is connected from the third brush to the opposing main brush (usually grounded). In shunt generators, the field circuit is brought out from the generator through a field or "F" terminal, and is completed through the regulating device.

Third brush generators may or may not be used with some external type of generator output control such as light switch controlled field resistance, step-voltage or two-step control, or vibrating voltage regulator. The third brush characteristic limits the maximum output which the generator can produce for any particular voltage. By shifting the third brush, generator output may be changed to permit greater or lesser output. Many third brush generators, particularly the later models used with vibrating voltage regulators, have a fixed third brush which is fastened in place so it cannot be adjusted, and all regulation in this type application is provided by operation of the voltage regulator.

Shunt generators must be used with a current and voltage regulator if full control of the generator output under all conditions of operation is to be realized. The shunt generator, whether of the two-brush, two-pole or four-brush, four-pole design, will increase in output as speed and voltage increase until the generator destroys itself from overload, provided that its output is not controlled. The voltage regulator prevents excessive voltage in the generator and electrical circuit, and tapers the generator output down when electrical load requirements are reduced. The current regulator acts as a current limiting device and prevents the generator output from exceeding a pre-determined safe maximum output when electrical load requirements are high.

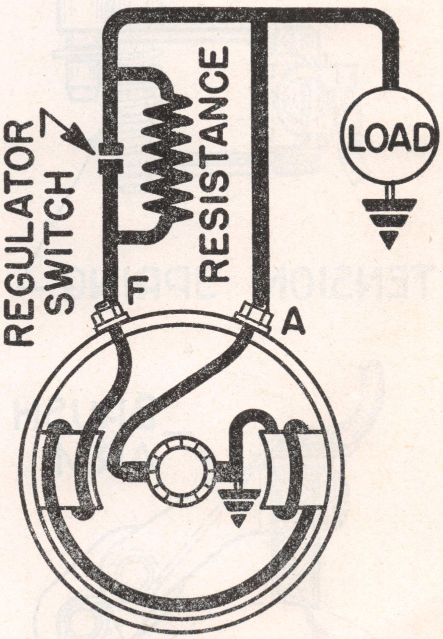
Another system of classification may be applied to generators which is based on whether the generator field circuit is internally or externally grounded. Standard duty Auto-Lite, standard duty Delco-Remy, and Leece-Neville generators have the field circuit connected to the insulated main brush (or third brush) **inside** the generator, with the opposite end of the field circuit connected to ground (or the return circuit) **outside** the generator. Heavy-duty Auto-Lite, heavy-duty Delco-Remy, and Ford generators have the field circuit connected to ground **inside** the generator, with the opposite end of the field circuit connected to the insulated side of the circuit **outside** the generator. It is necessary to keep these differences of connections in mind when checking and repairing generators, since the methods of checking and adjustment will differ somewhat for the two systems of connecting the fields. The two terms, **standard-duty**, and **heavy-duty**, must not be necessarily construed as referring to size of unit, sturdiness of construction, amount of output, or type of vehicle on which the unit is used. They are merely two names which have been applied to the two systems of connecting the field circuits, as a convenient means of differentiating between them. So-called **standard-duty units** may be used on large, heavy-duty vehicles, while so-called **heavy-duty** units may be found on small, light vehicles.



Simplified circuit of generator with field circuit grounded outside generator. The field circuit is connected to ground either through the regulator contacts, or through the regulator resistance to permit high or low generator output.

COMMUTATOR END FRAMES

There are two general types of brush holders in use in generators, the swivel type, and the box type. The swivel type brush holder has the brush rigidly fastened to the brush arm by means of a screw or screws. The brush arm is assembled to and



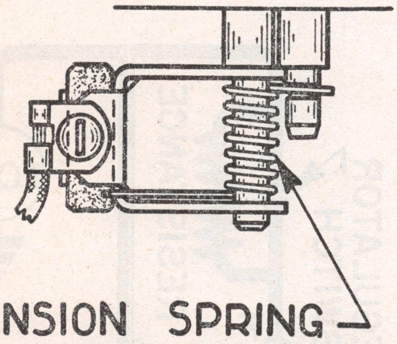
Simplified circuit of generator with field circuit grounded inside generator. The field circuit is connected to the insulated side of the circuit either through the regulator contacts or through the regulator resistance.

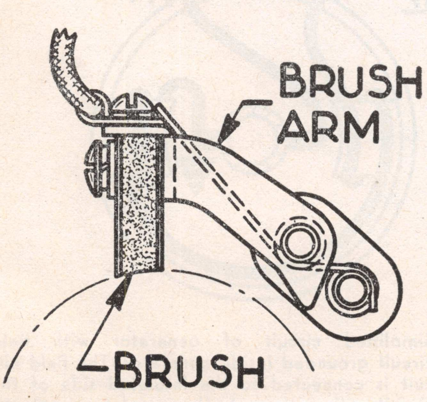
swings about a hinge pin, and the brush is kept in contact with the commutator by means of a spring around the hinge pin. As the brush wears, the angle at which it rests on the commutator changes. In the box type brush holder, the brush rides freely in a box, and is kept in contact with the commutator by means of a spring or spring arm. A lead or leads from the brush to the brush holder maintains adequate electrical connection between the brush and the holder. On this type holder, the angle at which the brush rests on the commutator remains the same during the life of the brush.

The hinge and stop pins used with swivel type brush holders may be pressed out of the commutator end frame and replaced, on many types of generators. On others, they form an integral part of the brush rigging, are riveted to the end frame, so the end frame must be replaced if parts are damaged.

Many box type brush holders are riveted to the commutator end frame so that the frame, with the brush holders, must be serviced as a unit. Other generators use box type brush holders which are mounted on a brush plate, and the brush plate is in turn mounted to the commutator end frame. On such generators, the brush plate may be detached from the commutator end frame. On some units, the brush plate is subject to further disassembly, since the brush holders are fastened to the plate by means of screws, nuts, and lockwashers. On others, the brush holders are riveted to the ring and cannot be detached.

The brush spring tension of both types of brush holders may be measured by placing the armature in position in the commutator end frame with the brushes resting on the armature commutator in normal operating position. On swivel type brush holders, a spring gauge may then be hooked over the brush screw and the pull necessary to lift the brush from the commutator measured. On the box type brush holder, the spring gauge should be hooked to the spring or spring arm above the brush, and the pull necessary to lift the arm from the brush measured. Improper brush spring tension usually requires replacement of the brush spring. Leece-Neville generators have a ratchet arrangement which permits shifting of the spring end from one notch to another to change the brush spring tension.





Swivel type brush holder.

New brushes should be installed when necessary. Brushes must be seated, and this can be done by using a fine grade of sandpaper, or with a brush seating stone. If sandpaper is used, it should be grade No. 00. Wrap a strip of sandpaper around the commutator with the sanded side out, drop the brushes down on the sandpaper and pull the sandpaper under the brushes in the direction of normal armature rotation. Repeat until a good brush seat is established. The brush seating stone is an abrasive material which, held against the revolving commutator, disintegrates, is carried under the brushes and seats them in a few seconds. The generator may be driven on the test stand during the brush seating operation with the brush seating stone, or it may be connected to a battery and motored. Do not use the brush seating stone more than a few seconds, since this unnecessarily wears brushes and commutator. Blow out dust after seating brushes. NEVER USE EMERY CLOTH TO SEAT BRUSHES. Emery may embed in the commutator and brushes and cause rapid brush or commutator wear.

When taking brushes out of brush holders, do not pull them out against the brush spring tension by the pigtail leads. This may loosen the connection in the brush and cause high resistance to develop which, in turn, could cause heat and damage to the unit. Pull the spring or arm back first, then lift brush out. Do not snap the spring or arm down on the brush, this might crack or break the brush.

It will be noted that some of the larger size generators have brush plates or holders supporting the main brushes which may be shifted with respect to the commutator end frame. This permits adjustment of the "neutral" point, which is the brush position at which best commutation and least arcing will take place. If the brush plate position is marked before disassembly, it can be reassembled in approximately the same original location. The procedure for checking and adjusting the brushes for neutral point is covered in the paragraphs headed GENERATOR TESTS AND ADJUSTMENTS. The procedure for testing and adjusting third brush generators is outlined in the same paragraphs.

FIELD FRAMES

Generators may have two or four field coils. The coils are connected in series, with one end of the assembly being connected to ground or an insulated brush, and the other end being connected to the "F" or field terminal. The details of the various wiring connections have already been covered under WIRING CIRCUITS, above.

In the disassembly procedure, before removing the field coils from the field frame, the "F" terminal stud may be detached from the field frame by removing the nut and washers and pushing the stud through the frame. Or the lead may be unsoldered from the stud. The pole shoe screws may then be backed out from the pole shoes with a pole shoe screwdriver. A hammer and punch should not be used to remove the pole shoe screws, since this will batter the screw heads and possibly the countersink in the field frame. The screws will be ruined so they cannot be used again, and the field frame may be damaged so new screws cannot be drawn down tightly enough. On reassembly, the pole shoe spreader should be inserted between the poles to prevent distortion of the field frame and to insure that the pole shoes are brought up tightly against the frame as the screws are tightened. If the field frame is struck a few sharp blows with a rawhide hammer as the screws are being tightened, it will assure proper alignment and tightness of the pole shoes against the field frame.

All soldered connections should be made with rosin flux. Never use acid flux on electrical connections.

FIELD COILS

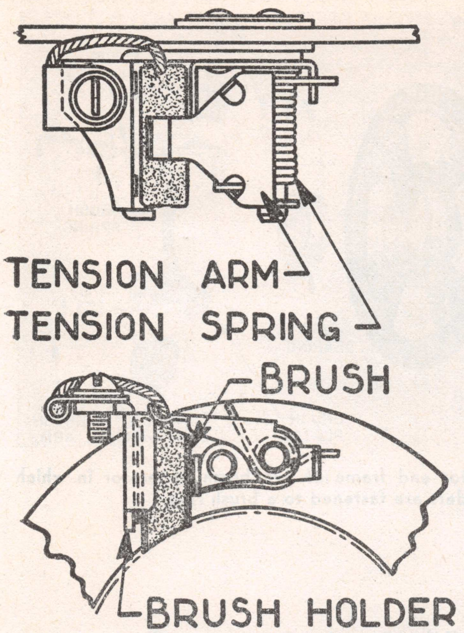
Field coils should not be cleaned in any degreasing tank or by any degreasing method, since this might damage the insulation and cause a ground or short to develop when the field coils are reassembled into the field frame.

If the insulation has become chafed, worn, burned, or otherwise defective, it is sometimes possible to rewrap the field coils with insulating tape and repaint them with shellac or insulating compound. This job must be neatly done, so the rewrapped coils will fit properly under the pole shoes on reassembly. Make soldered connections with rosin flux.

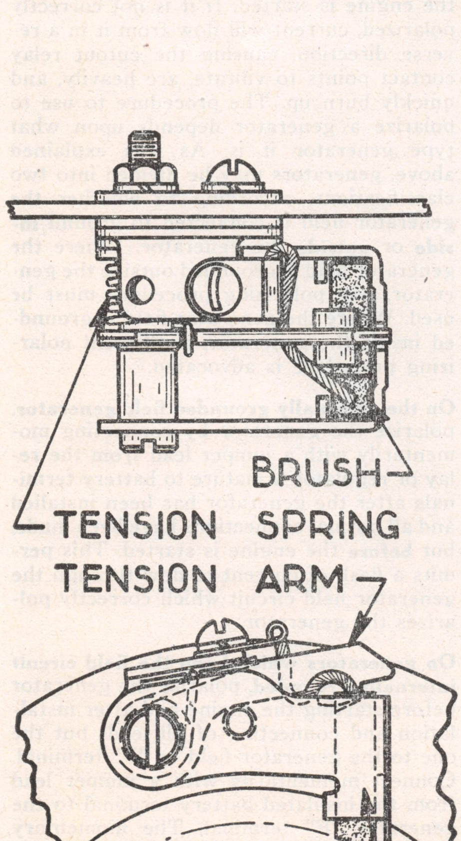
BUSHINGS AND BEARINGS

Ball and roller bearings should be checked and serviced in the manner prescribed by the bearing manufacturer. This includes washing the bearing in clean gasoline, kerosene, or carbon tetrachloride. Swish the bearings in the cleaner and revolve them while submerged until all grease and dirt is washed out. After cleaning, the bearing should immediately be spun in clean, light oil until all solvent is removed, and then repacked with ball bearing grease. When removing and replacing bearings, care must be used to avoid damaging the bearings or bearing races. Pressure must not be exerted through the ball bearings Pressure should be exerted on the bearing race which is being pressed on or off the shaft, or in or out of the frame.

Worn bushings may be pressed out in an arbor press and new bushings pressed in Some bushings are designed to be pressed



Box type brush holder. The brush pressure against the commutator may be provided by a spring arm, a coil spring, or a spiral spring.



Box type brush holder used on heavy-duty generators. On any of this type, complete disassembly of the brush holder is possible, so that insulators, washers, arms, springs, etc., may be replaced.

into the frame with special arbors which correctly size them. Others must be reamed or burnished to size. Where there is an oil wick placed in a hole on the side of the bushing so the wick is in contact with and lubricates the armature shaft, the bushing must be drilled after installation to accommodate the oil wick. This drilling operation may throw up a burr in the bushing which must be removed by burnishing. Bushings should be reamed concentric with the machined registers on the frames so the armature will be centered with the generator frames on reassembly. Where there is an oil wick which extends down through a hole bored along a side of the bushing, the wick should either be removed, or special care should be used when placing the armature shaft into the bushing, to avoid damaging the wick, or jamming it between the shaft and bushing.

ARMATURE

The armature should not be cleaned in any solvent or degreasing compound, since this might damage the insulation so that a short or ground would subsequently occur. If the commutator is worn, rough, out-of-round, dirty, gummed, or if it has high mica, it should be turned down in a lathe and the mica undercut. Any slight burrs which might be left after the undercutting operation may be removed with a strip of No. 00 sandpaper. Emery cloth must not be used on commutators, since particles of emery may become embedded and cause rapid brush wear.

If the armature shaft is worn at the bearing surfaces, it may be possible to save the armature by grinding the shaft down and installing undersized bushings in the end frames. This does not apply to applications using ball bearings.

During the disassembly of the generator, the coverband should be checked to see if there is any thrown solder present; this would show up as small specks of solder on the coverband in line with the commutator riser bar connections. Thrown solder is an indication that the generator has overheated due to overload which causes the solder in the commutator riser bars to melt and be thrown out. Where thrown solder is found, the applications should be checked so the cause of trouble may be found and corrected. Conditions which might cause thrown solder are high regulator setting (or third brush setting on third brush units), loose connections or defective wires in the charging circuit, or loose regulator or generator mounting which prevents a good ground circuit. Any of these latter produces excessive resistance in the circuit which tends to increase the voltage in the generator excessively so that the generator becomes overloaded. This excessive resistance must be eliminated. In addition, the armature must be repaired, since thrown solder indicates that poor connections are developing between the commutator bars and the armature winding leads. Every time the commutator bars which are poorly connected pass under the generator brushes, arcing occurs, and if operation long continues, the bars will become burned. It may be possible to save an armature which has undergone this sort of abuse by resoldering the leads to the commutator bars with rosin flux, and then turning the commutator down and undercutting the mica. If the bars have been badly burned, the armature cannot be saved.

The armature may be checked for grounds with a test lamp and test points. Check with test points from the commutator to the core or shaft. If the lamp lights, the armature is grounded. Grounds which are apparent may often be repaired.

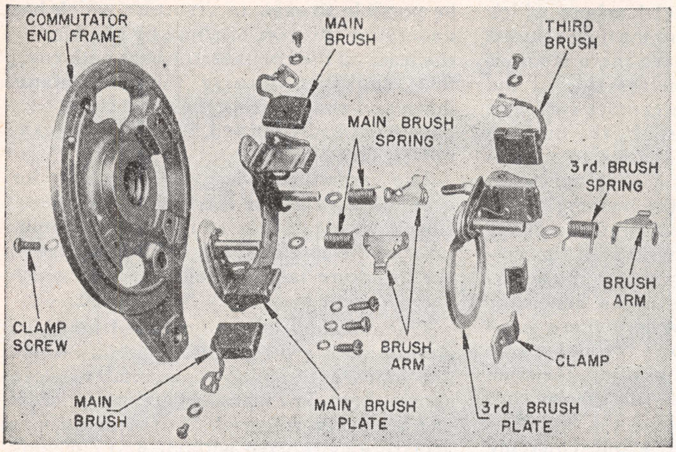
The armature may be checked for short circuits on a growler. Short circuits which are apparent (filled commutator slots, shorts between leads where they cross over) may be repaired. Do not discard an armature as shorted without first checking to see whether the commutator slots are clean. Slots filled with copper or brush dust may cause shorts between adjacent commutator bars. These shorts can be eliminated by cleaning out the slots. There are a few armatures, such as the ones used in Auto-Lite GDJ-4800 series generators which, because of the internal connections and low resistance, cannot be checked on the growler, since the growler will indicate these armatures are shorted. Such armatures may be checked by using an alternating current milliammeter and making a test between bars.

GENERATOR TESTS AND ADJUSTMENTS

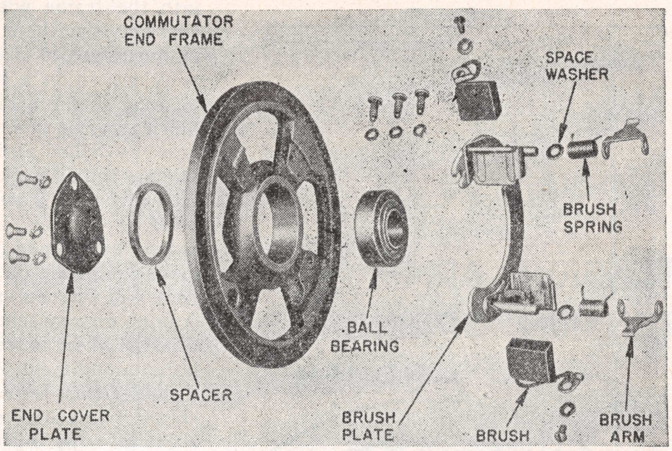
After a generator has been disassembled and reassembled, or after any repair, it may be tested to see if it will perform according to specifications. In addition, on third brush units with an adjustable third brush, the third brush position may be changed as required to secure the specified output. Some heavy-duty generators have adjustable main brushes, and on these units, the main brush position should be checked and adjusted as necessary to set them on neutral.

Third Brush Generator Output Adjustment: In order to check the output of a third brush generator, connect a test ammeter into the generator charging circuit and connect a test voltmeter across the generator. Generator output must be checked at the specified voltage since third brush generator output changes with voltage. Normally, with a fully charged battery in the circuit, the proper voltage will be developed. If the proper voltage cannot be attained, a ¼ ohm variable resistance must be connected into the circuit, and resistance cut in until the proper voltage is obtained. On generators with adjustable third brushes, the output may be adjusted by loosening the third brush clamping screw or nut, and moving the third brush in the direction of armature rotation to increase the generator output, or in the opposite direction to reduce the generator output. After each change of output, the variable resistance should be readjusted in order to maintain the proper voltage reading. Generator should be checked and adjusted after it has reached operating temperature. **Never set the generator output above the specified**

GENERATORS



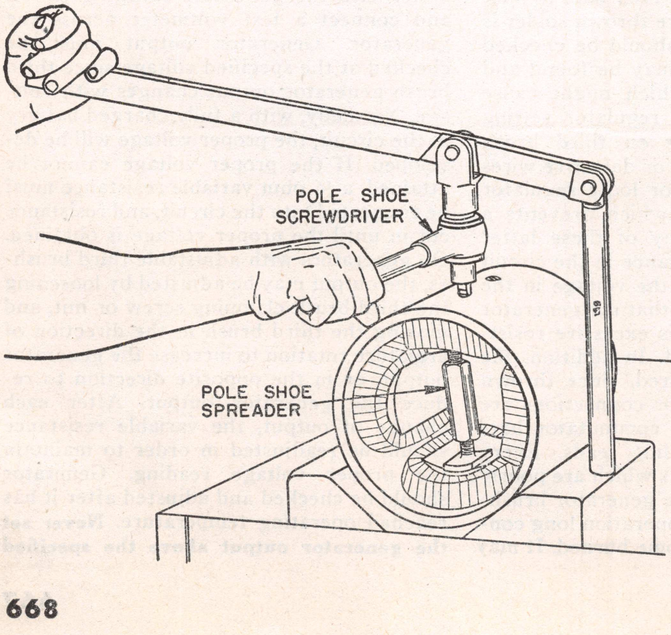
Disassembly of commutator end of third brush generator. The third brush is mounted on a separate ring which is held in place by a clamp. The clamp may be loosened to permit adjustment of the third brush position. Many late type generators have the third brush holder riveted in a fixed position to the commutator end frame.



Disassembly of commutator end frame of two brush generator in which brush holders are fastened to a brush ring.

maximum, since this would cause damage to the generator due to overload.

Neutral Point: On heavy-duty generators with adjustable main brushes, the neutral point of the brushes should be checked for, and proper brush adjustment made. If, before disassembly, the relationship between the brushes or brush ring and the commutator end frame is marked by a punch prick or some similar means, reassembly can be made so the parts will be in their proper relative positions. The neutral point of the brushes is the point at which the minimum amount of arcing will be obtained in normal generator operation. To check for neutral position, connect a battery of the proper voltage from the generator armature terminal (usually marked "A") to the generator field frame. Leave the generator field or "F" terminal disconnected. Note the tendency of the generator armature to rotate. To avoid applying excessive voltages across the generator armature, it is well to start with only one or two battery cells (2 or 4 volts) and increase the voltage cell by cell until the armature begins to rotate, or until a fairly high voltage is being used. It would be inadvisable to go beyond the normal voltage of the generator, or to leave the battery connected for more than a few seconds if the armature does not begin to rotate. If the brushes are set on neutral point, the armature will not rotate. The brushes should be set slightly ahead of neutral for best all around performance. In this position, the armature will rotate slowly in its normal direction of rotation with the battery connected as above. To make a brush adjustment, the brush ring or holder clamping screws should be loosened slightly, and the brushes shifted until the position is found at which the armature tends to rotate slowly in the direction of normal rotation. Usually, only a slight adjustment will be found necessary.



Using a pole shoe screwdriver to remove or tighten pole shoe screws. The pole shoe spreader should be used on reassembly.

Polarizing the Generator: The generator must be correctly polarized with respect to the battery it is to charge after the generator is installed in the vehicle and before the engine is started. If it is not correctly polarized, current will flow from it in a reverse direction, causing the cutout relay contact points to vibrate, arc heavily, and quickly burn up. The procedure to use to polarize a generator depends upon what type generator it is. As was explained above, generators may be divided into two classifications, according to whether the generator field is connected to ground **inside** or **outside** the generator. Where the generator field is grounded outside the generator, one polarizing procedure must be used. Where the generator field is grounded inside the generator, a different polarizing procedure is advocated.

On the externally grounded field generator, polarize the generator by connecting momentarily with a jumper lead from the relay or regulator armature to battery terminals after the generator has been installed and all normal connections have been made, but **before** the engine is started. This permits a flash of current to flow through the generator field circuit which correctly polarizes the generator.

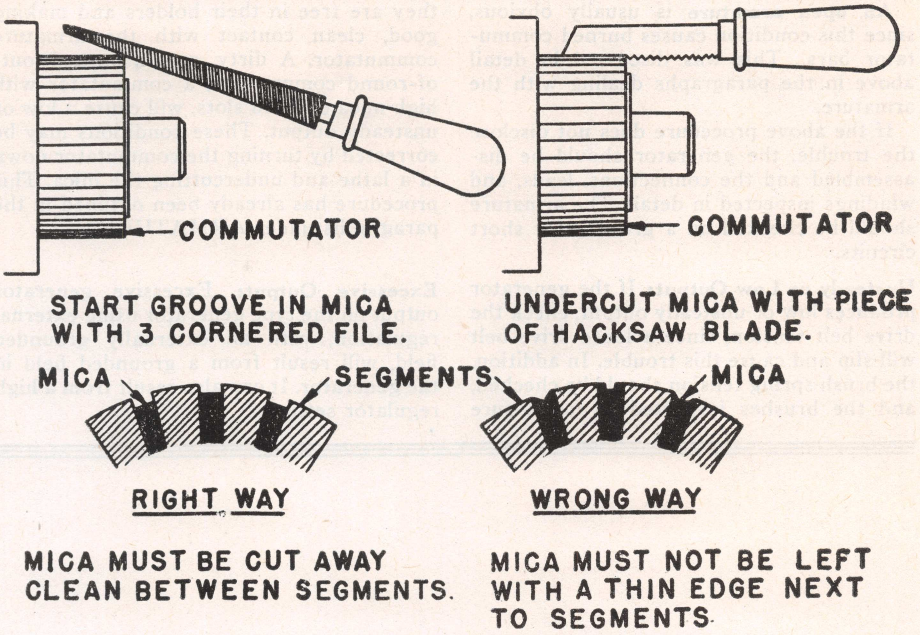
On generators which have the field circuit internally grounded, polarize the generator before starting the engine and after installation and connecting of all leads but the one to the generator field or "F" terminal. Connect momentarily with a jumper lead from the insulated battery terminal to the generator "F" terminal. The momentary flash of current through the generator field circuit will correctly polarize the generator. The "F" terminal lead may then be connected in the normal manner. On many generators of this type, it is also possible to polarize by the other method, that is, by connecting around the relay with a jumper lead after all normal connections have been made. On other generators, however, particularly 12- and 24-volt units, damage may occur if this method is used, since higher voltage, higher output generators have low resistance armatures. The low resistance will permit a high current to flow through the armature if the relay is by-passed with a jumper lead, so that the commutator may become burned in spots. Therefore, on this type generator, particularly the 12- and 24-volt units, connecting from the battery to the "F" terminal is advocated, since this permits current to flow through the generator field circuit only.

Open Circuit Operation: The generator should not be allowed to operate for any length of time with the generator armature terminal disconnected and the field terminal connected. This is open circuit operation which would permit a high voltage to develop in the generator fields and armature which might damage them severely.

CHECKING AN INOPERATIVE GENERATOR

It is often desirable to check an improperly operating generator with a test light to gain an idea of the source of trouble before disassembling the generator. This is a help in the repair procedure, and insures that conditions in the generator which contributed to the improper operation will be eliminated. Listed below are the various common generator troubles, with a detailed analysis of the checking procedures to follow for each.

No Output: When no output can be obtained from the generator, remove the coverband and check for sticking brushes, burned or gummed commutator, weak brush spring tension, or other causes of poor contact between the brushes and the commutator. Check for loose or broken leads, terminals, or screws. Opens or grounds in the generator may be located with a test light, as follows.

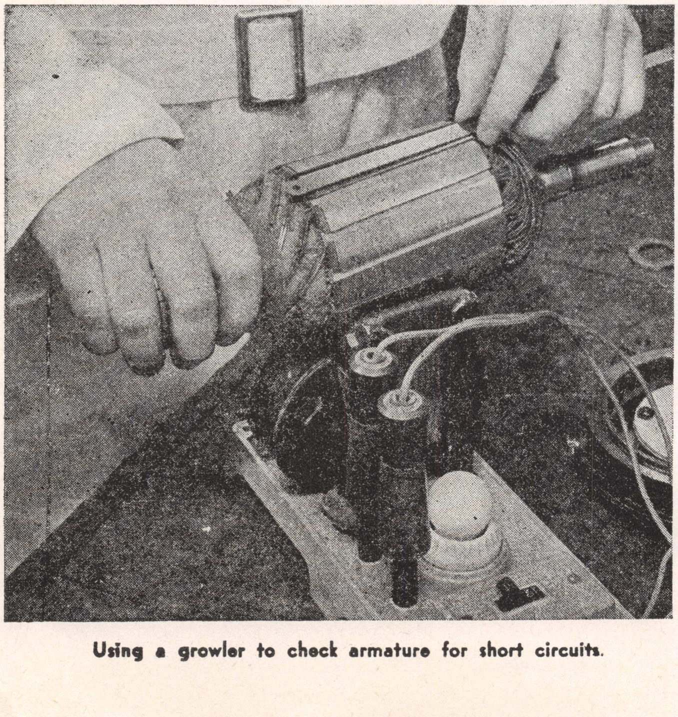

COMMUTATOR
START GROOVE IN MICA WITH 3 CORNERED FILE.
MICA
SEGMENTS
RIGHT WAY
MICA MUST BE CUT AWAY CLEAN BETWEEN SEGMENTS.
COMMUTATOR
UNDERCUT MICA WITH PIECE OF HACKSAW BLADE.
MICA
WRONG WAY
MICA MUST NOT BE LEFT WITH A THIN EDGE NEXT TO SEGMENTS.

UNDERCUTTING MICA

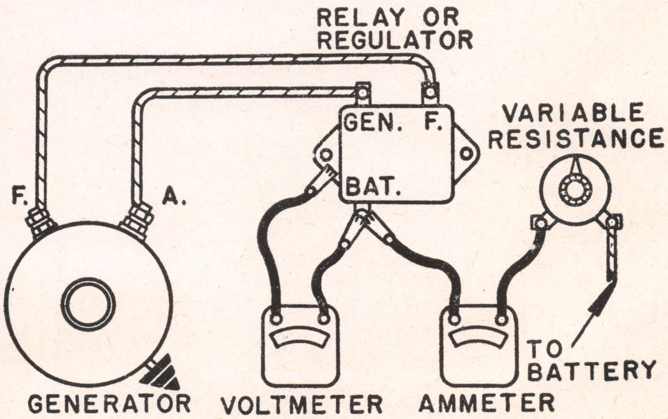
Using a file and hacksaw blade to undercut mica. The hacksaw blade should be ground to the proper width. There are numerous makes of undercutting tools which will satisfactorily perform this operation.

Check for ground by raising the grounded brush or brushes from the commutator and insulating them with cardboard. Check from the generator main brush lead or the armature terminal to the generator frame with the test points. If the generator is of the type having the field internally grounded, disconnect the field ground lead before making this check and test the field circuit for ground separately. If the test lamp lights, a ground exists. Raise and insulate other brushes, and check in turn the brush holders, armature commutator, and fields, to locate the ground. If a grounded field is found, the regulator used on the application should be inspected, since a grounded field will permit a high field current which may burn the regulator contact points.

Check for an open field circuit, if the generator does not test grounded, by placing test points from one field lead to the other. Test for a shorted field by connecting a battery of the proper voltage and an ammeter in series with the field circuit and noting the current draw. Proceed with care in this check since a shorted field will draw a high current and cause damage to the ammeter. If a shorted field is found, check the regulator contact points, since the high field current will probably have caused the points to burn or oxidize, and they will require cleaning or replacement.



Using a growler to check armature for short circuits.



Voltmeter and ammeter connections to check third brush generator output. If specified voltage cannot be attained, use variable resistance.

GENERATORS

An open armature is usually obvious, since this condition causes burned commutator bars. This was discussed in detail above in the paragraphs dealing with the armature.

If the above procedure does not disclose the trouble, the generator should be disassembled and the connections, leads, and windings inspected in detail. The armature should be checked on a growler for short circuits.

Unsteady or Low Output: If the generator produces low or unsteady output, check the drive belt tension, since a loose drive belt will slip and cause this trouble. In addition, the brush spring tension should be checked, and the brushes inspected to make sure they are free in their holders and making good, clean contact with the armature commutator. A dirty, rough, burned, out-of-round commutator, a commutator with high mica or filled slots, will cause a low or unsteady output. These conditions may be corrected by turning the commutator down in a lathe and undercutting the mica. This procedure has already been outlined in the paragraphs under ARMATURE.

Excessive Output: Excessive generator output on the type generator using external regulation, with an externally grounded field, will result from a grounded field in the generator. It can also result from a high regulator setting.

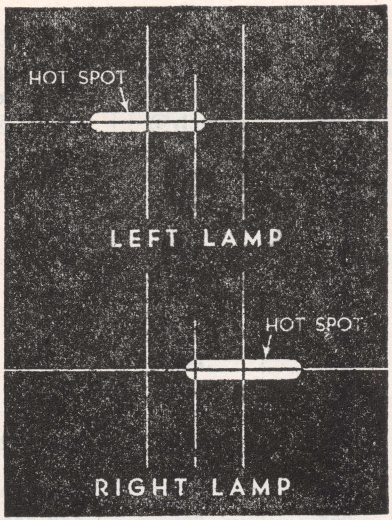
Excessive output on the type generator using external regulation with an internally grounded field can result, as a rule, only from an excessively high regulator setting.

Excessive output from a third brush generator which does not have external regulator is likely due to an incorrect third brush setting.

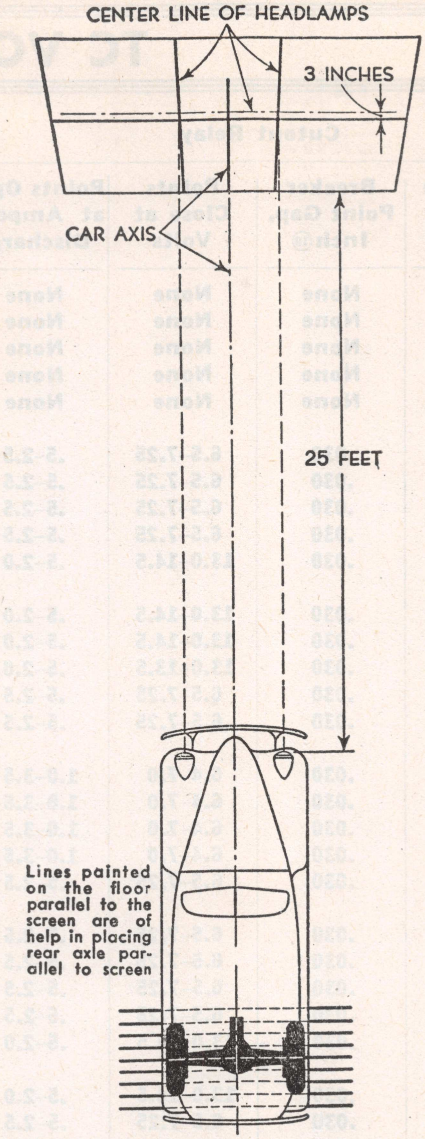
Noisy Generator: A noisy generator can result from loose mounting or drive pulley, from worn or dirty bearings, improperly seated brushes, or a bent brush holder. The procedure for seating brushes is detailed in the paragraphs under COMMUTATOR END FRAMES.

HEADLAMPS

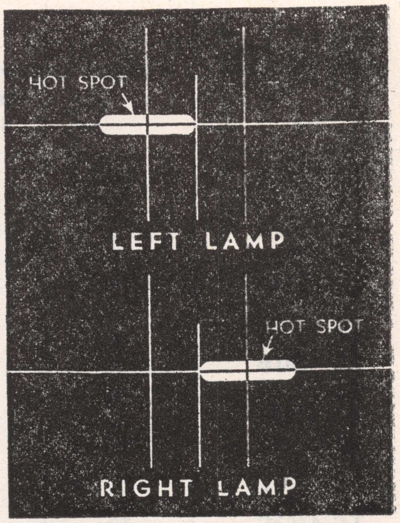
BEAM PATTERNS


HOT SPOT
LEFT LAMP
HOT SPOT
RIGHT LAMP

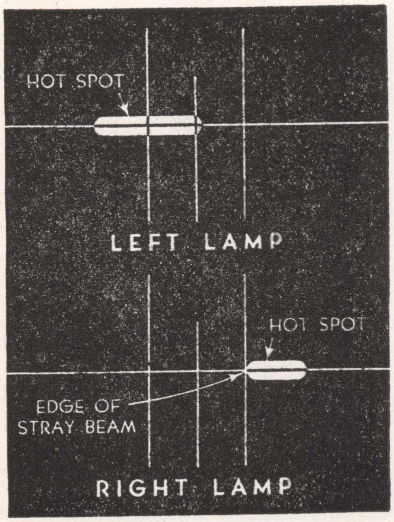
SEALED BEAM


CENTER LINE OF HEADLAMPS
3 INCHES
CAR AXIS
25 FEET

Lines painted on the floor parallel to the screen are of help in placing rear axle parallel to screen

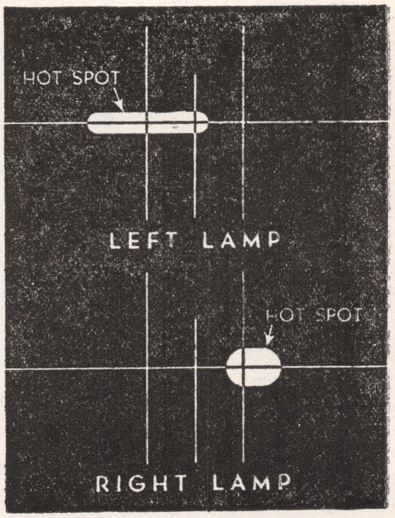

HOT SPOT
LEFT LAMP
HOT SPOT
RIGHT LAMP

DEPRESS BEAM

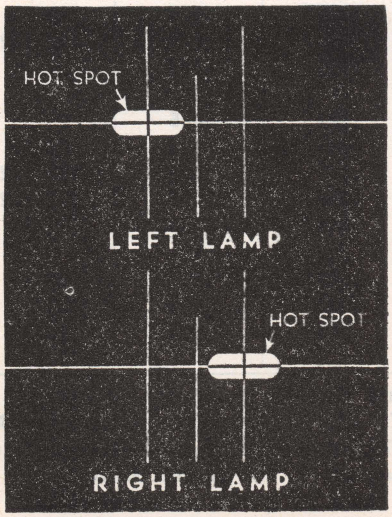

HOT SPOT
LEFT LAMP
HOT SPOT
EDGE OF STRAY BEAM
RIGHT LAMP

FLEXBEAM

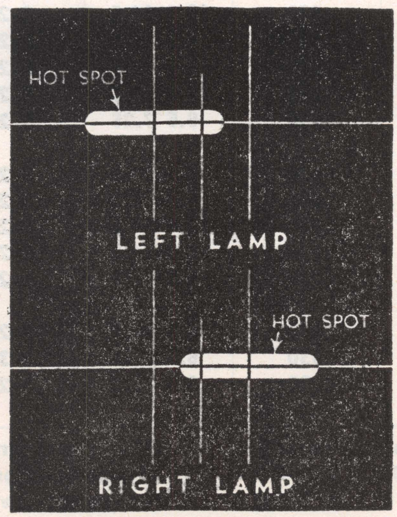
Diagrams on this page show how hot spot of upper beam should be aimed with lens in place.


HOT SPOT
LEFT LAMP
HOT SPOT
RIGHT LAMP

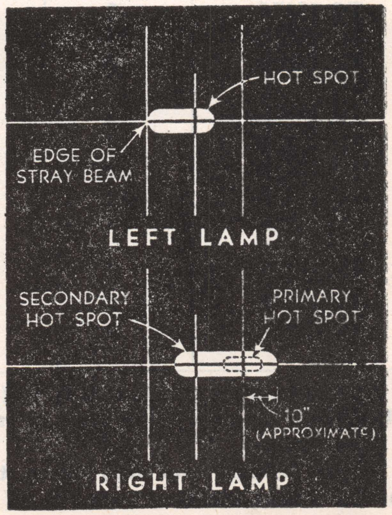
SOLAR


HOT SPOT
LEFT LAMP
HOT SPOT
RIGHT LAMP

BI-RAY
RITE WAY


HOT SPOT
LEFT LAMP
HOT SPOT
RIGHT LAMP

CONTROL BEAM
GLOLITE
PARABEAM
STABILITE
TILTRAY
TWILITE
TWOLITE


HOT SPOT
EDGE OF STRAY BEAM
LEFT LAMP
SECONDARY HOT SPOT
PRIMARY HOT SPOT
10" (APPROXIMATE)
RIGHT LAMP

MULTIBEAM
TRIBEAM

GENERATOR REGULATORS

TC VOLTAGE REGULATOR

Unit Number	Volts	Cutout Relay				Voltage Regulator		
		Armature Air Gap, Inch⑨	Breaker Point Gap, Inch⑩	Points Close at Volts	Points Open at Amperes Discharge	Armature Air Gap, Inch①	Regulator Point Gap, Inch②	Winding Resistance, Ohms③
TC-4101A	6	None	None	None	None	.030	.005	43–48
TC-4102A	6	None	None	None	None	.030	.005	43–48
TC-4103A	6	None	None	None	None	.030	.005	43–48
TC-4201A	6	None	None	None	None	.030	.005	43–48
TC-4202A	6	None	None	None	None	.030	.005	43–48
TC-4301A	6	.020	.030	6.5–7.25	.5–2.5	.045	.005	29–33
TC-4301B	6	.020	.030	6.5–7.25	.5–2.5	.045	.005	29–33
TC-4302A	6	.020	.030	6.5–7.25	.5–2.5	.045	.005	29–33
TC-4302B	6	.020	.030	6.5–7.25	.5–2.5	.045	.005	29–33
TC-4303A	12	.020	.030	13.0–14.5	.5–2.0	.045	.005	102–112
TC-4303B	12	.020	.030	13.0–14.5	.5–2.0	.045	.005	102–112
TC-4303C	12	.020	.030	13.0–14.5	.5–2.0	.045	.005	102–112
TC-4303D	12	.020	.030	13.0–13.5	.5–2.0	.045	.005	102–112
TC-4304A	6	.020	.030	6.5–7.25	.5–2.5	.045	.005	29–33
TC-4305A	6	.020	.030	6.5–7.25	.5–2.5	.045	.005	29–33
TC-4305B	6	.020	.030	6.4–7.0	1.0–3.5	.036⑧	.005	29–33
TC-4305C	6	.020	.030	6.4–7.0	1.0–3.5	.045	.005	29–33
TC-4305D	6	.020	.030	6.4–7.0	1.0–3.5	.045	.005	29–33
TC-4305E	6	.020	.030	6.4–7.0	1.0–3.5	.045	.005	29–33
TC-4305F	6	.020	.030	6.5–7.25	.5–2.5	.045	.005	29–33
TC-4306A	6	.020	.030	6.5–7.25	.5–2.5	.045	.005	29–33
TC-4307A	6	.020	.030	6.5–7.25	.5–2.5	.045	.005	29–33
TC-4308A	6	.020	.030	6.5–7.25	.5–2.5	.045	.005	29–33
TC-4309A	6	.020	.030	6.5–7.25	.5–2.5	.045	.005	29–33
TC-4310A	12	.020	.030	13.0–14.5	.5–2.0	.045	.005	102–112
TC-4310B	12	.020	.030	13.0–14.5	.5–2.0	.045	.005	102–112
TC-4311A	6	.020	.030	6.5–7.25	.5–2.5	.045	.005	29–33
TC-4312A	6	.020	.030	6.5–7.25	.5–2.5	.045	.005	29–33
TC-4313A	6	.020	.030	6.5–7.25	.5–2.5	.045	.005	29–33
TC-4314A	6	.020	.030	6.5–7.25	.5–2.5	.045	.005	29–33
TC-4315A	12	.020	.030	13.0–14.5	.5–2.0	.045	.005	102–112
TC-4316A	6	.020	.030	6.5–7.25	.5–2.5	.045	.005	29–33
TC-4317A	6	.020	.030	6.5–7.25	.5–2.5	.045	.005	29–33
TC-4318A	12	.020	.030	13.0–14.5	.5–2.0	.045	.005	102–112
TC-4319A	6	.020	.030	6.5–7.25	.5–2.5	.045	.005	29–33
TC-4320A	6	.020	.030	6.5–7.25	.5–2.5	.045	.005	29–33
TC-4320B	6	.020	.030	6.5–7.25	.5–2.5	.045	.005	29–33
TC-4321A	12	.020	.030	13.0–14.5	.5–2.0	.045	.005	102–112
TC-4322A	12	.020	.030	13.0–14.5	.5–2.0	.045	.005	102–112
TC-4323A	6	.020	.030	6.5–7.25	.5–2.5	.048	.005	29–33
TC-4323B	6	.020	.030	6.5–7.25	.5–2.5	.048	.005	29–33
TC-4324A	6	.020	.030	6.4–7.0	1.0–3.5	.045	.005	29–33
TC-4325A	6	.020	.030	6.5–7.25	.5–2.5	.048	.005	29–33

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① With points closed and spring tension on armature. Dimension given can be plus or minus .001″.

② Minimum.

③ For TC-4100 and 4200 series, the resistance given is for the shunt winding taken at 75 degrees F. The anti-flutter winding should show a resistance of from 36 to 44 ohms. For the TC-4300 series, test should show the resistance given at 77 degrees F. for 6-volt regulators and from 70 to 80 degrees F. for 12-volt units.

④ Closing voltage must be below opening voltage by from 1.2 to 1.4 volts.

GENERATOR REGULATORS

SPECIFICATIONS

Voltage Regulator								
Points to Open at Voltage and Temperature				Points to Close at Voltage and Temperature				Unit Number
50°	70°	90°	110°	50°	70°	90°	110°	
8.38–8.82	8.26–8.67	8.13–8.54	8.02–8.44	6.58–6.98	6.46–6.86	6.34–6.76	6.24–6.67	TC-4101A
7.98–8.42	7.86–8.27	7.73–8.15	7.61–8.05	6.58–6.98	6.46–6.86	6.34–6.76	6.24–6.67	TC-4102A
8.38–8.82	8.26–8.67	8.13–8.54	8.02–8.44	6.58–6.98	6.46–6.86	6.34–6.76	6.24–6.67	TC-4103A
8.38–8.82	8.26–8.67	8.13–8.54	8.02–8.44	6.58–6.98	6.46–6.86	6.34–6.76	6.24–6.67	TC-4201A
8.38–8.82	8.26–8.67	8.13–8.54	8.02–8.44	6.58–6.98	6.46–6.86	6.34–6.76	6.24–6.67	TC-4202A
8.4–8.9	8.25–8.75	8.1–8.6	7.96–8.46	④	④	④	④	TC-4301A
8.4–8.9	8.25–8.75	8.1–8.6	7.96–8.46	④	④	④	④	TC-4301B
8.4–8.9	8.25–8.75	8.1–8.6	7.96–8.46	④	④	④	④	TC-4302A
8.4–8.9	8.25–8.75	8.1–8.6	7.96–8.46	④	④	④	④	TC-4302B
16.9–17.7	16.6–17.4	16.3–17.1	16.02–16.82	⑤	⑤	⑤	⑤	TC-4303A
16.9–17.7	16.6–17.4	16.3–17.1	16.02–16.82	⑤	⑤	⑤	⑤	TC-4303B
16.9–17.7	16.6–17.4	16.3–17.1	16.02–16.82	⑤	⑤	⑤	⑤	TC-4303C
15.75–16.15	15.45–15.85	15.15–15.55	14.85–15.25	⑥	⑥	⑥	⑥	TC-4303D
8.14–8.64	8.00–8.50	7.86–8.36	7.72–8.22	④	④	④	④	TC-4304A
8.4–8.9	8.25–8.75	8.1–8.6	7.96–8.46	④	④	④	④	TC-4305A
7.9–8.4	7.75–8.25	7.6–8.1	7.46–7.96	⑦	⑦	⑦	⑦	TC-4305B
7.9–8.4	7.75–8.25	7.6–8.1	7.46–7.96	⑦	⑦	⑦	⑦	TC-4305C
7.9–8.4	7.75–8.25	7.6–8.1	7.46–7.96	⑦	⑦	⑦	⑦	TC-4305D
7.9–8.4	7.75–8.25	7.6–8.1	7.46–7.96	⑦	⑦	⑦	⑦	TC-4305E
8.4–8.9	8.25–8.75	8.1–8.6	7.96–8.46	④	④	④	④	TC-4305F
8.4–8.9	8.25–8.75	8.1–8.6	7.96–8.46	④	④	④	④	TC-4306A
8.14–8.64	8.00–8.50	7.86–8.36	7.72–8.22	④	④	④	④	TC-4307A
8.4–8.9	8.25–8.75	8.1–8.6	7.96–8.46	④	④	④	④	TC-4308A
8.4–8.9	8.25–8.75	8.1–8.6	7.96–8.46	④	④	④	④	TC-4309A
16.9–17.7	16.6–17.4	16.3–17.1	16.02–16.82	⑤	⑤	⑤	⑤	TC-4310A
16.9–17.7	16.6–17.4	16.3–17.1	16.02–16.82	⑤	⑤	⑤	⑤	TC-4310B
8.4–8.9	8.25–8.75	8.1–8.6	7.96–8.46	④	④	④	④	TC-4311A
8.4–8.9	8.25–8.75	8.1–8.6	7.96–8.46	④	④	④	④	TC-4312A
8.4–8.9	8.25–8.75	8.1–8.6	7.96–8.46	④	④	④	④	TC-4313A
8.4–8.9	8.25–8.75	8.1–8.6	7.96–8.46	④	④	④	④	TC-4314A
16.9–17.7	16.6–17.4	16.3–17.1	16.02–16.82	⑤	⑤	⑤	⑤	TC-4315A
8.4–8.9	8.25–8.75	8.1–8.6	7.96–8.46	④	④	④	④	TC-4316A
8.4–8.9	8.25–8.75	8.1–8.6	7.96–8.46	④	④	④	④	TC-4317A
16.9–17.7	16.6–17.4	16.3–17.1	16.02–16.82	⑤	⑤	⑤	⑤	TC-4318A
8.4–8.9	8.25–8.75	8.1–8.6	7.96–8.46	④	④	④	④	TC-4319A
8.4–8.9	8.25–8.75	8.1–8.6	7.96–8.46	④	④	④	④	TC-4320A
8.4–8.97	8.25–8.75	8.1–8.6	7.96–8.46	④	④	④	④	TC-4320B
16.9–17.	16.6–17.4	16.3–17.1	16.02–16.82	⑤	⑤	⑤	⑤	TC-4321A
16.9–17.7	16.6–17.4	16.3–17.1	16.02–16.82	⑤	⑤	⑤	⑤	TC-4322A
7.19–7.49	7.1–7.4	7.01–7.31	6.93–7.23	6.09–6.39	6.0–6.3	5.91–6.21	5.83–6.13	TC-4323A
7.19–7.49	7.1–7.4	7.01–7.31	6.93–7.23	6.09–6.39	6.0–6.3	5.91–6.21	5.83–6.13	TC-4323B
7.9–8.4	7.75–8.25	7.6–8.1	7.46–7.96	⑦	⑦	⑦	⑦	TC-4324A
7.19–7.49	7.1–7.4	7.01–7.31	6.93–7.23	6.09–6.39	6.0–6.3	5.91–6.21	5.83–6.13	TC-4325A

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⑤ Closing voltage must be below opening voltage by from 2.4 to 2.8 volts.

⑥ Closing voltage must be below opening voltage by from 2.0 to 2.4 volts.

⑦ Closing voltage must be below opening voltage by from 1.8 to 2.0 volts.

⑧ Plus or minus .002″.

⑨ Plus or minus .010″.

⑩ Plus or minus .005″.

VOLTAGE AND CURRENT

Unit Number	Cutout Relay					Voltage Regulator		
	Resistance of Winding, Ohms	Armature Air Gap, Inch	Point Gap, Inch	Points Close, Volts	Points Open, Reverse Current, Amperes	Resistance of Winding, Ohms	Armature Air Gap, Inch	Point Gap, Inch
VRA-4101A	49.7	.0595–.0625	.015⑧	13.0–13.5	.5–6.0	15.68–17.32	.040–.042	.010–.012
VRA-4102A	49.7	.0595–.0625	.015⑧	13.0–13.5	.5–6.0	15.68–17.32	.040–.042	.010–.012
VRA-4103A	49.7	.0595–.0625	.015⑧	13.0–13.5	.5–6.0	15.68–17.32	.040–.042	.010–.012
VRB-4002D	35–39	.034–.038	.015⑧	6.4–7.0	.5–3.0	10.4–11.2	.0595–.0625	.010–.020
VRB-4004B	35–39	.034–.038	.015⑧	6.4–7.0	.5–3.0	10.4–11.2	.0595–.0625	.010–.020
VRB-4004C	35–39	.034–.038	.015⑧	6.4–7.0	.5–3.0	10.4–11.2	.0595–.0625	.010–.020
VRB-4005A	35–39	.034–.038	.015⑧	6.4–7.0	.5–3.0	10.4–11.2	.0595–.0625	.010–.020
VRB-4005B	35–39	.034–.038	.015⑧	6.4–7.0	.5–3.0	10.4–11.2	.0595–.0625	.010–.020
VRB-4006A	35–39	.034–.038	.015⑧	6.4–7.0	.5–3.0	10.4–11.2	.0595–.0625	.010–.020
VRB-4007A	35–39	.034–.038	.015⑧	6.4–7.0	.5–3.0	10.4–11.2	.0595–.0625	.010–.020
VRB-4008A	35–39	.034–.038	.015⑧	6.4–7.0	.5–3.0	10.4–11.2	.0595–.0625	.010–.020
VRB-4008AP	35–39	.034–.038	.015⑧	6.4–7.0	.5–3.0	10.4–11.2	.0595–.0625	.010–.020
VRB-4008B	35–39	.034–.038	.015⑧	6.4–7.0	.5–3.0	10.4–11.2	.0595–.0625	.010–.020
VRB-4008C	35–39	.034–.038	.015⑧	6.4–7.0	.5–3.0	10.4–11.2	.0595–.0625	.010–.020
VRB-4008E	35–39	.034–.038	.015⑧	6.4–7.0	.5–3.0	10.4–11.2	.0595–.0625	.010–.020
VRB-4009A	35–39	.034–.038	.015⑧	6.4–7.0	.5–3.0	10.4–11.2	.0595–.0625	.010–.020
VRB-4010A	35–39	.034–.038	.015⑧	6.4–7.0	.5–3.0	10.4–11.2	.0595–.0625	.010–.020
VRB-4012A	35–39	.034–.038	.015⑧	6.4–7.0	.5–3.0	10.4–11.2	.0595–.0625	.010–.020
VRC-4101A	15.77–17.43	.0595–.0625	.015⑧	6.5–7.0	.5–4.0	4.27–4.72	.040–.042	.010–.020
VRC-4101B	15.77–17.43	.0595–.0625	.015⑧	6.5–7.0	.5–4.0	4.27–4.72	.040–.042	.010–.020
VRC-4102A	15.77–17.43	.0595–.0625	.015⑧	6.5–7.0	.5–4.0	4.27–4.72	.040–.042	.010–.020
VRD-4002A	35–39	.034–.038	.015⑧	6.4–7.0	.5–3.0	10.4–11.2	.0595–.0625	.010–.020
VRD-4002B	35–39	.034–.038	.015⑧	6.4–7.0	.5–3.0	10.4–11.2	.0595–.0625	.010–.020
VRD-4004A	35–39	.034–.038	.015⑧	6.4–7.0	.5–3.0	10.4–11.2	.0595–.0625	.010–.020
VRD-4006A	35–39	.034–.038	.015⑧	6.4–7.0	.5–3.0	10.4–11.2	.0595–.0625	.010–.020
VRD-4006B	35–39	.034–.038	.015⑧	6.4–7.0	.5–3.0	10.4–11.2	.0595–.0625	.010–.020
VRE-4002B	111–123	.034–.038	.015⑧	13.0–13.75	.5–3.0	45.8–49.6	.0595–.0625	.010–.020
VRE-4002C	111–123	.034–.038	.015⑧	13.0–13.75	.5–3.0	45.8–49.6	.0595–.0625	.010–.020
VRH-4101A	43.7–48.3	.0595–.0625	.015⑧	13.0–13.5	0.5–6.0	15.68–17.32	.040–.042	.010⑧
VRH-4104A-1	43.7–48.3	.0595–.0625	.015⑧	13.0–13.5	0.5–6.0	15.68–17.32	.040–.042	.010⑧
VRK-4001A	345	.034–.038	.015⑧	25.0–25.75	½–2.0	....	.0595–.0625	.010–.020
VRP-4001B	29.8–33.0	.031–.034	.015⑧	6.4–6.6	4–6⑦	10.8–12.0	.048–.052	.012⑧
VRP-4001F	29.8–33.0	.031–.034	.015⑧	6.4–6.6	4–6⑦	10.8–12.0	.048–.052	.012⑧
VRP-4002A	29.8–33.0	.031–.034	.015⑧	6.4–6.6	4–6⑦	10.8–12.0	.048–.052	.012⑧
VRP-4002C	29.8–33.0	.031–.034	.015⑧	6.4–6.6	4–6⑦	10.8–12.0	.048–.052	.012⑧
VRP-4003A	29.8–33.0	.031–.034	.015⑧	6.4–6.6	4–6⑦	10.8–12.0	.048–.052	.012⑧
VRP-4004A	29.8–33.0	.031–.034	.015⑧	6.4–6.6	4–6⑦	10.8–12.0	.048–.052	.012⑧
VRP-4004C	29.8–33.0	.031–.034	.015⑧	6.4–6.6	4–6⑦	10.8–12.0	.048–.052	.012⑧
VRP-4004D	29.8–33.0	.031–.034	.015⑧	6.4–6.6	4–6⑦	10.8–12.0	.048–.052	.012⑧
VRP-4004E	29.8–33.0	.031–.034	.015⑧	6.4–6.6	4–6⑦	10.8–12.0	.048–.052	.012⑧
VRP-4004F	29.8–33.0	.031–.034	.015⑧	6.4–6.6	4–6⑦	10.8–12.0	.048–.052	.012⑧
VRP-4004G	29.8–33.0	.031–.034	.015⑧	6.4–6.6	4–6⑦	10.8–12.0	.048–.052	.012⑧
VRP-4006A	29.8–33.0	.031–.034	.015⑧	6.4–6.6	4–6⑦	10.8–12.0	.048–.052	.012⑧
VRP-4006E	29.8–33.0	.031–.034	.015⑧	6.4–6.6	4–6⑦	10.8–12.0	.048–.052	.012⑧
VRP-4006F	29.8–33.0	.031–.034	.015⑧	6.4–6.6	4–6⑦	10.8–12.0	.048–.052	.012⑧

REGULATOR SPECIFICATIONS

Voltage Regulator			Current Regulator						
Operating Voltage at 50° F. ③	Operating Voltage at 70° F. ③	Operating Voltage at 100° F. ③	Armature Air Gap, Inch	Point Gap, Inch	Operating Amperage	Carbon Resistor R1, Ohms	Carbon Resistor R2, Ohms	Ground Polarity	Unit Number
14.51	14.45	14.36	.047-.049	.030-.033	19-21	130-140	②	P	VRA-4101A
14.51	14.45	14.36	.047-.049	.030-.033	39-41	130-140	②	P	VRA-4102A
14.31	14.25	14.16	.047-.049	.030-.033	19-21	130-140	②	P	VRA-4103A
7.51	7.45①	7.36①	.0595-.0625	.010-.020	27-29	57-63	None	P	VRB-4002D
7.51	7.45①	7.36①	.0595-.0625	.010-.020	27-29	28-32	6.5-7.5①	P	VRB-4004B
7.51	7.45①	7.36①	.0595-.0625	.010-.020	24-26	57-63	None	P	VRB-4004C
7.51	7.45①	7.36①	.0595-.0625	.010-.020	21-23	28-32	None	P	VRB-4005A
7.51	7.45①	7.36①	.0595-.0625	.010-.020	27-29	57-63	None	P	VRB-4005B
7.51	7.45①	7.36①	.0595-.0625	.010-.020	11-13	28-32	None	P	VRB-4006A
7.51	7.45①	7.36①	.0595-.0625	.010-.020	29-31	57-63	10-12①	N	VRB-4007A
7.51	7.45①	7.36①	.0595-.0625	.010-.020	29-31	57-63	10-12①	P	VRB-4008A
7.51	7.45①	7.36①	.0595-.0625	.010-.020	29-31	57-63	10-12①	P	VRB-4008AP
7.51	7.45①	7.36①	.0595-.0625	.010-.020	24-26	57-63	10-12①	P	VRB-4008B
7.51	7.45①	7.36①	.0595-.0625	.010-.020	27-29	28-32	6.5-7.5	P	VRB-4008C
7.51	7.45①	7.36①	.0595-.0625	.010-.020	31-33	57-63	10-12	P	VRB-4008E
7.51	7.45①	7.36①	.0595-.0625	.010-.020	24-26	57-63	10-12①	P	VRB-4009A
7.51	7.45①	7.36①	.0595-.0625	.010-.020	27-29	28-32	6.5-7.5	P	VRB-4010A
7.51	7.45①	7.36①	.0595-.0625	.010-.020	27-29	28-32	6.5-7.5	P	VRB-4012A
7.51	7.45	7.36	.047-.049	.030-.033	39-41	76-84	④	P	VRC-4101A
7.51	7.45	7.36	.047-.049	.030-.033	49-51	76-84	④	P	VRC-4101B
7.51	7.45	7.36	.047-.049	.030-.033	39-41	76-84	④	P	VRC-4102A
7.51	7.45	7.36	None	None	None	None	None	P	VRD-4002A
7.51	7.45	7.36	None	None	None	None	None	P	VRD-4002B
7.51	7.45	7.36	None	None	None	None	None	N	VRD-4004A
7.51	7.45	7.36	None	None	None	None	None	P	VRD-4006A
7.51	7.45	7.36	None	None	None	None	None	P	VRD-4006B
14.59	14.50	14.37	.0595-.0625	.010-.020	16-18	57-63	None	P	VRE-4002B
14.59	14.50	14.37	.0595-.0625	.010-.020	19-21	57-63	None	P	VRE-4002C
14.51	14.45	14.36	.047-.049	.010	54-56	76-84	⑤	P	VRH-4101A
14.51	14.45	14.36	.047-.049	.010	54-56	76-84	⑤	N	VRH-4104A-1
27.84⑥	27.50⑥	26.99⑥	.0595-.0625	.010-.020	9.9-10.1	158-162	195-205	P	VRK-4001A
7.41	7.35	7.27	.048-.052⑨	.012⑧	31-33	57-63	13.5-16.5	P	VRP-4001B
7.41	7.35	7.27	.048-.052⑨	.012⑧	39-41	57-63	13.5-16.5	P	VRP-4001F
7.41	7.35	7.27	.048-.052⑨	.012⑧	34-36	36-40	6.5-7.5	P	VRP-4002A
7.41	7.35	7.27	.048-.052⑨	.012⑧	34-36	36-40	6.5-7.5	P	VRP-4002C
7.41	7.35	7.27	.048-.052⑨	.012⑧	34-36	36-40	6.5-7.5	P	VRP-4003A
7.41	7.35	7.27	.048-.052⑨	.012⑧	34-36	36-40	6.5-7.5	P	VRP-4004A
7.41	7.35	7.27	.048-.052⑨	.012⑧	31-33	57-63	13.5-16.5	P	VRP-4004C
7.41	7.35	7.27	.048-.052⑨	.012⑧	27-29	28-32	6.5-7.5	P	VRP-4004D
7.41	7.35	7.27	.048-.052⑨	.012⑧	39-41	57-63	13.5-16.5	P	VRP-4004E
7.41	7.35	7.27	.048-.052⑨	.012⑧	34-36	36-40	6.5-7.5	P	VRP-4004F
7.41	7.35	7.27	.048-.052⑨	.012⑧	24-26	36-40	6.5-7.5	P	VRP-4004
7.41	7.35	7.27	.048-.052⑨	.012⑧	29-31	57-63	10-12	P	VRP-4006A
7.41	7.35	7.27	.048-.052⑨	.012⑧	31-33	57-63	13.5-16.5	P	VRP-4006E
7.41	7.35	7.27	.048-.052⑨	.012⑧	39-41	57-63	13.5-16.5	P	VRP-4006F

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GENERATOR REGULATORS

Continued from previous page

VOLTAGE AND CURRENT

Unit Number	Cutout Relay					Voltage Regulator		
	Resistance of Winding, Ohms	Armature Air Gap, Inch	Point Gap, Inch	Points Close, Volts	Points Open, Reverse Current, Amperes	Resistance of Winding, Ohms	Armature Air Gap, Inch	Point Gap, Inch
VRP-4010A	29.8–33.0	.031–.034	.015⑧	6.4–6.6	4–6⑦	10.8–12.0	.048–.052	.012⑧
VRR-4003A	29.8–33.0	.031–.034	.015⑧	6.4–6.6	4–6⑦	10.8–12.0	.048–.052	.012⑧
VRS-4004B	111–125	.031–.034	.015⑧	13.0–13.75	1.0–5.0⑩	43.7–49.3	.048–.052	.012⑧
VRS-4005A	111–125	.031–.034	.015⑧	13.0–13.75	1.0–5.0⑩	43.7–49.3	.048–.052	.012⑧
VRS-4005C	111–125	.031–.034	.015⑧	13.0–13.75	1.0–5.0⑩	43.7–49.3	.048–.052	.012⑧
VRV-4001A	267–297	.048–.052	.015⑧	26.0–27.0	1.9–3.0	179–201	.048–.052	.012⑧
VRW-4002A	29.8–33.0	.031–.034	.015⑧	6.4–6.6	4–6⑬	10.8–12.0	.048–.052	.012⑧
VRW-4004A	29.8–33.0	.031–.034	.015⑧	6.4–6.6	4–6⑬	10.8–12.0	.048–.052	.012⑧
VRX-4001A	111–125	.034–.038	.015⑧	13.0–13.75	3.5–5.0	43.7–49.3	.048–.052	.012⑧
VRY-4201A	15.8–17.4	.0595–.0625	.015⑧	6.4–6.6	0.5–6.0	4.3–4.7	.040–.042	010–.012
VRY-4202A	15.8–17.4	.0595–.0625	.015⑧	6.4–6.6	0.5–6.0	4.3–4.7	.040.–042	.010–.020

① These specifications are for units after Serial No. 8R-000001 and VR coil replacements. Before Serial No. 8R-000001, the resistance of the VR coil winding is 12.8 to 14.3 ohms. Operating voltage @ 70 deg. is from 7.5 to 7.8. At 100 deg., 7.46 to 7.76.

② For R2 resistor, 13.5 to 16.5 ohms. For R3 resistor, .6 to .7 ohms.

③ Plus or minus .15 volt.

④ For R2 resistor, 5 to 6 ohms. For R3 resistor, .18 to .22 ohms.

⑤ For R2 resistor, 13.5 to 16.5 ohms. For R3 resistor, 28 to 32 ohms. For R4 resistor, .9 to 1.1 ohms.

GENERATOR OUTPUT REGULATORS

Generator output regulators are electromagnetic devices, and certain rules must be observed during adjustment of them.

1. Do not interchange regulator models unless the service manual states that it is possible to do so. Using the wrong polarity regulator on an application will result in quick failure of the equipment.
2. Do not close cut-out relay points by hand with battery connected. To do so will damage the relay points, and may cause the points to weld so that serious damage will result to the generator.
3. Regulator must be in operating position and at operating temperature when electrical checks are made.
4. After any voltage regulator adjustment, cover must be replaced, generator speed reduced until cut-out relay points open, and then generator must be brought back to speed, before voltage setting is checked.
5. Generator must be repolarized by momentarily connecting a jumper lead around regulator to permit a flash of current to flow from the battery to the generator. Reversed generator polarity will cause relay points to arc and burn.
6. Clean regulator points, when necessary, with a flat fine-cut file. Cavities may be cleaned out with a "spoon" file. Points may then be cleaned with carbon tetrachloride, and a clean piece of linen tape drawn between the points to remove any residue.

CUTOUT RELAY SPECIFICATIONS

Unit Number	Armature Air Gap, Inch	Point Gap, Inch	Cut-In Voltage	Points Open, Amperes Discharge
CB-4007	.010–.030	.025–.035	6.5–7.25	.5–2.5
CB-4009	.010–.030	.025–.035	6.5–7.25	.5–2.5
CB-4011	.010–.030	.025–.035	6.5–7.25	.5–2.5
CB-4012	.010–.030	.025–.035	6.5–7.25	.5–2.5
CB-4013	.010–.030	.025–.035	6.5–7.25	.5–2.5
CB-4014	.010–.030	.025–.035	6.5–7.25	.5–2.5
CB-4021	.010–.030	.025–.035	6.5–7.25	.5–2.5
CB-4025	.010–.030	.025–.035	6.5–7.25	.5–2.5
CB-4026	.010–.030	.025–.035	6.5–7.25	.5–2.5

AUTO-LITE

GENERATOR OUTPUT REGULATORS

Auto-Lite has supplied four types of generator output regulators for truck applications since 1936. These are (1) TC (Two-charge) regulators, (2) Voltage regulator, (3) Current and voltage regulator, and (4) heavy-duty current and voltage regulator.

TC (two-charge) REGULATOR

TC-4300 Series: The TC regulator, also known as the two-step regulator, lockout voltage control, and step-voltage control, has been supplied as a combination circuit breaker and regulator and as a regulator only. When the unit is a regulator only, it is used in connection with a separately mounted cutout relay. The operation of the regulator unit is identical in both types.

Such parts as the cutout relay or TC regulator armature and carbon resistor, may be detached by unscrewing the attaching screws. The TC regulator unit and cutout relay are mounted to the base by attaching nuts which may be removed to detach the units after the necessary leads have been unsoldered. Care must be used in

REGULATOR SPECIFICATIONS

Voltage Regulator			Current Regulator						
Operating Voltage at 50° F. ③	Operating Voltage at 70° F. ③	Operating Voltage at 100° F. ③	Armature Air Gap, Inch	Point Gap, Inch	Operating Amperage	Carbon Resistor R1, Ohms	Carbon Resistor R2, Ohms	Ground Polarity	Unit Number
7.41	7.35	7.27	.048–.052⑨	.012⑧	31–33	57–63	13.5–16.5	P	VRP-4010A
7.51	7.45	7.37	None	None	None	None	None	P	VRR-4003A
14.59⑪	14.50⑪	14.37⑪	.048–.052⑨	.012⑧	14–16	57–63	28–32	P	VRS-4004B
14.59⑪	14.50⑪	14.37⑪	.048–.052⑨	.012⑧	16–18	57–63	28–32	P	VRS-4005A
14.59⑪	14.50⑪	14.37⑪	.048–.052⑨	.012⑧	19–21	57–63	28–32	P	VRS-4005C
28.84⑫	28.50⑫	27.98⑫	.048–.052⑨	.012⑧	9.8–10.2	158–162	195–205	P	VRV-4001A
7.51	7.45	7.37	.048–.052	.012⑧	13–15	28–32	None	P	VRW-4002A
7.51	7.45	7.37	.048–.052	.012⑧	15–17	57–63	28–32	P	VRW-4004A
14.59⑪	14.50⑪	14.37⑪	.048–.052	.012⑧	29.0–31.0	76–84	19–21	P	VRX-4001A
7.41	7.35	7.26	.047–.049	.030–.033	25–27	76–84	⑭	P	VRY-4201A
7.41	7.35	7.26	.047–.049	.030–.033	25–27	76–84	⑭	P	VRY-4202A

⑥ Plus or minus .10 volt.

⑦ Points open 4.2 to 4.8 volts from sealed position.

⑧ Minimum.

⑨ Stamped ST-281-7. If stamped ST-281-6, set air gap at .034–.038.

⑩ Points open 8.2 to 9.3 volts from sealed position.

⑪ Plus or minus .30 volt.

⑫ Plus or minus .50 volts.

⑬ Points open 4.2 to 4.8 volts from sealed position.

⑭ For R2 resistor, 6.5 to 7.5 ohms. For R3 resistor, 76 to 84 ohms.

handling the parts, particularly the armatures, since a slight distortion of the armature hinge spring might damage it beyond repair. In reassembly, use rosin, not acid flux for soldering leads.

Cutout Relay Unit Check: With the unit connected to the proper generator and battery in the normal manner, connect a voltmeter from the "A" terminal to the base of the unit as shown in Fig. 1. Or the cutout relay can be tested by connecting it with a potentiometer and two 6-volt batteries as shown in Fig. 2.

By either method, slowly increase the voltage (increasing generator speed or turning potentiometer knob) until the cutout relay contacts close. With the potentiometer method, the light will go on as the contacts close.

Cutout Relay Adjustment: Disconnect the unit and adjust as follows (see Figs. 3 and 4):

Armature air gap is measured with the contacts closed and is adjusted by raising or lowering the stationary contact "A".

Contact gap is adjusted by bending the armature stop "B".

Closing voltage is checked as above, and is adjusted by increasing or decreasing the tension of the armature spring. Armature spring tension is adjusted by bending the lower spring hanger "F". Increasing the tension raises the closing voltage; lowering the tension decreases the closing voltage.

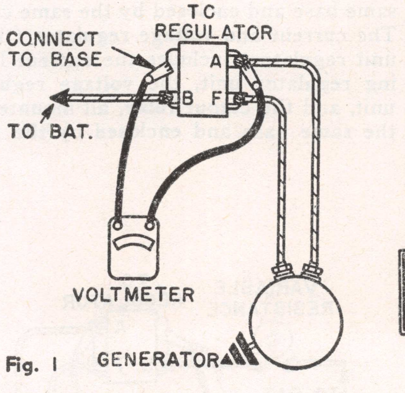
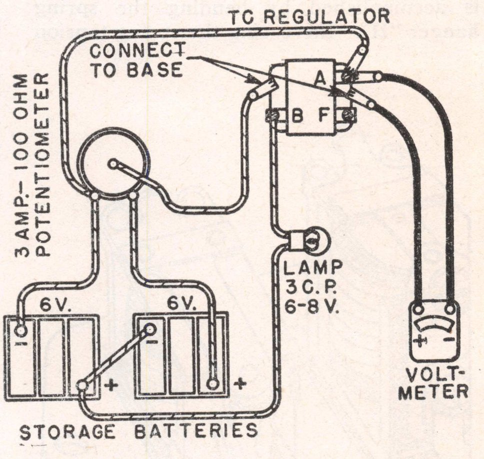


Fig. I

TC REGULATOR. Showing voltmeter connections with unit connected to generator and battery to check circuit breaker closing voltage.



TC REGULATOR. Showing voltmeter and potentiometer connections with two 6-volt batteries to check circuit breaker closing voltage.

TC regulator check: With the TC regulator connected to the proper battery and generator in the normal manner, connect a voltmeter from the "A" terminal to the base of the regulator as shown in Fig. 5. Or the TC regulator may be tested by connecting it with a potentiometer and two 6-volt batteries as shown in Fig. 6

By either method, slowly increase the voltage until the TC regulator contacts open. With the generator-battery method, the variable resistance may have to be operated to cut in resistance and increase the voltage to a value sufficient to operate the TC regulator if the battery is not fully charged. With the potentiometer-battery method, dimming or going out of the light indicates opening of the contacts.

Slowly decrease the voltage and note the voltage at which the contacts close.

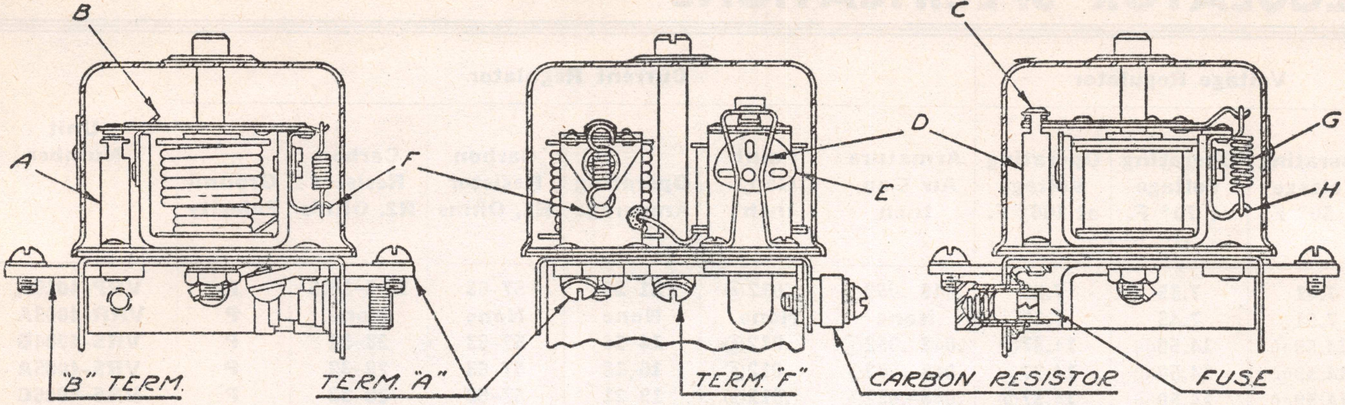


Fig. 3 **TC REGULATOR.** Showing adjustments of circuit breaker and regulator.

TC Regulator Adjustment: Disconnect TC regulator and adjust as follows, referring to Fig. 3:

Armature air gap is measured with the regulator contacts closed. It can be adjusted by raising or lowering the upper contact "C". This contact is mounted on a bridge "D", which can be contracted or expanded as already illustrated to lower or raise the stationary contact.

Contact gap is measured with the armature held down against the brass cam "E". Adjust by turning the cam.

Voltage Settings: The **opening** voltage of the TC regulator contacts is adjusted by varying the tension of spring "G". This is accomplished by bending the spring hanger "H". Increasing the spring tension raises the opening voltage, decreasing the tension lowers it. The **closing** voltage of the contacts is adjusted by turning the brass cam "E". This changes the gap between the armature and winding core when the contacts are open. Decreasing this gap lowers the closing voltage, raising this gap increases the closing voltage. Contact gap must be not less than .005 inch after this adjustment.

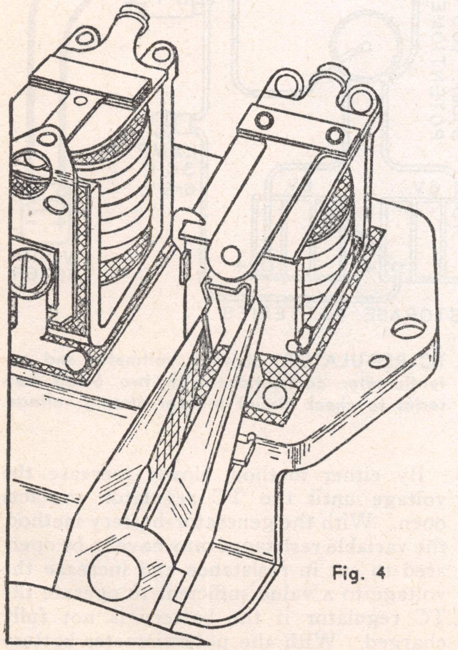


Fig. 4

TC REGULATOR. Showing procedure of expanding or contracting the bridge supporting the stationary contact to raise or lower the contact.

VOLTAGE REGULATOR CURRENT AND VOLTAGE REGULATOR

MODELS VRB, VRD, VRE, VRF, VRJ, VRK, VRP, VRR, VRS, VRT, VRU, VRV, VRW, VRX

The voltage regulator (two-unit regulator) includes the voltage regulator unit and the circuit breaker, mounted on the same base and enclosed by the same cover. The current and voltage regulator (three-unit regulator) includes the current limiting regulator unit, the voltage regulator unit, and the cutout relay, all mounted on the same base and enclosed by the same cover. The cutout relay and the voltage regulator unit are checked and adjusted in a similar manner, regardless of whether they are in the two-unit, or three-unit, regulator.

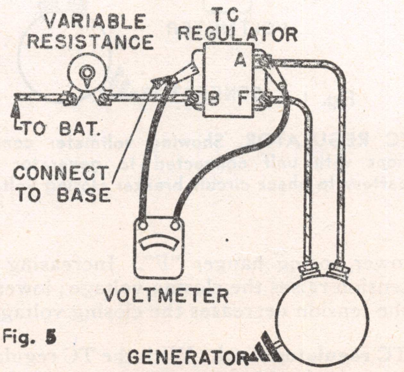


Fig. 5

TC REGULATOR. Showing voltmeter connections with regulator connected to generator and battery to check opening and closing voltages of contacts. Resistance is required when battery is not sufficiently charged to provide enough voltage to operate the regulator.

The armatures on the cutout relay, voltage regulator, and current regulator can all be detached by removing the attaching screws and unsoldering leads. The upper contact brackets on the voltage regulator and current regulator may be detached by removing the attaching screws. The resistors under the base may be removed. Any of the units may be detached from the regulator base by unsoldering leads and unscrewing the attaching nuts under the base. Handle parts with care, particularly the armatures, since any distortion of the armature hinge springs might ruin them.

On reassembly of the upper contact brackets on the current and voltage regulator, note particularly that the connector strap is mounted so as to be directly connected to the voltage regulator upper contact bracket, but that it is insulated from the current regulator upper contact bracket by an insulating washer. Where the regu-

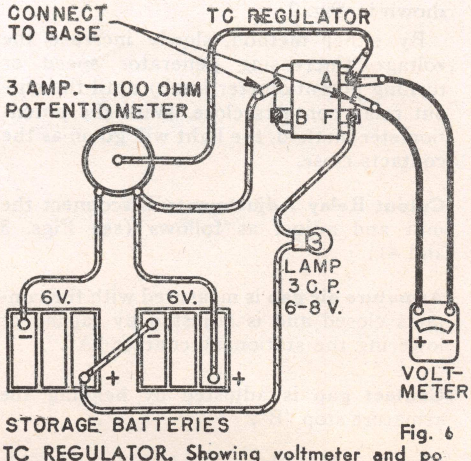


Fig. 6

TC REGULATOR. Showing voltmeter and potentiometer connections with two 6-volt batteries for checking opening and closing voltages of regulator contacts.

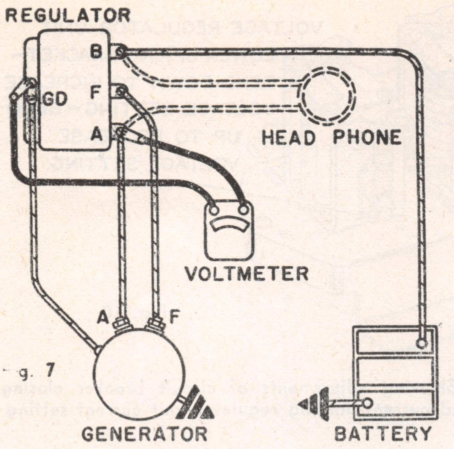


Fig. 7

VR TWO & THREE ELEMENT REGULATORS. Showing voltmeter connections to check closing and opening voltage of circuit breaker for the type on which upper contact is mounted on a spring.

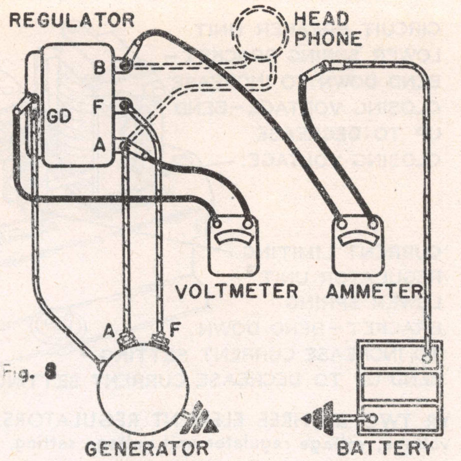


Fig. 8

VR TWO & THREE ELEMENT REGULATORS. Showing voltmeter and ammeter connections to check closing voltage and reverse current to open contacts of circuit breaker for type on which upper contact is mounted directly to the armature.

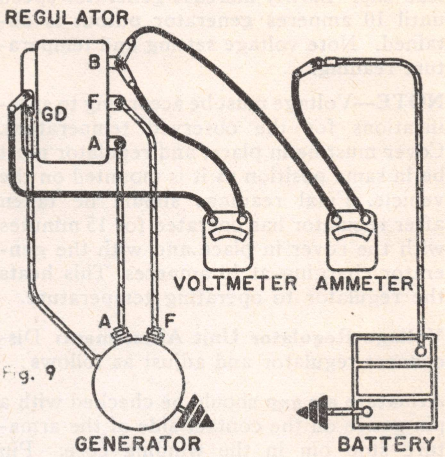


Fig. 9

VR TWO & THREE ELEMENT REGULATORS. Showing voltmeter and ammeter connections to check the voltage regulator unit and current limiting regulator unit electrical settings.

lator has more than one resistor, be sure to replace them in their correct relative positions. On reassembly, use rosin, not acid flux, to resolder leads. After assembly is complete, strike bottom of regulator sharply on bench several times to make sure all parts are settled in place. Recheck all adjustments.

Checking Resistances: In addition to the mechanical and electrical setting checks and adjustments outlined below for these units, the resistance of the windings and resistors may also be checked. Resistors should be removed to check their resistance.

Cutout relay voltage winding resistance is checked with ohmeter connected between the regulator "A" terminal and the regulator base.

Voltage regulator winding resistance is checked by unsoldering the voltage regulator winding lead from the circuit breaker yoke or frame, and measuring between this lead and the regulator base with an ohmeter.

Cutout Relay Check: There are two types of cutout relay in use, requiring somewhat different methods of checking and adjusting. One type has the upper contact mounted on a spring, the second type has the upper contact mounted directly on the armature.

1. Type with upper contact mounted on a spring (see Fig. 7). With the regulator connected to the proper generator and battery in a normal manner, connect a voltmeter from the regulator "A" terminal to the regulator base. Slowly increase the voltage until the contacts close. Do not allow the armature to move on down and seal to the yoke. Take the contact closing voltage reading as the contacts close. Without increasing the voltage beyond that required to close the contacts, decrease the voltage until the contacts open. Note opening voltage.

2. Type with upper contact mounted directly on the armature (see Fig. 8). With the regulator connected to the proper generator and battery in the normal manner, connect a voltmeter from the regulator "A" terminal to the regulator base. Connect an ammeter in series in the charging circuit at the regulator "B" terminal. Connect voltmeter lead clip to regulator "A" terminal, and not to the wiring lead clip. Slowly increase voltage and note the voltage reading at which the contacts close. Increase the charging rate to 15 amperes, then reduce charging rate until the cutout relay points open. Note reverse current at which points open.

NOTE—An accurate way to determine the exact instant at which the points close is to connect a headphone (2,000 ohms or higher) between the "B" terminal and the "A" terminal and to take the voltage reading just as the click caused by the closing of the contacts is heard.

Cutout Relay Adjustment: Disconnect egulator and adjust cutout relay as follows:

Armature air gap should be measured with the contacts open, with a flat gauge between the winding core and the armature, as close to the armature hinge as possible. Adjust by bending the upper armature stop. The upper armature stop may be at the side, at the end, or in the center of the armature. Where the application has a second set of contacts (used in connection with an indicating lamp) the upper contact bracket is bent to adjust the air gap. Be sure the bracket does not rub against the side of the armature or touch the yoke. Contacts must align after adjustment is complete.

Contact gap is measured with the contacts open, and is adjusted by expanding or contracting the bridge supporting the stationary contact to raise or lower the contact. Be sure contacts are aligned when adjustment is complete.

Closing voltage is checked as already detailed, and is adjusted by bending the lower spring bracket of the spiral spring. Bending the spring bracket down increases the closing voltage, bending up lowers the closing voltage. The cutout relay closing voltage must always be 0.5 volts lower than the voltage regulator voltage setting. After each adjustment, replace the cover and retest the cutout relay action.

Opening voltage or amperage is checked as already explained, and is adjusted by raising or lowering the stationary contact. This adjustment is made by expanding or contracting the bridge supporting the stationary contact. Lowering the contact lowers the opening voltage and increases the opening amperage. Raising the stationary contact increases the opening voltage and lowers the opening amperage. After each adjustment replace the cover and retest the cutout relay action.

Voltage Regulator Unit Check: In addition to an ammeter and a voltmeter, Auto-Lite recommends the use of a reliable thermometer in checking the voltage regulator unit voltage setting. The thermometer should be placed so that its bulb is approximately two inches from the side of the regulator, but it must not touch the regulator.

With the regulator connected to the proper generator and a fully charged battery (1.275 or better) of the proper capacity, connect a voltmeter from the regulator "B" terminal to the regulator base, and connect an ammeter in series in the charging circuit at the "B" terminal (see Fig. 9). Connect voltmeter lead clip to the "B" terminal and not to the ammeter lead clip. Slowly increase generator speed until 10 amperes generator output is obtained. Note voltage setting and temperature reading.

NOTE—Voltage must be according to specifications for the observed temperature. Cover must be in place, and regulator must be in same position as it is mounted on the vehicle. Final readings should be taken after regulator has operated for 15 minutes with the cover in place and with the generator charging at 10 amperes. This heats the regulator to operating temperature.

Voltage Regulator Unit Adjustment: Disconnect regulator and adjust as follows:

Armature air gap should be checked with a pin gauge on the contact side of the armature stop pin in the winding core. Pin gauge should be placed as close to the armature stop pins as possible. The points should barely be touching as the air gap is checked. To perform this check accurately, connect a 3 candlepower test light and a 6 volt battery in series with the regulator "F" terminal and the regulator base. With the points open, the light will dim or go out. With the points closed, the light will burn. A low limit, and a high limit pin gauge may be used. With low limit gauge in place, push armature down. (Push against armature and not spring.) Light should dim or go out. With the high limit gauge in place, push armature down. Light should stay lighted. To adjust, loosen the screw holding the upper bracket slightly and raise or lower the contact bracket as required. Tighten screw when adjustment is completed. Be sure points align. Recheck adjustment after screw is tightened.

Voltage setting is checked as above, and is adjusted by bending the lower spring arm to increase or decrease the spiral spring tension (see Fig. 10). Increasing the tension raises the voltage setting, lowering the tension reduces the setting. After each change of adjustment, replace cover, stop generator, and bring it back to speed at which 10 amperes charging rate is produced.

Current Limiting Regulator Unit Check: The current limiting regulator unit current setting is checked with the same meter connections as used for checking the voltage regulator unit voltage setting. In addition, an electrical load must be placed across the battery which will be somewhat above the current setting of the current limiting regulator unit. This load may consist of a bank of light bulbs, or a carbon pile rheostat. Increase generator speed and note current setting. Regulator must be at operating temperature and cover must be in place. Current setting must be within plus or minus 5% of the current setting shown on the regulator nameplate.

Current Limiting Regulator Unit Adjustment: Disconnect the regulator and adjust as follows (see Fig. 10):

Armature air gap is checked and adjusted in the same manner as detailed for the voltage regulator unit.

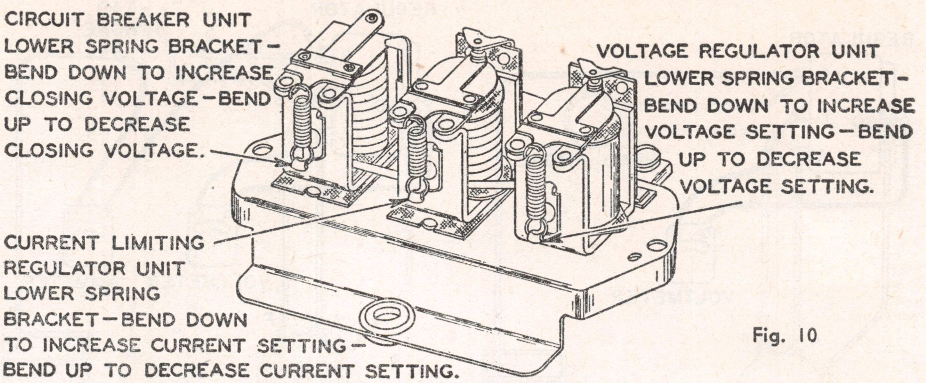

CIRCUIT BREAKER UNIT LOWER SPRING BRACKET—BEND DOWN TO INCREASE CLOSING VOLTAGE—BEND UP TO DECREASE CLOSING VOLTAGE.
VOLTAGE REGULATOR UNIT LOWER SPRING BRACKET—BEND DOWN TO INCREASE VOLTAGE SETTING—BEND UP TO DECREASE VOLTAGE SETTING.
CURRENT LIMITING REGULATOR UNIT LOWER SPRING BRACKET—BEND DOWN TO INCREASE CURRENT SETTING—BEND UP TO DECREASE CURRENT SETTING.

Fig. 10

VR TWO & THREE ELEMENT REGULATORS. Showing adjustments of circuit breaker closing voltage, voltage regulator unit voltage setting, and current limiting regulator unit current setting.

Contact gap is checked with the armature held down against the stop pin in the winding core. Do not touch spring. Too much variation from the specifications indicates wrong length of the armature stop pin and a new unit will be needed.

Current setting is checked as above, and is adjusted by bending the lower spring bracket. Bending the spring bracket down to increase the spiral spring tension increases the current setting, bending up lowers the current setting.

HEAVY-DUTY CURRENT AND VOLTAGE REGULATOR

MODELS VRA, VRC, VRG, VRH, VRY

The heavy duty voltage regulator unit, current limiting regulator unit, and cutout relay unit are all mounted on the same base and are enclosed by the same cover. These units can be disassembled down to their winding assemblies, so that nearly all parts can be removed. Before any disassembly is begun however, all lead and lead connection positions should be carefully noted, so that, upon reassembly, the proper connections can be made.

To disassemble, remove cover and detach the fiber mounting plate with the three units on it by removing attaching screws, lockwashers and washers. The units can be removed from the mounting plate by disconnecting and unsoldering leads, and then unscrewing the attaching nuts on the under side of the mounting plate.

The armatures may be removed from any of the units by first unhooking the spiral spring from the upper spring hanger on the armature (unsoldering it if necessary) and then removing two armature attaching screws. The armature stops (with small fiber bumper) can be removed from the regulator units by unscrewing the attaching screws. The stationary contact support bracket on the cutout relay may be removed by first unsoldering the heavy lead, and then removing the two attaching screws, lock washers, flat washers, large insulating washers and small insulating washers. Insulating strip will also come off. The "U" shaped brackets may be removed from any of the three units by removing

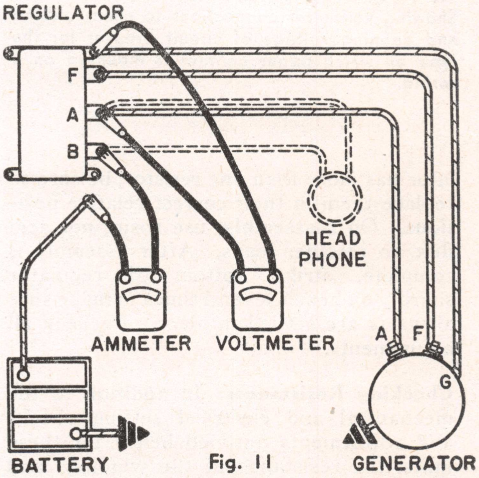


Fig. 11

HEAVY DUTY VR REGULATORS. Showing voltmeter and ammeter connections to check the closing voltage and reverse current to open circuit breaker contacts.

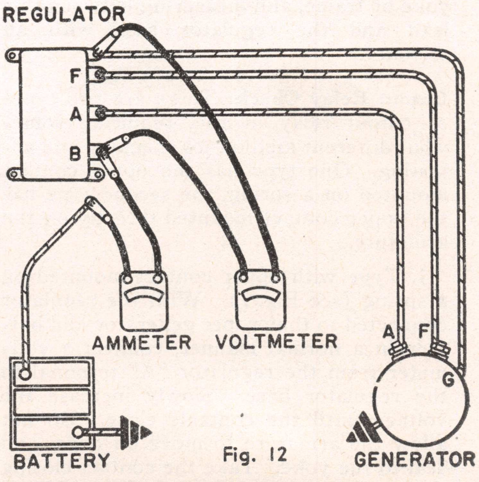


Fig. 12

HEAVY DUTY VR REGULATORS. Showing voltmeter and ammeter connections to check electrical settings of the voltage and current regulator units.

two attaching screws. The winding assemblies may now be removed from the frames by unscrewing the attaching nuts on the bottoms of the frames.

Use care in handling parts, to avoid damaging them. This applies particularly to the armatures, which could be damaged by bending of the armature spring hinges or contact springs. Windings could also be damaged by careless handling, unnecessary bending or flexing of leads, etc.

On reassembly, be sure all connections are made properly, and make sure the resistors (on bottom side of the mounting plate) are returned to their correct positions. All armatures must be pushed down firmly against the frame when the attaching screws are tightened, so that there will not be any air gap between the armatures and frames. Be sure the small and large insulating washers and insulating strip are properly placed when the cutout relay stationary contact support bracket is attached, so that the bracket will be insulated from the frame. Use rosin, not acid flux when making soldered connections. After assembly is complete, strike bottom of regulator sharply on bench several times to make sure all parts are settled in place. Strike squarely on all four mounting lugs. Recheck all adjustments.

Checking Resistances: In addition to the mechanical and electrical setting checks and adjustments outlined below, the resistance of the windings and resistors may also be checked. Resistors should be removed from the mounting plate to check them.

Cutout relay voltage winding resistance check is made by disconnecting the voltage winding grounding lead (clip of lead fastened under mounting plate attaching screw) and checking with an ohmeter from this lead to the stationary contact bracket.

Voltage regulator unit winding resistance is checked by disconnecting the two winding lead clips from the regulator mounting plate and measuring resistance between these clips with an ohmeter.

Current limiting regulator unit frequency (shunt) winding resistance may be checked by disconnecting the lead from the regulator frame or base, and measuring from this lead to the frame with an ohmeter.

Cutout Relay Check: With the regulator connected to the proper generator and battery in the normal manner, connect a voltmeter from the regulator "A" terminal to the regulator ground screw. Be sure the voltmeter lead clip is connected to the regulator "A" terminal and not to the wiring lead clip. Connect an ammeter in series in the charging circuit at the regulator "B" terminal (see Fig. 11).

Slowly increase voltage and note the voltage at which contacts close. Slowly decrease voltage and note reverse current at which cutout relay contacts open. An accurate way to determine the exact instant at which points close is to connect a headphone (2,000 ohms or higher) between the "A" and "B" terminals of the regulator and take the voltage reading just as the click caused by the closing of the contacts is heard.

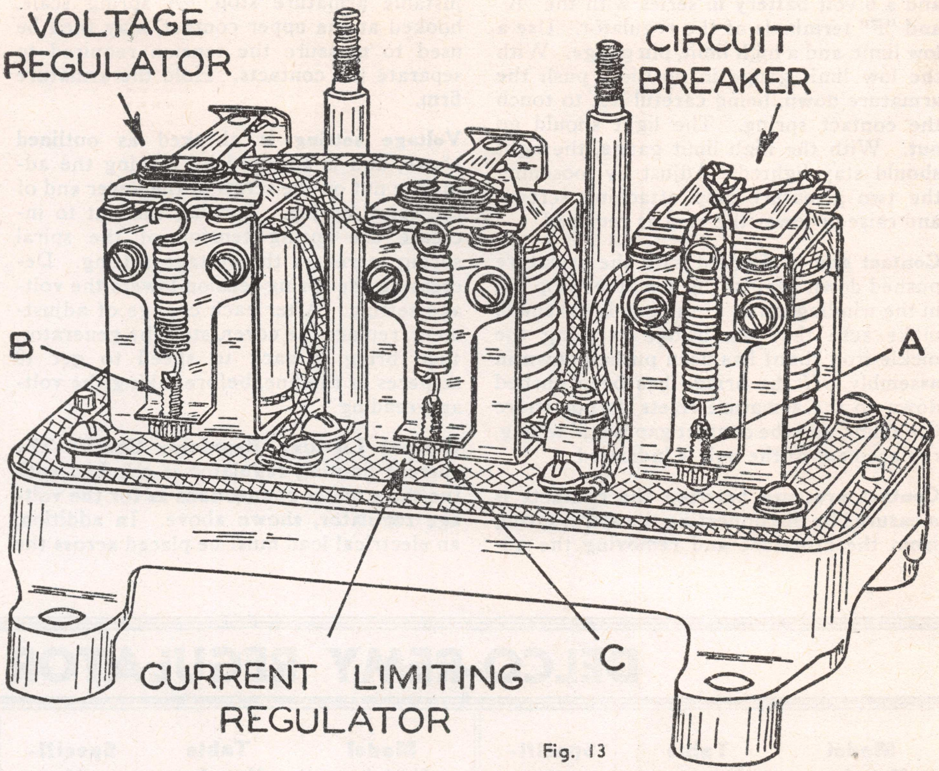


Fig. 13

HEAVY DUTY VR REGULATORS. Showing electrical setting adjustments of the three elements in the regulator.

Cutout Relay Adjustment: Disconnect regulator and adjust cutout relay as follows:

Armature air gap is measured with the contacts open. Use a flat gauge inserted on the contact side of the brass pin in the winding core. Adjust by raising or lowering the upper armature stop.

Contact gap is measured with the contacts open, and is adjusted by bending the supporting arms of the stationary contacts. Be sure that both sets of contacts are in perfect alignment and that both sets of contacts close at the same instant. A straight edge may be used to check the alignment of the contacts.

Closing voltage of the cutout relay is checked as outlined above and is adjusted by turning the adjusting nut on the screw at the lower end of the spiral spring. Turning the nut to increase the spring tension raises the closing voltage. Lowering the spring tension decreases the closing voltage. After each adjustment replace cover and retest setting. The cutout relay closing voltage must always be 0.5 volt less than the voltage regulator setting.

Opening amperage of the contacts is checked as above, and is adjusted by raising or lowering the stationary contacts. Raising the stationary contacts (thereby increasing the air gap when the points are closed) lowers the opening amperage. Lowering the stationary contacts increases the opening amperage. Recheck adjustment by replacing cover and retesting setting.

Voltage Regulator Unit Check: With the regulator connected to the proper generator and a fully charged battery in the normal manner, connect a voltmeter from the regulator "B" terminal to the regulator ground screw. Connect an ammeter in series in the charging circuit at the regulator "B" terminal (see Fig 12). The battery must be fully charged (1.275 or better) or the check cannot properly be made. Be sure that the voltmeter lead clip is connected to the "B" terminal, and not to the ammeter lead clip, to avoid a false reading due to the voltage drop at the ammeter clip connection.

Slowly increase generator speed until 10 amperes is flowing in the line. Note voltage setting. Cover must be in place, regulator must be at operating temperature, and in operating position. Operate regulator for 15 minutes, if necessary, to bring unit to operating temperature.

Voltage Regulator Unit Adjustment: Disconnect regulator and adjust as follows:

Armature air gap should be checked with the contacts just breaking. Use a pin gauge placed between the armature and winding core, on the contact side of the brass armature stop pin in the core. To determine accurately the instant at which the contacts separate, connect a 3 candlepower test light and a 6 volt battery in series with the "A" and "F" terminals of the regulator. Use a low limit, and a high limit, pin gauge. With the low limit gauge in position, push the armature down, being careful not to touch the contact spring. The light should go out. With the high limit gauge, the light should stay lighted. Adjust by loosening the two armature stop attaching screws, and raise or lower the stop as required.

Contact gap is checked with the armature pushed down against the armature stop pin in the winding core. If the gap is too small, make sure that the bridge carrying the nickle-iron shunt has been pushed down in assembly. If the bridge has been pushed down so the armature rivets do not strike the shunt, and the contact gap is still wrong, replacement of the unit is indicated.

Contact pressure between the contacts is measured by disconnecting the spiral spring from the armature and removing the adjustable armature stop. A spring scale, hooked at the upper contact, may then be used to measure the tension required to separate the contacts. Hold the armature firm.

Voltage setting is checked as outlined above, and is adjusted by turning the adjusting nut on the screw at the lower end of the spiral spring. Turning the nut to increase the spring tension of the spiral spring increases the voltage setting. Decreasing the spring tension lowers the voltage setting. After each change of adjustment, replace the cover, stop the generator, then bring it back to speed to get 10 amperes in the line, before taking the voltage reading.

Current Limiting Regulator Check: The current limiting regulator is checked with the same meter connections as for the voltage regulator, shown above. In addition, an electrical load must be placed across the battery which will be somewhat above the current setting of the current limiting regulator unit (see Fig. 13). This load may consist of a carbon pile rheostat or a bank of light bulbs. Increase generator speed and note the current setting, which should be within plus or minus 5% of the current setting on the regulator nameplate. Current setting should be noted with the regulator at operating temperature, cover must be in place and regulator must be in operating position.

Current Limiting Regulator Adjustment: Disconnect the regulator and adjust as follows:

Contact pressure, armature air gap, and contact gap are checked in the same manner as detailed for the voltage regulator.

Current setting is adjusted by varying the spiral spring tension in the manner outlined for the voltage regulator.

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Model Number	Table Number ①	Specification Number
5524	3 (P)	324
5525	3 (P)	327
5526	3 (P)	326
5529	3 (P)	342
5530	3 (P)	279
5531	3 (P)	1298
5533	3 (P)	339
5534	3 (P)	1403
5535	3 (P)	324
5536	3 (P)	324
5538	3 (P)	1403
5540	4	1242
5542	4	1242
5549	4	1242
5551	4	1242
5560	4	1289
5561	3	1288
5562	3	1292
5563	3 (P)	324
5565	3	1290
5567	3 (P)	1295
5569	3 (P)	1402
5570	3 (P)	1403
5571	3 (P)	1407
5572	3	1428
5573	3 (N)	324
5575	3 (N)	1412
5576	3 (P)	1415
5577	3 (P)	1417
5579	3 (P)	1426
5581	4	1242
5584	4	1296
5585	4	1297
5586	4	1289
5587	1 (N)	1401
5588	1 (N)	1294
5592	1 (N)	1294
5593	4	1296
5596	1 (P)	1411
5597	1 (P)	1293
5598	1 (P)	1404
5599	1 (N)	1293
5600	1 (P)	1406
5604	3 (P)	1434
5605	3 (P)	1298
5609	3 (P)	1298
5610	3 (N)	1447
5612	3	1450
5621	3 (P)	2002
5628	3 (P)	2005
5629	3 (P)	2008
5632	3 (P)	2006
5633	3 (N)	2010
5634	3 (P)	1426
5636	3 (P)	1407
5637	3 (P)	1434
5639	3 (N)	2010
5640	3 (P)	2009
5646	3 (P)	1290
5647	3 (P)	342
5648	3 (P)	1415
5649	3 (P)	326
5800	4	1408
5801	1 (N)	1404
5802	1 (P)	1409
5803	1 (P)	1406
5806	1 (P)	1420
5810	1 (P)	1416
5814	1 (N)	1294
5819	1 (N)	1422
5820	1 (P)	1406
5821	4	1424
5823	1 (N)	1420
5824	4	1289
5825	1 (P)	1427
5826	1 (P)	1429
5828	1 (P)	1422
5829	1 (P)	1430
5830	4	1296
5836	1 (P)	1435
5838	4	1289
5841	1 (P)	1437
5842	1 (N)	1437
5847	1 (P)	1441
5849	4	1440
5850	4	1242
5852	1 (P)	1442
5854	1 (N)	1443
5856	1 (P)	1444
5858	1 (N)	1445

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DELCO-REMY REGULATOR INDEX

Model Number	Table Number ①	Specification Number	Model Number	Table Number ①	Specification Number	Model Number	Table Number ①	Specification Number
5859	4	1446	1118209	2 (N)	1468	1118231	2 (P)	1459
5862	1 (P)	1449	1118210	2 (P)	1468	1118232	2 (P)	1477
5863	4	1408	1118212	2 (P)	1469	1118233	2 (N)	1484
5866	1 (P)	1438	1118214	2 (P)	1472	1118234	2 (P)	1484
5868	4	1433						
			1118215	2 (P)	1473	1118236	2②	1481
5870	1 (P)	1449	1118217	2 (P)	1474	1118237	2 (N)	1469
5877	1 (P)	1463	1118218	2 (P)	1475	1118241	2 (P)	1490
5883	4	1464	1118219	2 (N)	1472	1118244	2 (P)	1491
5885	1 (P)	1482	1118220	2 (P)	1476	1118245	2 (P)	1492
SM1527	3 (P)	1288						
			1118221	2 (N)	1481	1118451	3 (P)	1295
SM1719	4	1289	1118222	2 (P)	1477	1118452	3 (P)	1298
1118201	2 (N)	1460	1118225	2 (P)	1479	1118453	3 (N)	1448
1118202	2 (P)	1460	1118227	2 (P)	1480	1118456	3 (P)	279
1118204	2 (P)	1465	1118229	2 (N)	1477	1118457	3 (P)	1288
1118206	2 (P)	1459	1118230	2 (P)	1481			
1118208	2 (P)	1467				1118458	3 (P)	1292
						1118465	3 (P)	2008

① For table No. 1, see "Two Core Regulator" table. For table No. 2, see "Single Core Regulator" table. For table No. 3, see "Heavy Duty Regulator" table. For table No. 4, see "Step Voltage Control Regulator" table.

② Insulated. P--Used with positive grounded battery. N--Used with negative grounded battery.

Table No. 1. TWO-CORE REGULATORS

Specification Number	Current Regulator					Voltage Regulator						Cutout Relay			
	Current Setting, Amperes	Air Gap, Inch	Point Opening, Inch	Contact Spring Tension, Oz.	Fibre Bumper Clearance, Inch	Voltage Setting at 70° F. ①	Voltage Setting at 150° F. ①	Air Gap, Inch	Point Opening, Inch	Contact Spring Tension, Oz.	Fibre Bumper Clearance, Inch	Volts to Close Points at 70° F.	Air Gap, Inch	Point Opening, Inch	Points Open, Amperes, Reverse Current
1293	26–28	.075	.020	3.5	.010	7.0–7.4	6.95–7.15	.063	.020	3.5	.010	6.9–7.6	.020	.020	0–4.0
1294	-----	.075	.020	3.5	.010	7.5–7.9	7.4–7.6	.063	.020	3.5	.010	6.9–7.6	.020	.020	0–4.0
1300	20–23	.075	.020	3.5	.010	7.5–7.95	7.4–7.6	.063	.020	3.5	.010	6.9–7.6	.020	.020	0–4.0
1401	20–22	.075	.020	3.5	.010	7.0–7.4	6.95–7.15	.063	.020	3.5	.010	6.9–7.6	.020	.020	0–4.0
1404	16–18	.075	.020	3.5	.010	14.2–15.0	14.1–14.5	.063	.020	3.5	.010	12.8–14.4	.020	.020	0–4.0
1406	-----	.075	.020	3.5	.010	7.25–7.65	7.2–7.4	.063	.020	3.5	.010	6.9–7.6	.020	.020	0–4.0
1409	-----	.075	.020	3.5	.010	14.2–15.0	14.1–14.5	.063	.020	3.5	.010	12.8–14.2	.020	.020	0–4.0
1411	20–22	.075	.020	3.5	.010	7.0–7.4	6.95–7.15	.063	.020	3.5	.010	6.9–7.6	.020	.020	0–4.0
1416	24–26	.075	.020	3.5	.010	7.0–7.4	6.95–7.15	.063	.020	3.5	.010	6.9–7.6	.020	.020	0–4.0
1418	28–30	.075	.020	3.5	.010	7.5–7.9	7.4–7.6	.063	.020	3.5	.010	6.9–7.6	.020	.020	0–4.0
1419	24–26	.075	.020	3.5	.010	7.5–7.95	7.4–7.6	.063	.020	3.5	.010	6.7–7.6	.020	.020	0–4.0
1420	16–18	.075	.020	3.5	.010	14.2–15.0	14.1–14.5	.063	.020	3.5	.010	12.3–13.7	.020	.020	0–4.0
1421	13	.075	.020	3.5	.010	7.5–7.95	7.4–7.6	.063	.020	3.5	.010	6.4–7.1	.020	.020	0–4.0
1422	26–28	.075	.020	3.5	.010	7.0–7.4	6.95–7.15	.063	.020	3.5	.010	6.3–6.9	.020	.020	0–4.0
1423	-----	.075	.020	3.5	.010	6.95–7.45	6.95–7.15	.063	.020	3.5	.010	6.9–7.6	.020	.020	0–4.0

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Table No. 1. TWO-CORE REGULATORS

Specification Number	Current Regulator					Voltage Regulator						Cutout Relay			
	Current Setting, Amperes	Air Gap, Inch	Point Opening, Inch	Contact Spring Tension, Oz.	Fibre Bumper Clearance, Inch	Voltage Setting at 70° F. ①	Voltage Setting at 150° F. ①	Air Gap, Inch	Point Opening, Inch	Contact Spring Tension, Oz.	Fibre Bumper Clearance, Inch	Volts to Close Points at 70° F.	Air Gap, Inch	Point Opening, Inch	Points Open, Amperes, Reverse Current
1427	11.5–13.5	.075	.020	3.5	.010	14.2–15.0	14.1–14.5	.063	.020	3.5	.010	12.8–14.2	.020	.020	0–4.0
1429	19–21	.075	.020	3.5	.010	14.2–15.0	14.1–14.5	.063	.020	3.5	.010	12.8–14.2	.020	.020	0–4.0
1430	7–9	.075	.020	3.5	.010	14.2–15.0	14.1–14.5	.063	.020	3.5	.010	12.3–13.7	.020	.020	0–4.0
1431	9–11	.075	.020	3.5	.010	14.2–15.0	14.1–14.5	.063	.020	3.5	.010	12.3–13.7	.020	.020	0–4.0
1432	26–28	.075	.020	3.5	.010	7.5–7.9	7.4–7.6	.063	.020	3.5	.010	6.9–7.6	.020	.020	0–4.0
1435	24–26	.075	.020	3.5	.010	14.2–15.0	14.1–14.5	.063	.020	3.5	.010	12.3–13.7	.020	.020	0–4.0
1436	12–14	.075	.020	3.5	.010	14.2–15.0	14.1–14.5	.063	.020	3.5	.010	12.3–13.7	.020	.020	0–4.0
1437	24–28	.075	.020	3.5	.010	14.2–15.0	14.1–14.5	.063	.020	3.5	.010	12.3–13.7	.020	.020	0–4.0
1438	-----	.075	.020	3.5	.010	14.2–15.0	14.1–14.5	.063	.020	3.5	.010	12.4–13.6	.020	.020	0–4.0
1439	-----	.075	.020	3.5	.010	7.25–7.65	7.2–7.4	.063	.020	3.5	.010	6.2–6.9	.020	.020	0–4.0
1441	34–36	.075	.020	3.5	.010	7.0–7.4	6.95–7.15	.063	.020	3.5	.010	6.9–7.6	.020	.020	0–4.0
1442	34–36	.075	.020	3.5	.010	7.0–7.4	6.95–7.15	.063	.020	3.5	.010	6.3–6.9	.020	.020	0–4.0
1443	29–31	.075	.020	3.5	.010	7.0–7.4	6.95–7.15	.063	.020	3.5	.010	6.9–7.6	.020	.020	0–4.0
1444	14–16	.075	.020	3.5	.010	14.2–15.0	14.1–14.5	.063	.020	3.5	.010	12.3–13.7	.020	.020	0–4.0
1445	-----	.075	.020	3.5	.010	7.5–7.9	7.4–7.6	.063	.020	3.5	.010	6.3–6.9	.020	.020	0–4.0
1449	-----	.075	.020	3.5	.010	7.3–7.6	7.25–7.35	.063	.020	3.5	.010	6.2–6.8	.020	.020	0–4.0
1455	32–34	.075	.020	3.5	.010	7.0–7.4	6.95–7.15	.063	.020	3.5	.010	6.3–6.9	.020	.020	0–4.0
1456	32–34	.075	.020	3.5	.010	7.0–7.4	6.95–7.15	.063	.020	3.5	.010	6.9–7.6	.020	.020	0–4.0
1463	28–30	.075	.020	3.5	.010	7.0–7.4	6.95–7.15	.063	.020	3.5	.010	6.3–6.9	.020	.020	0–4.0
1482	38–40	.075	.020	3.5	.010	7.0–7.4	6.95–7.15	.063	.020	3.5	.010	6.3–6.8	.020	.020	0–4.0

NOTE--See the Delco-Remy numerical index for specification number desired.

① Operate generator at 25% above speed at which it first reaches rated output and adjust current to 8 to 10 amperes.

Table No. 2. SINGLE-CORE REGULATORS

Specification Number	Current Regulator		Voltage Regulator		Cutout Relay			
	Current Setting Amperes ①	Air Gap Inch	Voltage Setting ②	Air Gap Inch	Voltage to Close Points ①	Air Gap Inch	Point Opening Inch	Points Open Amperes. Reverse Current
1459	---------	.080	7.2–7.4	.070	6.2–6.7	.020	.020	0–4.0
1460	32–34	.080	7.2–7.4	.070	6.2–6.7	.020	.020	0–4.0
1465	---------	.080	7.2–7.4	.070	6.2–6.7	.020	.020	0–4.0
1467	28–30	.080	7.0–7.2	.070	6.2–6.7	.020	.020	0–4.0
1468	16–18	.080	14.0–14.2	.070	12.4–13.4	.020	.020	0–4.0
1469	38–40	.080	7.0–7.2	.070	6.2–6.7	.020	.020	0–4.0
1472	24–26	.080	14.0–14.2	.070	12.4–13.4	.020	.020	0–4.0
1473	22–24	.080	7.0–7.2	.070	6.2–6.7	.020	.020	0–4.0
1474	19–21	.080	14.0–14.2	.070	12.4–13.4	.020	.020	0–4.0
1475	7–9	.080	14.0–14.2	.070	12.4–13.4	.020	.020	0–4.0
1476	12–13	.080	14.0–14.2	.070	12.4–13.4	.020	.020	0–4.0
1477	34–36	.080	7.0–7.2	.070	6.2–6.7	.020	.020	0–4.0
1478	12.5–13.5	.080	7.4–7.6	.070	6.3–6.9	.020	.020	0–4.0
1479	14–16	.080	14.0–14.2	.070	12.4–13.4	.020	.020	0–4.0
1480	---------	.080	14.0–14.2	.070	12.4–13.4	.020	.020	0–4.0

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Table No. 2. SINGLE-CORE REGULATORS

Current Regulator			Voltage Regulator		Cutout Relay			
Specification Number	Current Setting Amperes ①	Air Gap Inch	Voltage Setting ②	Air Gap Inch	Voltage to Close Points ①	Air Gap Inch	Point Opening Inch	Points Open Amperes, Reverse Current
1481	26–28	.080	7.0–7.2	.070	6.2–6.7	.020	.020	0–4.0
1484	24–26	.080	7.0–7.2	.070	6.2–6.7	.020	.020	0–4.0
1485	9–11	.080	14.0–14.2	.070	12.4–13.4	.020	.020	0–4.0
1489	18–20	.080	7.1–7.3	.070	6.2–6.7	.020	.020	0–4.0
1490	30–32	.080	14.0–14.2	.070	12.4–13.4	.020	.020	0–4.0
1491	48–50	.080	6.8–6.9	.070	6.1–6.4	.020	.020	0–4.0
1492	38–40	.080	13.6–13.8	.070	12.4–13.0	.020	.020	0–4.0

NOTE--See the Delco-Remy numerical index for specification number desired.

① Operating temperature.

② Setting on closed circuit at operating temperature. Operate generator at which it will produce rated output and adjust current to 8 to 10 amperes.

Table No. 3. HEAVY-DUTY REGULATORS

Current Regulator			Voltage Regulator		Cutout Relay			
Specification Number	Current Setting Amperes	Point Opening Inch	Voltage Setting ①	Point Opening Inch	Voltage to Close Points	Air Gap Inch	Point Opening Inch	Points Open Amperes. Reverse Current
279	50	.015	15.0	.015	13.5	.057	.020	0–3.0
324	--	.015	15.0	.015	13.5	.057	.020	0–3.0
326	40	.015	15.0	.015	13.5	.057	.020	0–3.0
327	40	.015	15.0	.015	13.5	.057	.020	0–3.0
339	--	.015	8.5	.015	7.0	.057	.020	0–3.0
342	18	.015	15.0	.015	13.5	.057	.020	0–3.0
1288	14	.015	30.0	.015	26.0	.057	.020	0–3.0
1290	25	.015	30.0	.015	26.0	.057	.020	0–3.0
1291	14	.015	40.0	.015	35.0	.057	.020	0–3.0
1292	10	.015	30.0	.015	26.0	.057	.020	0–3.0
1295	40	.015	8.5	.015	7.0	.057	.020	0–3.0
1298②	80	.015	15.0	.015	13.5	.057	.020	0–3.0
1299②	100	.015	15.0	.015	13.5	.057	.020	0–3.0
1402	30	.015	15.0	.015	13.5	.057	.020	0–3.0
1403	--	.015	8.5	.015	7.0	.057	.020	0–3.0
1407	57	.015	15.0	.015	13.5	.057	.020	0–3.0
1412	33	.015	15.0	.015	13.5	.057	.020	0–3.0
1413	10	.015	40.0	.015	35.0	.057	.020	0–3.0
1414	40	.015	40.0	.015	35.0	.057	.020	0–3.0
1415	33	.015	15.0	.015	13.5	.057	.020	0–3.0
1417	50	.015	8.5	.015	7.0	.057	.020	0–3.0
1425	50	.015	15.0	.015	13.5	.057	.020	0–3.0
1426	55	.015	15.0	.015	13.5	.057	.020	0–3.0
1428	25	.015	40.0	.015	35.0	.057	.020	0–3.0
1434	40	.015	15.0	.015	13.5	.057	.020	0–3.0

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Table No. 3. HEAVY-DUTY REGULATORS

	Current Regulator		Voltage Regulator		Cutout Relay			
Specification Number	Current Setting Amperes	Point Opening Inch	Voltage Setting ①	Point Opening Inch	Voltage to Close Points	Air Gap Inch	Point Opening Inch	Points Open Amperes. Reverse Current
1447	55	.015	15.0	.015	13.5	.057	.020	0-3.0
1448	40	.015	15.0	.015	13.5	.057	.020	0-3.0
1450②	③	.015	15.0	.015	13.5	.057	.020	0-3.0
1451	10	.015	37.5	.015	33.0	.057	.020	0-3.0
1452	20	.015	15.0	.015	13.5	.057	.020	0-3.0
1453②	57	.015	15.0	.015	13.5	.057	.020	0-3.0
1454	50	.015	30.0	.015	26.0	.057	.020	0-3.0
1457	20	.015	40.0	.015	35.0	.057	.020	0-3.0
1466	40	.015	37.5	.015	33.0	.057	.020	0-3.0
1470	35	.015	15.0	.015	13.5	.057	.020	0-3.0
1471②	75	.015	15.0	.015	13.5	.057	.020	0-3.0
2001④	120	.015	15.0	.015	13.5	.057	.020	0-3.0
2002②	③	.015	15.0	.015	13.5	.057	.020	0-3.0
2003	25	.015	37.5	.015	33.0	.057	.020	0-3.0
2004	25	.015	7.5	.015	6.5-6.9	.057	.020	0-3.0
2005	25	.015	7.5	.015	6.5-6.9	.057	.020	0-3.0
2006	17	.015	15.0	.015	13.5	.057	.020	0-3.0
2007	25	.015	15.0	.015	13.5	.057	.020	0-3.0
2008	25	.015	15.0	.015	13.5	.057	.020	0-3.0
2009	35	.015	7.5	.015	6.5-6.9	.057	.020	0-3.0
2010	55	.015	15.5	.015	13.5	.057	.020	0-3.0
2011	14	.015	40.0	.015	35.0	.057	.020	0-3.0
2012	15	.015	30.0	.015	26.0	.057	.020	0-3.0
2013②	50	.015	15.0	.015	13.5	.057	.020	0-3.0
2014	14	.015	37.5	.015	33.0	.057	.020	0-3.0
2015	50	.015	15.0	.015	13.5	.057	.020	0-3.0
2016	12	.015	30.0	.015	26.0	.057	.020	0-3.0
2017②	75	.015	30.0	.015	26.0	.057	.020	0-3.0
2018	15	.015	30.0	.015	26.0	.057	.020	0-3.0
2019	40	.015	7.5	.015	6.5-6.9	.057	.020	0-3.0
2020	50	.015	30.0	.015	26.0	.057	.020	0-3.0

NOTE--See the Delco-Remy numerical index for specification number desired.

① Setting made on open circuit at from 135 to 145 degrees F. Do not operate generator at more than 1500 R. P. M.

② On these units, set voltage regulator air gap .018″-.020″: cutout relay air gap .050″: field relay air gap .010″: field relay open circuit voltage 8 volts on 12-volt systems and 16 volts on 24-volt systems. Set relay before voltage regulator.

③ Must be set at from 135 to 145 degrees to 57 amperes. Regulates at 70 amperes with unit at from 60 to 70 degrees F.

④ See footnote 2 for correct settings. In addition, the cutout solenoid point opening should be .050″.

Table No. 4. STEP-VOLTAGE CONTROL REGULATORS

Specification Number	Voltage Control Unit								Cutout Relay			
	Air Gap Inch	Point Opening Inch	Contact Spring Tension Oz.	Armature Travel Inch	Voltage to Open Points at 70°F.	Voltage to Open Points at 180°F.	Voltage to Close Points at 70°F.	Voltage to Close Points at 180°F.	Air Gap Inch	Point Opening Inch	Voltage to Close Points at 70°F.	Points Open, Amperes Reverse Current
1227	.057	.015	----	----	8.5–8.9	8.5–8.7	7.0–7.5	7.0–7.2	.015	.020	6.75–7.5	0–2.5
1242	.035	.010	.7 .9	.035	8.3–8.7	7.75–8.2	7.25–7.75	6.55–7.1	.015	.020	6.3–6.9	0–3.0
1289	.035	.010	.5–1.1	.030	15.4–16.35	14.4–15.35	13.9–15.1	12.8–14.1	.015	.020	13.0–14.2	0–4.0
1296	.035	.010	7–.9	.035	8.3–8.7	7.75–8.2①	7.25–7.75	6.55–7.1①	.020	.020	6.3–6.9	0–3.0
1297	.035	.010	.7–.9	.035	8.3–8.7	7.75–8.2①	7.25–7.75	6.55–7.1①	.015	.020	6.3–6.9	0–3.0
1405	.035	.010	.7–.9	.035	8.3–8.7	7.75–8.2	7.25–7.75	6.55–7.1	.020	.020	6.4–7.0	0–3.5
1408	.045	.015	.7–1.4	.045	7.65–8.05	7.55–7.95	6.65–7.15	6.35–6.95	.015	.020	6.3–6.9	0–4.0
1410	.035	.010	.5–1.1	.035	8.1–8.55	7.65–8.05①	7.15–7.55	6.35–6.95①	.020	.020	6.3–6.9	0–3.5
1424	.045	.015	.5–1.1	.045	7.65–8.05	7.55–7.95	6.65–7.15	6.35–6.95	.020	.020	6.3–6.9	0–4.0
1433	.035	.010	.5–1.1	.035	7.45–7.85	6.95–7.35①	6.0 max.	6.0 max.①	.015	.020	6.3–6.9	0–4.0
1440	.045	.015	.7–1.4	.045	14.1–14.7	14.1–14.7	12.0 max.	12.0 max.	.015	.020	12.9–13.9	0–4.0
1446	.015	.022	.7–.9	.060	28.5–31.5	26.5–28.5	15.0 max.	15.0 max.	.020	.030	24.5–27.5	3.0 max.
1462	.030	.010	.5–1.1	.030	14.6–15.55	13.6–14.55	13.3–14.5	12.2–13.5	.020	.020	12.4–13.6	4.0 max.
1464	.035	.010	.5–1.1	.035	7.9–8.3	7.35–7.8①	6.95–7.45	6.25–6.8①	.020	.020	6.0–6.6	3.0 max.
1483	.035	.010	.5–1.1	.030	14.5–15.2	13.5–14.2	12.5–13.2	11.5–12.2	.020	.020	13.2–14.0	0–4.0

Note—See the Delco-Remy numerical index for specification number desired. ① **Voltage at 150 degrees F.**

CUTOUT RELAY SPECIFICATIONS

Model Number	Air Gap with Points Closed, Inches	Point Opening, Inches	Armature Attracted to Core, Volts	Armature Released from Core, Amperes	Model Number	Air Gap with Points Closed, Inches	Point Opening, Inches	Armature Attracted to Core, Volts	Armature Released from Core, Amperes
263-A②	.015	.020	7.0–7.5	0–3.0	265-G②	.015	.020	7.0–7.5	0–3.0
263-B	.015	.020	13.5–14.0	0–2.0	265-H②	.015	.020	7.0–7.5	0–3.0
263-C②	.015	.020	7.0–7.5	0–3.0	265-I②	.015	.020	7.0–7.5	0–3.0
263-D②	.015	.020	7.0–7.5	0–3.0	265-J②	.015	.020	7.0–7.5	0–3.0
263-E	.015	.020	13.5–14.0	0–2.0	265-K②	.015	.020	7.0–7.5	0–3.0
263-F②	.015	.020	7.0–7.5	0–3.0	265-L②	.015	.020	7.0–7.5	0–3.0
263-G②	.015	.020	7.0–7.5	0–3.0	265-M②	.015	.020	7.0–7.5	0–3.0
264-A②	.015	.020	7.0–7.5	0–3.0	265-N②	.015	.020	7.0–7.5	0–3.0
264-B②	.015	.020	7.0–7.5	0–3.0	265-O②	.015	.020	7.0–7.5	0–3.0
264-C②	.015	.020	7.0–7.5	0–3.0	265-P②	.015	.020	7.0–7.5	0–3.0
265-B②	.015	.020	7.0–7.5	0–3.0	265-Q②	.015	.020	7.0–7.5	0–3.0
265-C②	.015	.020	7.0–7.5	0–3.0	265-R②	.015	.020	7.0–7.5	0–3.0
265-D②	.015	.020	7.0–7.5	0–3.0	265-S②	.015	.020	7.0–7.5	0–3.0
265-E②	.015	.020	7.0–7.5	0–3.0	265-T②	.015	.020	7.0–7.5	0–3.0
265-F②	.015	.020	7.0–7.5	0–3.0	265-U②	.015	.020	7.0–7.5	0–3.0

Continued on next page

Continued from previous page

CUTOUT RELAY SPECIFICATIONS

Model Number	Air Gap with Points Closed, Inches	Point Opening, Inches	Armature Attracted to Core, Volts	Armature Released from Core, Amperes	Model Number	Air Gap with Points Closed, Inches	Point Opening, Inches	Armature Attracted to Core, Volts	Armature Released from Core, Amperes
265-V②	.015	.020	7.0–7.5	0–3.0	1116753	.015	.020	13.5–14.0	0–2.0
265-W	.015	.020	13.5–14.0	0–2.0	1116755②	.015	.020	7.0–7.5	0–3.0
266-E②	.015	.020	7.0–7.5	0–3.0	1116761	.015	.020	13.5–14.0	0–2.0
266-F②	.015	.020	7.0–7.5	0–3.0	1116766①	.020	.020	6.75–7.5	0–3.5
266-G②	.015	.020	7.0–7.5	0–3.0	1116768	.020	.030	35–37	0–1.5
266-H②	.015	.020	7.0–7.5	0–3.0	1116773①	.020	.020	6.75–7.5	0–3.5
266-I②	.015	.020	7.0–7.5	0–3.0	1116777	.015	.020	13.0–13.8	0–3.0
266-J②	.015	.020	7.0–7.5	0–3.0	1116787	.015	.020	13.5–14.0	0–2.0
266-K②	.015	.020	7.0–7.5	0–3.0	1116788②	.015	.020	7.0–7.5	0–3.0
266-N②	.015	.020	7.0–7.5	0–3.0	1116795	.020	.030	28.0–30.0	0–3.0
266-P②	.015	.020	7.0–7.5	0–3.0	1116808	.015	.020	13.0–13.8	0–3.0
267-A	.015	.020	13.5–14.0	0–2.0	1116809①	.020	.020	6.75–7.5	0–3.5
267-B	.015	.020	13.5–14.0	0–2.0	1116810	.015	.020	13.5–14.0	0–2.0
267-C	.015	.020	13.5–14.0	0–2.0	1116814	.015	.020	13.5–14.0	0–2.0
267-D	.015	.020	13.5–14.0	0–2.0	1116816①	.020	.020	6.75–7.5	0–3.5
267-E	.015	.020	13.5–14.0	0–2.0	SM1418	.015	.020	13.5–14.0	0–2.0
269-K②	.015	.020	7.0–7.5	0–3.0	SM1495②	.015	.020	7.0–7.5	0–3.0
270-B①	.020	.020	6.75–7.5	0–3.5	SM1728	.015	.020	13.5–14.0	0–2.0
270-C①	.020	.020	6.75–7.5	0–3.5	SM1849	.015	.020	13.5–14.0	0–2 0
1116751②	.015	.020	7.0–7.5	0–3.0					

① 6.2 oz. armature spring tension. ② 3.5 oz. armature spring tension.

GENERATOR OUTPUT REGULATORS

Generator output regulators are electromagnetic devices, and certain rules must be observed during adjustment of them.

1. Do not interchange regulator models unless the service manual states that it is possible to do so. Using the wrong polarity regulator on an application will result in quick failure of the equipment.
2. Do not close cutout relay points by hand with battery connected. To do so will damage the relay points, and may cause the points to weld so that serious damage will result to the generator.
3. Regulator must be in operating position and at operating temperature when electrical checks are made.
4. After any voltage regulator adjustment, cover must be replaced, generator speed reduced until cutout relay points open, and then generator must be brought back to speed, before voltage setting is checked.
5. Generator must be repolarized by momentarily connecting a jumper lead around regulator to permit a flash of current to flow from the battery to the generator. Reversed generator polarity will cause relay points to arc and burn.
6. Clean regulator points, when necessary, with a flat fine-cut file. Cavities may be cleaned out with a "spoon" file. Points may then be cleaned with carbon tetrachloride, and a clean piece of linen tape drawn between the points to remove any residue.

DELCO-REMY

Delco-Remy has supplied seven types of generator output regulators for truck applications since 1936. These are, (1) Step-Voltage Control, (2) Two-core Voltage Regulator, (3) Two-core Current-and-Voltage Regulator, (4) Single-core Voltage Regulator, (5) Single-core Current-and-Voltage Regulator, (6) Heavy-duty Voltage Regulator, and (7) Heavy-duty Current-and-Voltage Regulator.

STEP-VOLTAGE CONTROL

5539, 5540, 5542, 5544, 5546 to 5556, 5558, 5560, 5581 to 5586, 5589, 5590, 5593 to 5595, 5800, 5804, 5805, 5816, 5821, 5824, 5830, 5833, 5834, 5838, 5839, 5845, 5849 to 5851, 5857, 5859, 5863, 5864, 5868, 5869, 5879 to 5884, 5886 to 5893.

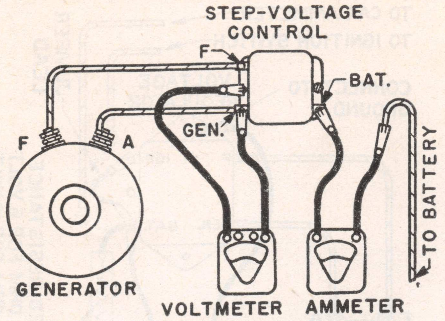
The step-voltage control, also called the two-step regulator, lock-out voltage control, and two-charge regulator, consists of the voltage control unit and cut-out relay, mounted together on the same base and enclosed by the same cover. The step-voltage control may mount on the generator, or separately. It is important to be able to recognize the Delco-Remy step-voltage control, and differentiate between it and the Delco-Remy two-core voltage regulator since they have a similar appearance. The step-voltage control has two shunt (fine-wire) windings, both paper covered. The two-core voltage regulator has one shunt (paper covered) and one series winding of a few turns of heavy wire.

The only replaceable parts in the step-voltage control are the step-voltage control armature which includes both step-voltage control contact points, the cut-out relay armature, which includes the upper cut-out relay contact point, and the resistance. Replacement of an armature is made by unsoldering a lead and removing two mounting screws. The new armature must be carefully handled, to avoid distorting the flat hinge spring. Adjustment is made as follows:

Cutout relay check.

With the step-voltage control connected to the proper generator and battery in the normal manner, connect a voltmeter from the step-voltage control "GEN" terminal to the control base. Connect an ammeter into the charging circuit at the "BAT" terminal.

Slowly increase generator speed and note the relay closing voltage. Decrease generator speed and note reverse current necessary to open the points.


STEP-VOLTAGE CONTROL
F
BAT.
GEN.
F
A
TO BATTERY
GENERATOR
VOLTMETER
AMMETER

STEP-VOLTAGE CONTROL. Showing meter connections to check the closing voltage of the cut-out relay, and reverse current to open the relay contact points.

Cutout relay adjustment.

Disconnect step-voltage control and adjust relay as follows:

Air gap is checked with the contact points held closed, between the center of the core and the armature. Adjust by loosening the two armature mounting screws at the back of the relay, and raising or lowering the armature as required.

Point opening is checked with points open, and adjusted by bending the upper armature stop. Where the unit has a set of auxiliary contact points mounted above the cut-out relay contact points, bend the upper auxiliary contact point support arm, to adjust point opening.

Closing voltage is checked with voltmeter connected as above, and is adjusted by bending the spring post down to decrease the tension of the flat spring and the closing voltage. Bending up raises the spring tension and closing voltage.

Step-voltage control unit check.

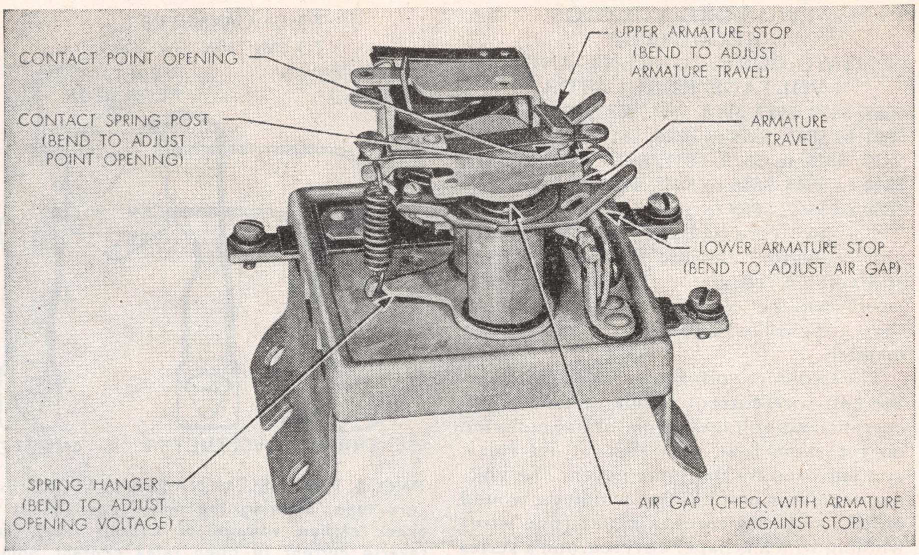
With the step-voltage control connected to the proper generator and battery, connect a voltmeter from the step-voltage control "BAT" terminal to the control base, and connect a ¼ ohm variable resistance into the charging circuit. The resistance will be required if the battery is so low that sufficient voltage cannot be attained to cause the step-voltage control to operate and open its points. Slowly increase generator speed and note the voltage at which the step-voltage control contact points open. Cut in resistance if voltage does not increase sufficiently with generator operating at medium speed. Reduce generator speed (or cut out resistance) until step-voltage control contact points close. Note closing voltage.

Step-voltage control unit adjustment.

Disconnect step-voltage control and adjust as follows:

Contact spring tension is measured with a spring gauge at the contacts, and is the amount of pull, in a line vertical to the flat spring, necessary to separate the contact points.

Air gap is checked with the armature held down against the lower armature stop, and is measured between the center of the winding core and the armature. It is adjusted by bending the lower armature stop.

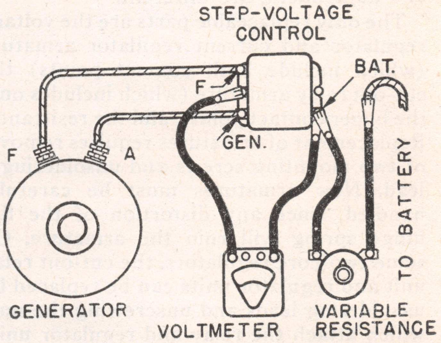

CONTACT POINT OPENING
CONTACT SPRING POST (BEND TO ADJUST POINT OPENING)
UPPER ARMATURE STOP (BEND TO ADJUST ARMATURE TRAVEL)
ARMATURE TRAVEL
LOWER ARMATURE STOP (BEND TO ADJUST AIR GAP)
SPRING HANGER (BEND TO ADJUST OPENING VOLTAGE)
AIR GAP (CHECK WITH ARMATURE AGAINST STOP)

STEP-VOLTAGE CONTROL. Showing step-voltage control adjustments.

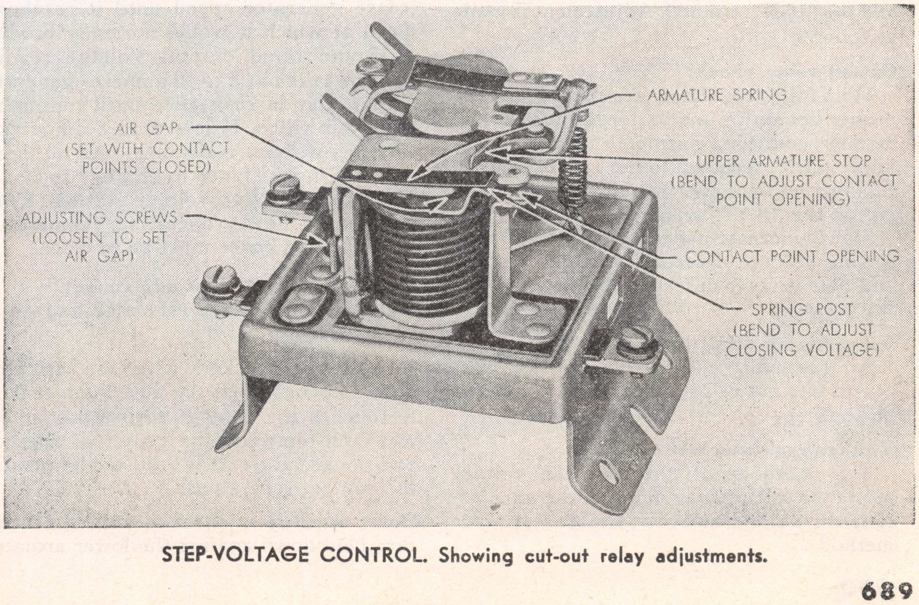
Armature travel is measured between the armature and the lower armature stop, after the armature has been released. The armature travel is adjusted by bending the upper armature stop.

Point opening is measured with the armature held down against the lower armature stop. It is adjusted by bending the contact spring post.

Voltage settings. The **opening** voltage of the step-voltage control contact points is checked with voltmeter connected as above, and is adjusted by bending the spiral spring hanger down to increase the opening voltage or up to decrease the opening voltage. The **closing** voltage is checked with voltmeter connected as above, and is adjusted by adjusting the Air Gap. To raise the closing voltage, increase the air gap. To lower the closing voltage, reduce the air gap. Only a slight readjustment is usually necessary. After this adjustment, it may be necessary to readjust the contact point opening slightly.


STEP-VOLTAGE CONTROL
BAT.
F
GEN.
F
A
TO BATTERY
GENERATOR
VOLTMETER
VARIABLE RESISTANCE

STEP-VOLTAGE CONTROL. Showing meter connections to check opening and closing voltages of the step-voltage control contact points. Variable resistance may be used where voltage does not increase sufficiently to allow these contacts to open.


AIR GAP (SET WITH CONTACT POINTS CLOSED)
ADJUSTING SCREWS (LOOSEN TO SET AIR GAP)
ARMATURE SPRING
UPPER ARMATURE STOP (BEND TO ADJUST CONTACT POINT OPENING)
CONTACT POINT OPENING
SPRING POST (BEND TO ADJUST CLOSING VOLTAGE)

STEP-VOLTAGE CONTROL. Showing cut-out relay adjustments.

TWO-CORE VOLTAGE REGULATOR
TWO-CORE CURRENT-AND-VOLTAGE REGULATOR

5557, 5559, 5587, 5588, 5591, 5592, 5596 to 5600, 5801 to 5803, 5806 to 5815, 5817 to 5820, 5822, 5823, 5825 to 5829, 5831, 5832, 5835 to 5837, 5840 to 5844, 5846 to 5848, 5852 to 5856, 5858, 5860 to 5862, 5865 to 5867, 5870 to 5878, 5885.

The two-core voltage regulator (two-unit regulator) and the two-core current-and-voltage regulator (three-unit regulator) will be considered together, since they are checked and adjusted in a similar manner.

The two-core voltage regulator unit (plus the two-core current regulator unit in the current-and-voltage regulator) is mounted on the same base with the cut-out relay, and enclosed by the same cover. The voltage regulator unit has two windings, wound on two separate cores, a shunt (fine wire) winding which is paper covered, and a series winding of a few turns of heavy wire. It is necessary to distinguish between this type unit, and the step-voltage control, considered on a previous page, because operation, and adjustment, are different.

The only replaceable parts are the voltage regulator and current regulator armature (which include both contact points) the cut-out relay armature (which includes only the upper contact point), and the resistance. Replacement of armatures requires removal of two mounting screws and unsoldering a lead. New armatures must be carefully handled, since any distortion of the flat hinge spring will ruin the armature. On some two-core regulators, the cut-out relay unit and regulator units can be replaced by unsoldering leads and unscrewing the nuts which attach the relay and regulator units to the mounting base. Other regulators are of a riveted construction and the units cannot be replaced.

The voltage regulators may have up to five terminals, while the current and voltage regulators may have up to six terminals. Somewhat different procedures are required, according to whether the regulator does or does not have an "IGN" terminal. Previous to 1938, all two-core regulators had the "IGN' terminal. Adjustment is made as follows:

Cutout relay check.

With the regulator connected to the proper generator and battery in the normal manner, connect a voltmeter from the regulator "GEN" terminal to the regulator base. Connect an ammeter into the charging circuit at the "BAT" terminal.

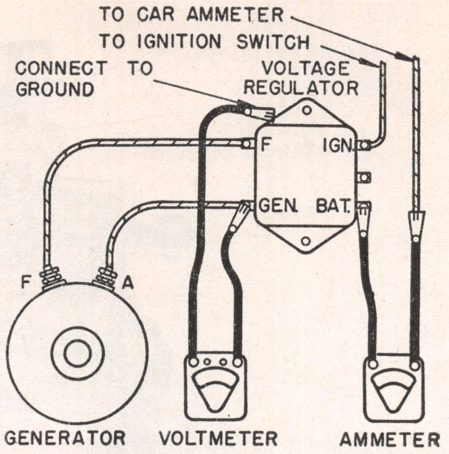
Slowly increase generator speed and note closing voltage. Decrease generator speed and note reverse current necessary to open the points.

Cutout relay adjustments.

Air gap, point opening, and closing voltage of cut-out relay is checked as outlined under Step-Voltage Control.

Voltage regulator unit check.

Two methods of checking the voltage regulator setting may be used, the fixed resistance method, and the variable resistance method.



TWO & THREE ELEMENT REGULATORS. Two core type. Showing the meter connections to check closing voltage of cut-out relay, and reverse current to open relay contact points. Make connections according to terminal markings and not positions shown.

With the fixed resistance method, disconnect the lead from the regulator "BAT" terminal and connect a fixed resistance (¾ ohm for 6-volt units and 1½ ohm for 12-volt units) from the "BAT" terminal to the regulator base. Connect voltmeter from this same "BAT" terminal to the regulator base. Where the unit has an "IGN" terminal, disconnect lead from the "IGN" terminal and connect a jumper lead from the "IGN" to "BAT" terminal. Increase generator speed until it reaches a speed at which it would normally produce maximum rated output. Note voltage setting. Regulator must be at operating temperature (150° F.) and cover must be in place.

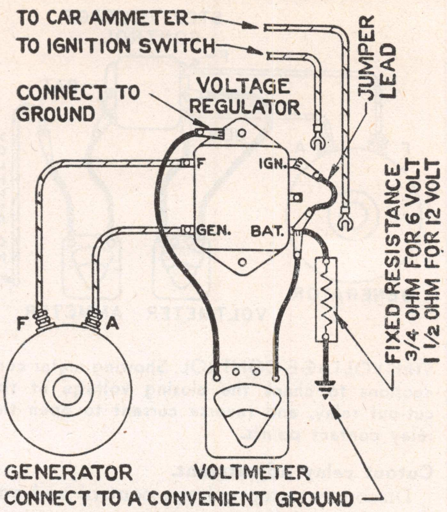
With the variable resistance method, connect in series into the charging circuit at the regulator "BAT" terminal an ammeter and a ¼ ohm variable resistance. Connect voltmeter from the "BAT" terminal to the regulator base. Where the unit has an "IGN" terminal, disconnect lead from "IGN" terminal and connect jumper lead between "IGN" and "BAT" terminals. Increase generator speed until it reaches a speed at which it would normally produce maximum rated output. Voltage reading must be taken at 8 to 10 amperes generator output. Cut in resistance until output attains this value. If less than 8 amperes is obtained without resistance, turn on lights, then cut in resistance to obtain 8 to 10 amperes output. Note voltage setting. Regulator must be at operating temperature (150° F.) and cover must be in place.

Voltage regulator unit adjustment.

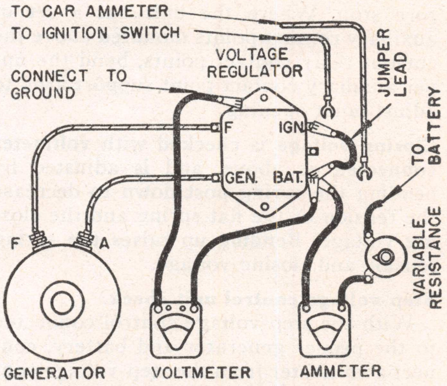
Disconnect voltage regulator and adjust as follows:

Air gap is checked with the armature moved down so that the fibre bumper barely touches the contact spring post and is measured between the center of the core and the armature. It is adjusted by bending the contact spring post.

Point opening is checked with the armature held down against the lower armature stop, and is adjusted by bending the lower armature stop.



TWO & THREE ELEMENT REGULATORS. Two core type. Showing meter connections for checking voltage regulator setting by the fixed resistance method. Where regulator does not have an "IGN" terminal, a jumper lead is not necessary. Make connections according to terminal markings and not positions shown.

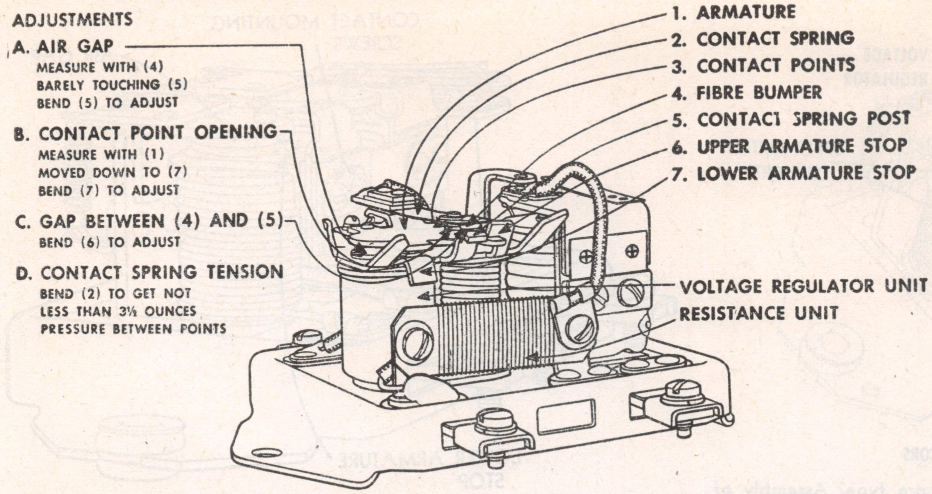


TWO & THREE ELEMENT REGULATORS. Two core type. Showing meter connections for checking voltage regulator setting by the variable resistance method. Where regulator does not have an "IGN" terminal, a jumper lead is not necessary. Make connections according to terminal markings and not positions shown.

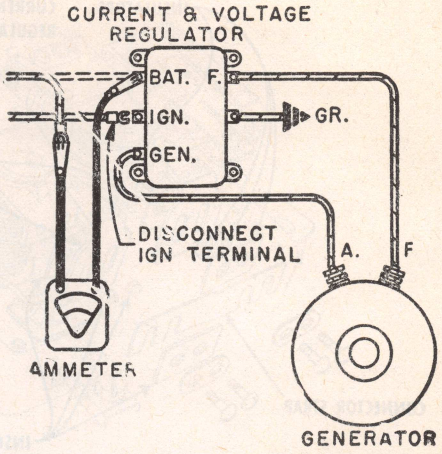
Gap between fibre bumper and contact spring post is measured with the armature at rest against the upper armature stop. and is adjusted by bending the upper armature stop.

Contact point spring tension is checked at the contact point on the flat spring, between the point and fibre bumper. The amount of pull in a direction vertical to the spring required to separate the contact points should be measured with a spring scale. Adjust by bending the flat spring slightly.

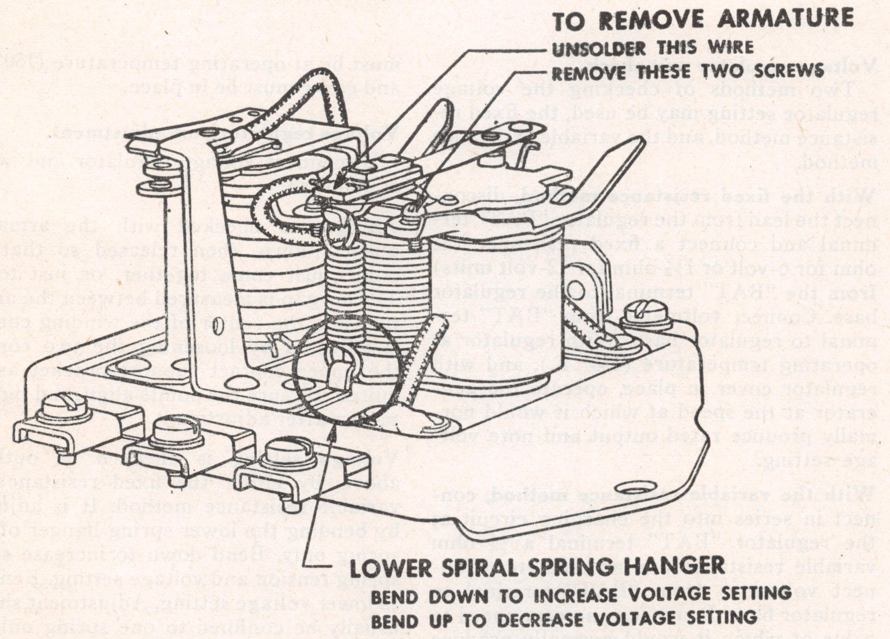
Voltage setting is checked as above, by either the fixed resistance, or variable resistance, method. It is adjusted by bending


ADJUSTMENTS
A. AIR GAP
MEASURE WITH (4)
BARELY TOUCHING (5)
BEND (5) TO ADJUST
B. CONTACT POINT OPENING
MEASURE WITH (1)
MOVED DOWN TO (7)
BEND (7) TO ADJUST
C. GAP BETWEEN (4) AND (5)
BEND (6) TO ADJUST
D. CONTACT SPRING TENSION
BEND (2) TO GET NOT
LESS THAN 3½ OUNCES
PRESSURE BETWEEN POINTS
1. ARMATURE
2. CONTACT SPRING
3. CONTACT POINTS
4. FIBRE BUMPER
5. CONTACT SPRING POST
6. UPPER ARMATURE STOP
7. LOWER ARMATURE STOP
VOLTAGE REGULATOR UNIT
RESISTANCE UNIT

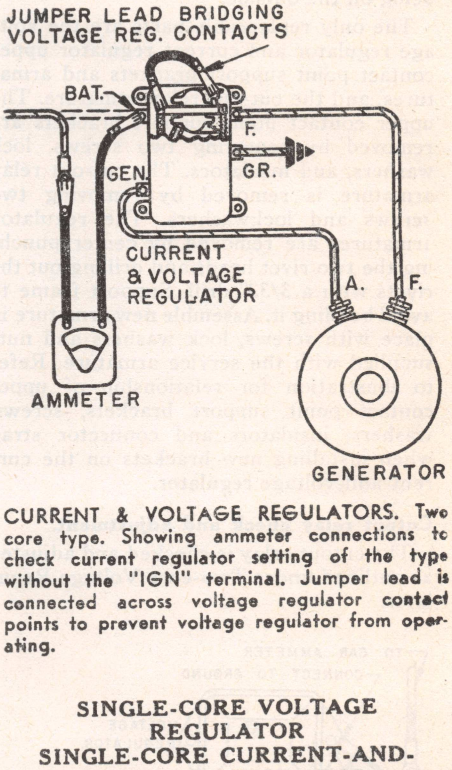
VOLTAGE REGULATORS. Two core type. Showing voltage regulator mechanical adjustments.


CURRENT & VOLTAGE
REGULATOR
BAT.
F.
IGN.
GR.
GEN.
DISCONNECT
IGN TERMINAL
A.
F
AMMETER
GENERATOR

CURRENT & VOLTAGE REGULATORS. Two core type. Showing ammeter connections to check current regulator setting of the type having an "IGN" terminal. "IGN" terminal lead is disconnected to prevent voltage regulator from operating.


TO REMOVE ARMATURE
UNSOLDER THIS WIRE
REMOVE THESE TWO SCREWS
LOWER SPIRAL SPRING HANGER
BEND DOWN TO INCREASE VOLTAGE SETTING
BEND UP TO DECREASE VOLTAGE SETTING

VOLTAGE REGULATORS. Two core type. Showing voltage regulator voltage setting adjustment.


JUMPER LEAD BRIDGING
VOLTAGE REG. CONTACTS
BAT.
F.
GR.
GEN.
CURRENT
& VOLTAGE
REGULATOR
A.
F.
AMMETER
GENERATOR

CURRENT & VOLTAGE REGULATORS. Two core type. Showing ammeter connections to check current regulator setting of the type without the "IGN" terminal. Jumper lead is connected across voltage regulator contact points to prevent voltage regulator from operating.

the lower spiral spring hanger. Bending the hanger down to increase the spiral spring tension increases the voltage setting, bending up lowers the voltage setting. After every change of adjustment, slow generator until relay contact points open, then bring generator back to speed. Cover must be in place and regulator must be at operating temperature when reading is taken. In addition, with the variable resistance method, 8 to 10 amperes must be flowing in the charging circuit; this requires readjustment of the variable resistance with each voltage setting adjustment so that the 8-10 ampere output is maintained.

Current regulator unit check.

When the regulator incorporates a current regulator unit, the current regulator unit current setting should be checked by connecting an ammeter into the circuit at the regulator "BAT" terminal, operating the generator at medium speed, and noting the current setting. During this check, the voltage regulator must not operate, and to assure this, either the voltage regulator contact points must be bridged by a jumper lead, or (where the unit has an "IGN" terminal) the "IGN" terminal lead may be temporarily disconnected. The lights and other accessories should be turned on during the current regulator check, to prevent high voltage.

Current regulator unit adjustment.

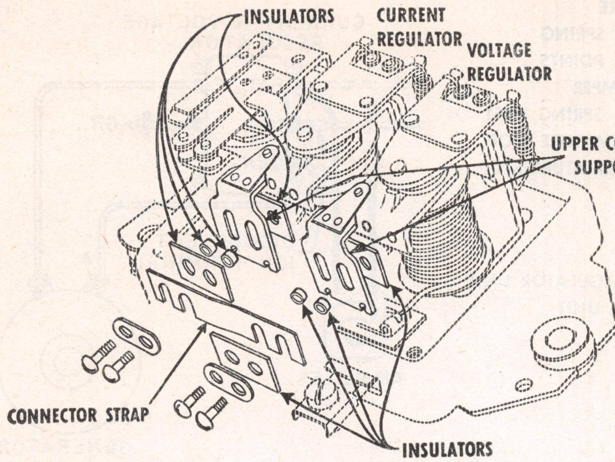
The current regulator air gap, point opening, gap between fibre bumper and contact spring post, and contact point spring tension, are all made with the regulator disconnected and in the manner detailed for the voltage regulator unit. The current setting is checked as above, and adjusted by bending the lower spring hanger up to lower the spiral spring tension and current setting, or down to increase the current setting

SINGLE-CORE VOLTAGE REGULATOR
SINGLE-CORE CURRENT-AND-VOLTAGE REGULATOR

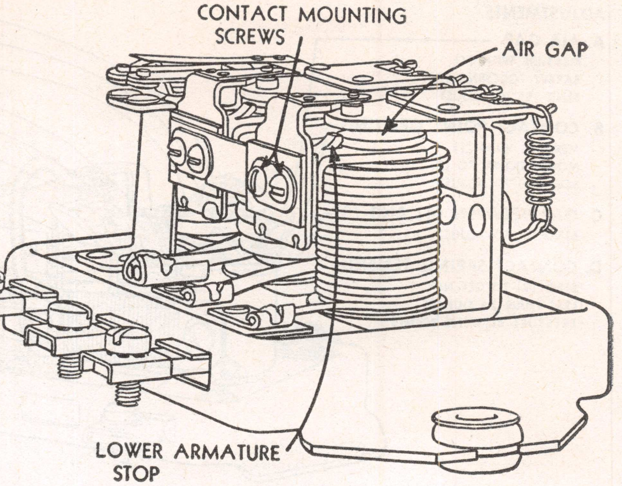
1118201 TO 1118260

The single-core voltage regulator (two-unit regulator) and the single-core current-and-voltage regulator (three-unit regulator) will be considered together, since they are checked and adjusted in a similar manner.

The single-core voltage regulator unit (plus the single-core current regulator unit in the current-and-voltage regulator) is mounted on the same base with the cut-out relay, and enclosed by the same cover. The voltage regulator unit has two windings, but they are both wound on the same core, the



CURRENT & VOLTAGE REGULATORS. Single core type. Assembly of contact point support brackets showing relationship of insulators, connector strap, screws and lock washers.



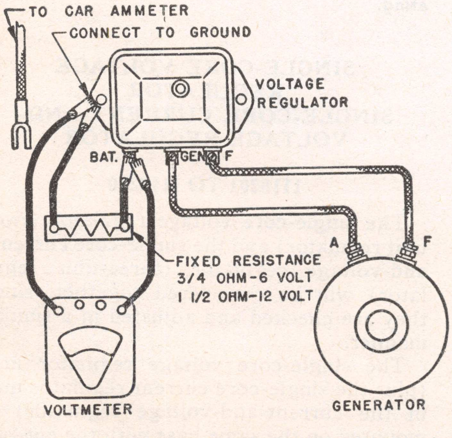
TWO & THREE ELEMENT REGULATORS. Single core type. Showing voltage regulator air gap adjustment.

series winding of a few turns of heavy wire being on the outside.

The only replaceable parts are the voltage regulator and current regulator upper contact point support brackets and armatures, and the cut-out relay armature. The upper contact point support brackets are removed by removing two screws, lock washers, and insulators. The cut-out relay armature is removed by removing two screws and lockwashers. The regulator armatures are removed by center punching the two rivet heads and drilling out the rivets with a 3/32" drill. Support frame to avoid bending it. Assemble new armature in place with screws, lock washers and nuts supplied with the service armature. Refer to illustration for relationship of upper contact point support brackets, screws, washers, insulators and connector strap when installing new brackets on the current-and-voltage regulator.

Cutout relay check and adjustment.

The cutout relay is checked and adjusted as outlined under Two-core Voltage Regulator.



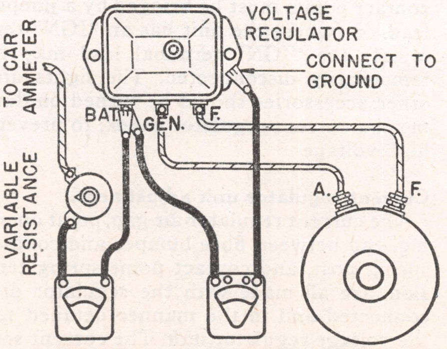
TWO & THREE ELEMENT REGULATORS. Single core type. Showing meter connections for checking voltage regulator setting by the fixed resistance method.

Voltage regulator unit check.

Two methods of checking the voltage regulator setting may be used, the fixed resistance method, and the variable resistance method.

With the fixed resistance method, disconnect the lead from the regulator "BAT" terminal and connect a fixed resistance (¾ ohm for 6-volt or 1½ ohm for 12-volt units) from the "BAT" terminal to the regulator base. Connect voltmeter from "BAT" terminal to regulator base. With regulator at operating temperature (150° F.), and with regulator cover in place, operate the generator at the speed at which it would normally produce rated output and note voltage setting.

With the variable resistance method, connect in series into the charging circuit at the regulator "BAT" terminal a ¼ ohm variable resistance and an ammeter. Connect voltmeter from "BAT" terminal to regulator base. Increase generator speed to value at which it would normally produce rated output. Voltage reading must be taken at 8-10 amperes. Cut in resistance to obtain this output. If less than 8 amperes is obtained, turn on lights and then cut in resistance. Note voltage setting. Regulator must be at operating temperature (150° F.) and cover must be in place.



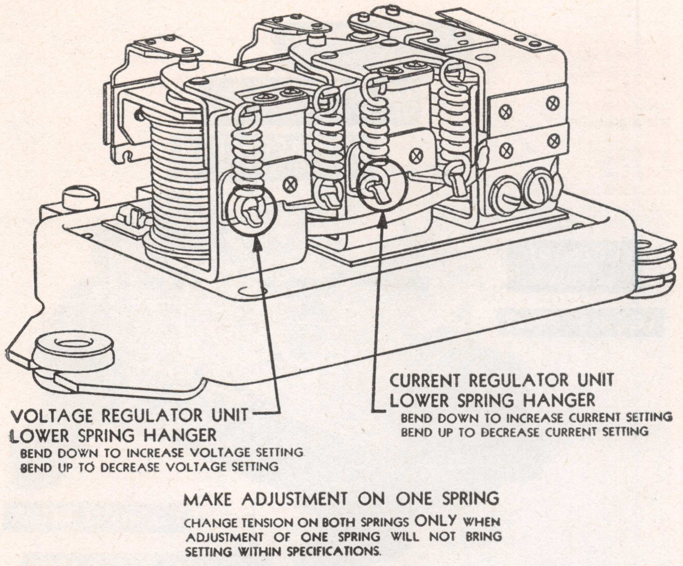
TWO & THREE ELEMENT REGULATORS. Single core type. Showing meter connections for checking voltage regulator setting by the variable resistance method.

Voltage regulator unit adjustment.

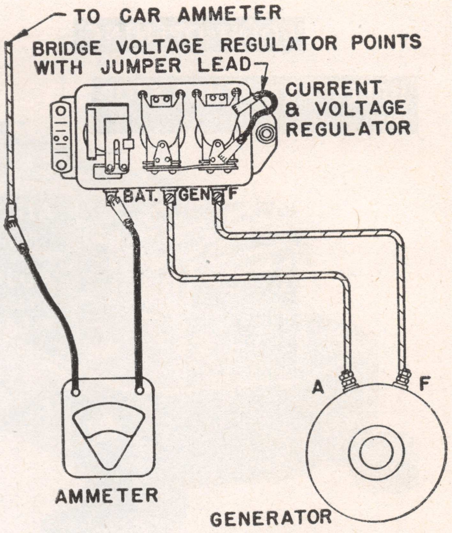
Disconnect voltage regulator and adjust as follows:

Air gap is checked with the armature pushed down, then released so that the points just come together, or just touch. The air gap is measured between the armature and the center of the winding core. It is adjusted by loosening the two contact the upper contact support bracket as required. Be sure the points align, and tighten screws after adjustment.

Voltage setting is checked as outlined above, by either the fixed resistance, or variable resistance method. It is adjusted by bending the lower spring hanger of one spring only. Bend down to increase spiral spring tension and voltage setting. Bend up to lower voltage setting. Adjustment should usually be confined to one spring only. If springs have been removed, or major adjustment is required, install one spring only and adjust to one half the specified voltage setting, install second spring and complete voltage setting adjustment on second spring only, to specified value. When installing and adjusting first spring, the generator speed must be kept to a fairly low value. To obtain this value of generator speed, connect voltmeter from regulator "GEN" terminal to regulator base, open regulator points by hand and slowly increase generator speed until 3 volts is obtained (6 volts on 12-volt system). Hold speed to this value, release armature and make adjustment to first spring. When ½ total specified voltage is obtained by adjusting first spring, reconnect voltmeter as above for fixed or variable resistance method, install and complete check and adjustment on second spring only. In making final adjustment, remember that the cover must be in place and the unit must be at operating temperature when the voltage reading is noted. Also, on the variable resistance method, the variable resistance must be re-


VOLTAGE REGULATOR UNIT
LOWER SPRING HANGER
BEND DOWN TO INCREASE VOLTAGE SETTING
BEND UP TO DECREASE VOLTAGE SETTING
CURRENT REGULATOR UNIT
LOWER SPRING HANGER
BEND DOWN TO INCREASE CURRENT SETTING
BEND UP TO DECREASE CURRENT SETTING
MAKE ADJUSTMENT ON ONE SPRING
CHANGE TENSION ON BOTH SPRINGS ONLY WHEN ADJUSTMENT OF ONE SPRING WILL NOT BRING SETTING WITHIN SPECIFICATIONS.

CURRENT & VOLTAGE REGULATORS. Single core type. Showing current and voltage regulator electrical setting adjustments.


TO CAR AMMETER
BRIDGE VOLTAGE REGULATOR POINTS WITH JUMPER LEAD
CURRENT & VOLTAGE REGULATOR
BAT.
GEN
F
A
F
AMMETER
GENERATOR

CURRENT & VOLTAGE REGULATORS. Single core type. Showing ammeter connections to check current regulator setting. Jumper lead is connected across voltage regulator contact points to prevent voltage regulator from operating.

adjusted with each adjustment of the voltage setting, to maintain the 8-10 ampere rate in the line.

Current regulator unit check.

When the regulator incorporates a current regulator unit, the current regulator unit current setting should be checked by connecting an ammeter into the circuit at the regulator "BAT" terminal, operating the generator at medium speed, and noting the current setting. During this check, the voltage regulator must not operate, therefore the voltage regulator contact points may be bridged with a jumper lead during the test. Lights and other accessories must be turned on to avoid high voltage.

Current regulator unit adjustment.

The current regulator air gap is checked and adjusted as for the voltage regulator. The current setting is checked as explained in the previous paragraph, and adjusted by bending the spring hanger of one spiral spring up to lower the spiral spring tension and reduce the current setting, or down to increase the current setting. Confine adjustment to one spring only, unless spring replacement is required, or unless the unit is badly out of adjustment. In that case, install one spring only, and adjust current setting to one half total specified value, then install second spring and complete adjustment on it to specified value, without again touching first spring. This insures that each spring will carry approximately one half the total required tension.

HEAVY-DUTY VOLTAGE REGULATOR
HEAVY-DUTY CURRENT-AND-VOLTAGE REGULATOR

5524 to 5538, 5561 to 5570, 5604 to 5649, 1118451 to 1118490

The heavy-duty voltage regulator (two-unit regulator) and the heavy-duty current-and-voltage regulator (three-unit regulator) will be considered together, since they are checked and adjusted in a similar manner. Only a few of the heavy-duty voltage regulators are in operation, most heavy-duty applications use the heavy-duty current-and-voltage regulator. Discussion below will be largely based on the latter unit.

The heavy-duty voltage regulator unit, current regulator unit, and cut-out relay, are all mounted on the same base and enclosed by the same cover. These units can be disassembled down to component windings, so that nearly all parts are serviceable items.

It is extremely necessary in working on this type regulator, to note the exact locations of all leads and lead connections, since mis-connecting leads on reassembly will cause improper operation of the regulator, with possible damage to the regulator, generator, and battery after reinstallation on the vehicle.

To disassemble, remove cover and detach fibre mounting plate with three units on it by removing attaching screws, washers and lock washers. Some applications use a jumper lead between the voltage regulator frame and cut-out relay lower contact bracket. This must be unsoldered and removed if further disassembly is to be made. The heavy leads between the cut-out relay, current regulator, and voltage regulator units are connected together in clamping brackets mounted in the mounting plate. Besides being fastened with screws and lockwashers, the leads may also be soldered, and to disconnect the leads, they must first be unsoldered before the screws can be removed. Other leads between the units and from the units to the mounting plate, should be disconnected. The cut-out relay, current regulator, and voltage regulator units can then be detached from the mounting plate by unscrewing from the under side, the attaching nuts and lockwashers.

The cutout relay unit can be further disassembled by removing the spiral spring, armature, attaching screws and the armature. The contact bracket may be removed by unsoldering the leads, and removing the attaching screws. The "U" shaped bracket at the top of the unit may now be removed. Unscrewing the attaching nut at the bottom of the relay frame permits removal of the winding assembly. Cut-out relay series winding may be removed by detaching the round fibre washer from the bottom of the winding core.

The current regulator unit may be disassembled by removing the spiral spring, the two armature attaching screws and the armature. Removing the four upper contact supporting plate attaching screws permits detaching of the plate (after disconnecting lead). Plate mounting bracket may be removed. Contact screw may be removed from its supporting plate by loosening the locking nut and backing out the contact screw. Winding assembly may be detached from the regulator frame by unscrewing attaching nut. Series winding can be removed from winding assembly by removing round insulating washer.

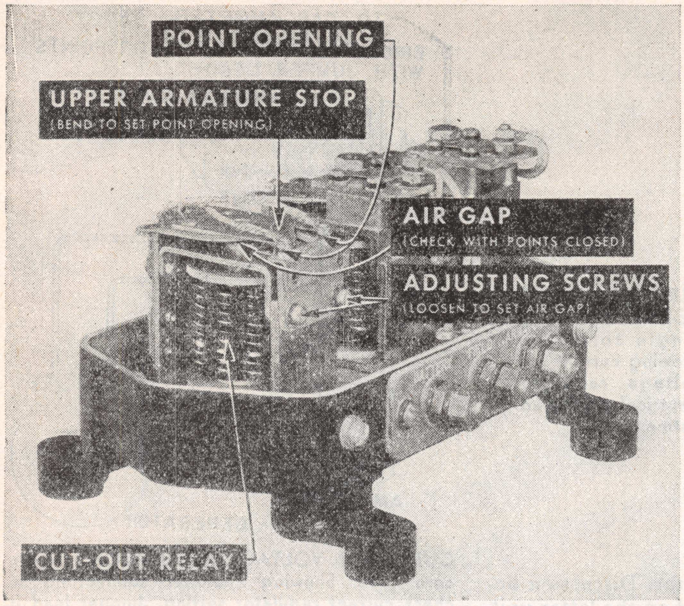
The voltage regulator unit is disassembled in the manner detailed for the current regulator, with the exception that the voltage regulator winding assembly cannot be disassembled, as it is serviced as a unit.

Reassembly is the reverse of the above. Care must be taken to reconnect all leads correctly. Use rosin flux to make soldered connections.

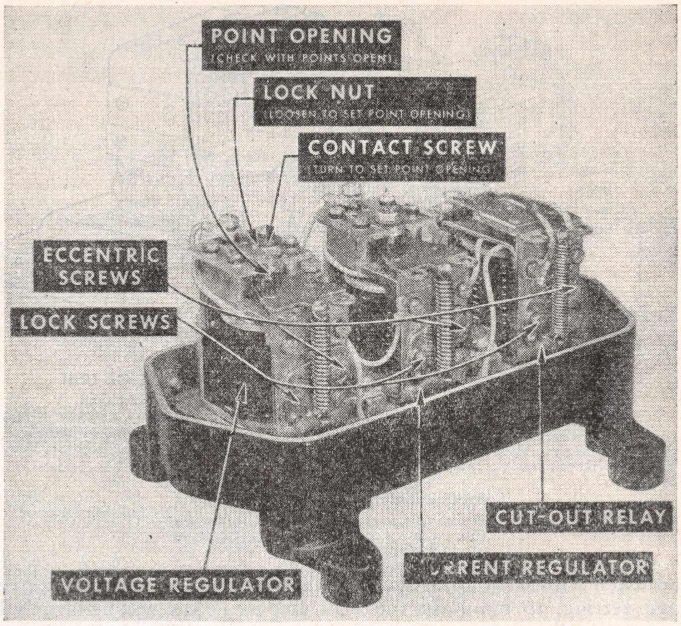
Cutout relay check.

With the regulator connected to the proper generator and battery in the normal manner, connect a voltmeter from the regulator "ARMATURE" terminal to the regulator ground screw.

Slowly increase generator speed and note the cutout relay closing voltage. If the rent necessary to open the points. If the voltage regulator is out of adjustment, it may operate to prevent the voltage from reaching a value sufficient to operate the cutout relay. Under such conditions, a jumper lead may be placed across the voltage regulator contact points to prevent it from operating. Avoid excessive generator speed.

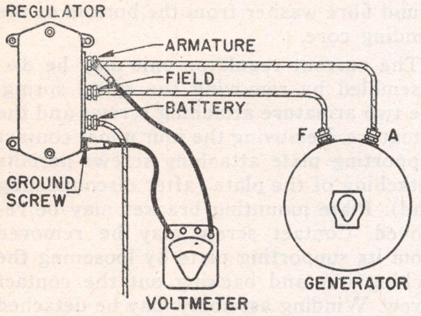

POINT OPENING
UPPER ARMATURE STOP
(BEND TO SET POINT OPENING)
AIR GAP
(CHECK WITH POINTS CLOSED)
ADJUSTING SCREWS
(LOOSEN TO SET AIR GAP)
CUT-OUT RELAY

CURRENT & VOLTAGE REGULATORS. Heavy duty type. Showing cut-out relay mechanical adjustments.


POINT OPENING
(CHECK WITH POINTS OPEN)
LOCK NUT
(LOOSEN TO SET POINT OPENING)
CONTACT SCREW
(TURN TO SET POINT OPENING)
ECCENTRIC SCREWS
LOCK SCREWS
CUT-OUT RELAY
VOLTAGE REGULATOR
RENT REGULATOR

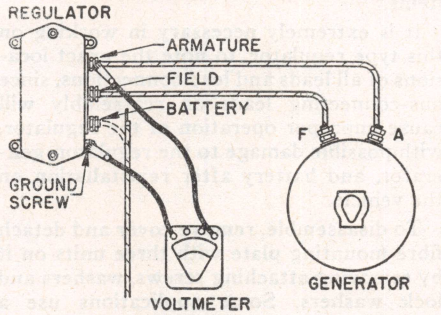
TWO & THREE ELEMENT REGULATORS. Heavy duty type. Showing relay and regulator electrical adjustments, and regulator point opening adjustment.

RELAY CLOSING VOLTAGE CHECK


REGULATOR
ARMATURE
FIELD
BATTERY
GROUND SCREW
F
A
VOLTMETER
GENERATOR

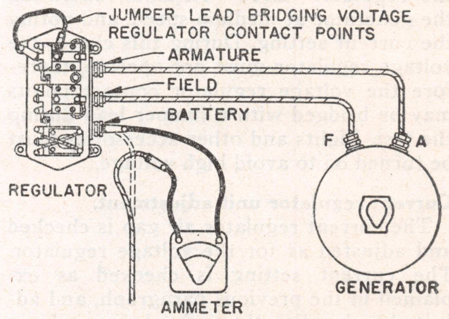
TWO & THREE ELEMENT REGULATORS. Heavy duty type. Showing meter connections to check cut-out relay closing voltage, and reverse current to open the relay contact points.

VOLTAGE REGULATOR CHECK


REGULATOR
ARMATURE
FIELD
BATTERY
GROUND SCREW
F
A
VOLTMETER
GENERATOR

CURRENT & VOLTAGE REGULATORS. Heavy duty type. Showing meter connections to check setting of voltage regulator.

CURRENT REGULATOR CHECK


JUMPER LEAD BRIDGING VOLTAGE REGULATOR CONTACT POINTS
ARMATURE
FIELD
BATTERY
REGULATOR
F
A
AMMETER
GENERATOR

CURRENT & VOLTAGE REGULATORS. Heavy duty type.

Cutout relay adjustment.

Disconnect regulator and adjust relay as follows:

Air gap is checked with contact points closed, and is measured between the armature and the winding core. It is adjusted by loosening the two screws attaching the lower contact bracket, and lowering or raising the contact bracket as required. Be sure points are lined up and tighten screws after adjustment.

Point opening is checked with points open, and is adjusted by bending the upper armature stop. If all points do not close at the same instant, either realign lower contact bracket, or slightly bend the spring fingers.

Closing voltage is checked with voltmeter connected as above, and is adjusted by loosening the locking screw and turning the eccentric to increase or lower the spiral spring tension. Increasing tension raises the closing voltage.

Voltage regulator unit check.

With the regulator connected to the proper generator in the normal manner and with the lead disconnected from the regulator "BATTERY" terminal so the regulator operates open circuit, connect a voltmeter from the regulator "ARMATURE" terminal to the ground screw. With generator operating at medium speed, note the voltage setting. The regulator must be at operating temperature.

Voltage regulator unit adjustment.

Disconnect regulator and adjust voltage regulator unit as follows:

Point opening is checked with the armature held down against the winding core. It is adjusted by loosening the lock nut and turning the contact screw. Care must be taken to avoid bending the flat springs upon which is mounted the contact screw. The spring rises slightly above the fiber insulator when the points come together, to provide a wiping action between the points so that better contact is maintained.

Voltage setting is checked as above, and is adjusted by loosening the lock screw and turning the eccentric to change the spiral spring tension. Increasing the tension increases the voltage setting.

Current regulator unit check.

The voltage regulator unit must not operate during the current regulator unit check. Therefore, a jumper lead must be placed across the voltage regulator contact points. With the regulator connected to the proper generator and battery in the normal manner, and with the jumper lead in place, insert an ammeter into the charging circuit at the regulator "BATTERY" terminal. Turn on lights and other accessories to avoid high voltage, operate generator at medium speed and note the current regulator setting.

A second method of checking the current regulator setting is to connect a load across the battery—such as a bank of lights—which is equal to the current regulator setting. With this set-up, the voltage will not increase enough to cause the voltage regulator to operate as generator speed increases

Current regulator unit adjustment.

The point opening of the current regulator is checked and adjusted in the same manner as for the voltage regulator unit.

Current setting is adjusted by loosening the lock screw and turning the eccentric to change the spiral spring tension. Increasing the spring tension increases the current setting.

FORD

GENERATOR OUTPUT REGULATORS

Ford has supplied three types of generator output regulators since 1936, the two rate relay (step-voltage control or two-charge regulator), the voltage regulator, and the current and voltage regulator.

TWO RATE RELAY

The two rate relay, also known as the step-voltage control or two-charge regulator, combines a cut-out relay and the two rate relay into one assembly. The two rate relay reduces the charging rate to about 20% of the maximum when the generator voltage reaches approximately 8.5 volts.

The entire assembly should be replaced if faulty operation is noted. The two units are checked as below.

Cut-Out Relay Check: With relay mounted and connected in a normal manner to the proper generator and battery, connect a test voltmeter from the negative armature brush (insulated main brush) of the generator to the generator frame. Slowly increase generator speed and note closing voltage of cut-out relay. Repeat test several times.

Two Rate Relay Check: With relay mounted and connected in normal manner to the proper generator and battery, and with test voltmeter connected as in previous paragraph, slowly increase generator speed. The two rate relay should limit the maximum voltage to 8.5 volts. If the battery is in a discharged condition so that the voltage does not increase sufficiently to cause the two rate relay to operate, insert a variable resistance into the charging circuit and cut in resistance until the voltage increases enough to operate the unit.

VOLTAGE REGULATOR CURRENT & VOLTAGE REGULATOR

The voltage regulator unit mounts on the same base with the cut-out relay. Later applications use a three unit (current and voltage) regulator, and they all mount on the same base and are enclosed by the same cover. These regulators are to be serviced as assemblies, and no disassembly is normally required.

Current & Voltage Regulator Operation: The regulator contact points are normally closed and the generator fields are subjected to full generator voltage. Field current with the regulator points closed is controlled by the generator voltage which in turn is controlled by the battery voltage, resistance of the circuit and the load. The opening voltage varies with different temperatures but, when at a given temperature the points open, the field current must pass through a series of resistances thus reducing the field current. With the field current reduced, the generator voltage drops and the regulator points again close, the voltage again rises and the points open, thus completing a cycle of operation. The greater the load or the lower the state of charge of the battery, the longer the points will remain closed for each cycle and the greater the charging current. When the battery becomes fully charged or the load is reduced, the regulator points open sooner and the length of the cycle is reduced, thus reducing the charging current. With a fully charged battery the generator output may be as low as 6 or 7 amperes when only the ignition is on. It may be as high as 30 to 35 amperes with a low battery and maximum load.

SPECIFICATIONS

CUTOUT RELAY

Points close (volts)	7.0
Points close (armature rpm.)	510
Points open, reverse current at 60° (amp.)	5.5
Points open, reverse current at 100° (amp.)	4.0

VOLTAGE REGULATOR

Operating voltage at 70°	7-7.6

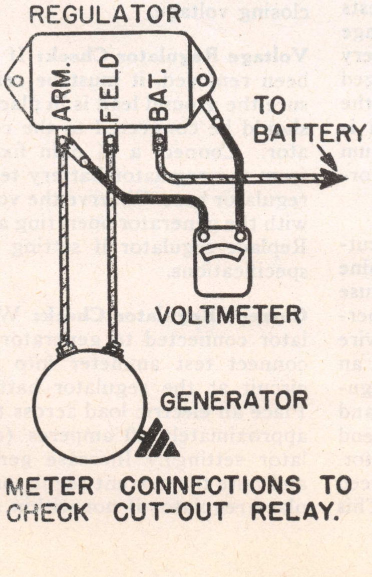
CURRENT REGULATOR

Operating amperage	30

Regulator, Test: As the point of regulation varies with the temperature of the regulator, some means of determining the temperature of a regulator must be used. There are various ways of doing this, but one method is to fasten an accurate thermometer to the regulator with adhesive tape so that the bulb contacts the regulator case.

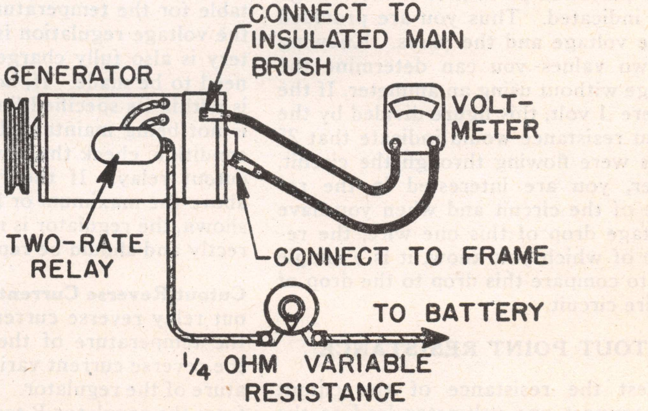
Voltage Drop: Test the voltage drop of the ground circuit by connecting one voltmeter lead to the generator ground brush or the generator frame. Increase the engine speed to a point where the battery gauge starts to read in the normal sector. Then connect the other voltmeter lead to the positive battery post. If the reading is in excess of .1 volt either the battery or the generator is not properly grounded and the condition must be corrected.

Battery Circuit Resistance: Now test the resistance of the generator battery circuit. Set the engine speed so that the battery gauge reads in the normal sector of the dial. Connect a voltmeter lead to the wire connected to the generator A terminal. Connect the other voltmeter lead to the wire at the G terminal on the regulator, which is the other end of the wire running from the generator armature terminal to the regulator. Read the voltage drop for this wire. Without disturbing the engine

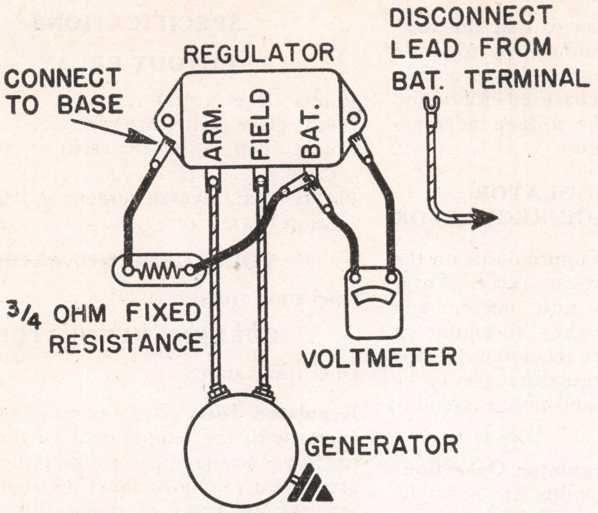


METER CONNECTIONS TO CHECK CUT-OUT RELAY.

FORD

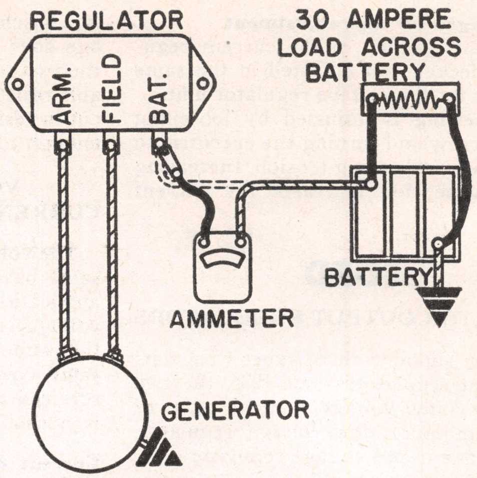


METER CONNECTIONS TO CHECK CUT-OUT RELAY AND TWO-RATE RELAY. USE VARIABLE RESISTANCE IN TWO-RATE RELAY CHECK WHEN BATTERY IS LOW.



METER AND RESISTANCE CONNECTIONS TO CHECK VOLTAGE REGULATOR.

FORD



METER CONNECTIONS TO CHECK CURRENT REGULATOR.

speed, connect the voltmeter lead at the regulator to the negative post of the battery and observe the reading. This reading should not be greater than 6½ times the voltage drop of the wire. If the reading is higher than this there is high resistance in the circuit which must be removed to prevent damage to the generator. If the voltage drop is excessive, check the voltage regulator unit.

If the reading is below this amount, the resistance of this circuit is normal. Then gradually decrease the generator speed and observe the speed at which the cutout points open. After this, gradually increase the generator speed and observe the speed at which the cutout points close. Repeat this opening and closing test several times.

The size of the wire running from the generator A terminal to the regulator G terminal is No. 10. The resistance of this size wire is .001 ohm per foot. The length of this wire is approximately 4 feet and therefore its resistance is .004 ohm. Knowing the resistance of this wire, when a voltmeter is placed in parallel to it the voltage drop is indicated. Thus you are provided with the voltage and the ohms. Knowing these two values you can determine the amperage without using an ammeter. If the drop were .1 volt, this figure divided by the .004 ohm resistance would indicate that 25 amperes were flowing through the circuit. However, you are interested in the resistance of the circuit and when you have the voltage drop of this one wire, the resistance of which you know, it is a simple matter to compare this drop to the drop of the entire circuit.

CUTOUT POINT RESISTANCE

To test the resistance of the cutout points, connect one voltmeter lead to the B terminal of the regulator and connect the other voltmeter lead to the regulator G terminal or to the armature brush. Speed up the engine so that the generator is charging at its maximum rate. Any reading above ½ volt indicates that the cutout points are burned and the regulator should be replaced. If the reading is less than ½ volt but over ¼ volt, more than normal resistance of the cutout points is indicated. When this condition exists, the cutout will eventually fail but it is not necessary to replace it at that time unless the resistance of the generator to battery circuit is not correct.

REGULATOR TEMPERATURE

Now determine the temperature of the regulator and check its operation. Connect one voltmeter lead to the regulator B terminal and ground the other voltmeter lead. Start the engine and set the throttle so that engine speed is 900 rpm. Disconnect the battery ground connection. This will break the circuit and the only complete circuit will be through the voltmeter, which has considerable resistance, and the ignition circuit. The generator voltage will increase, trying to overcome this resistance. If the reading obtained is between the maximum and the minimum indicated in the table for the temperature of the regulator, the voltage regulation is okeh. If the battery is also fully charged, no further tests need to be made. If, however, the voltage is within its specified limits but the battery is not being maintained in a fully charged condition, check the reverse current of the cutout relay. If the reading obtained is above the maximum or below the minimum shown, the regulator is not functioning correctly and should be replaced.

Cutout Reverse Current: To check the cutout relay reverse current, again determine the temperature of the regulator because the reverse current varies with the temperature of the regulator. Disconnect the wire from the regulator B terminal. Connect an ammeter lead to the B terminal of the regulator from which the wire was removed and connect the other ammeter lead to the end of the wire removed from the regulator. Start the engine and increase the speed until the cutout relay points just close. This will be indicated by a reverse reading of the meter. Slowly and evenly reduce the engine speed until a positive reading is obtained on the meter. Continue to reduce the speed until the points open. This will be indicated by the reading falling to zero. The highest reading obtained before the points opened is the amperage of the reverse current required to open the cutout relay points.

If the reverse current exceeds the amount shown, the regulator should be replaced or trouble will be experienced in maintaining the battery in its fully charged condition. If the cutout relay reverse current is not excessive and you are still unable to account for the battery not being fully charged, test the generator.

Cutout Relay Check: With the regulator connected in a normal manner to the proper generator and battery, connect a voltmeter from the regulator armature terminal to the regulator base. Increase generator speed slowly and note closing voltage of the cutout relay. Adjust if necessary by removing the regulator cover and bending in on the bimetal clip at the back of the relay to increase the spring tension and raise the cutout relay closing voltage. Bend out on the bimetal clip to lower the cutout relay closing voltage.

Voltage Regulator Check: If the cover has been removed, it must be reinstalled. Be sure the ground lead is in place. Regulator should be connected to the correct generator. Connect a ¾ ohm fixed resistance from the regulator battery terminal to the regulator base. Observe the voltage reading with the generator operating at 2300 R.P.M. Replace regulator if setting is not within specifications.

Current Regulator Check: With the regulator connected to generator and battery, connect test ammeter into the charging circuit at the regulator battery terminal. Place an electric load across the battery of approximately 30 amperes (current regulator setting). Increase generator speed and note the current regulator setting. Replace regulator if not within specifications

GENERATOR AND REGULATOR INDEX

Generator Number	Regulator Number	Setting Key Type①	Generator Number	Regulator Number	Setting Key Type①	Generator Number	Regulator Number	Setting Key Type①
628G	628R	528G	1382G	1382R	1079G	1579G	1579R	1579G
629G	629R	528G	1394G	1394R	1042G	1582G	1582R	1582G
1063G	1063R	1063G	1397G	1397R	1246G	1602G	1602R	1693G
1079G	1079R	1079G	1408G	1408R	1300G	1613G	1613R	1602G
1081G	1081R	1042G	1412G	1412R	1412G	1616G	1616R	1504G
1083G	1083R	1042G	1419G	1419R	1419G	1616GA	1616R	1504G
1088G	13CC6	1089G	1420G	13LC24	1275G	1618G	1618R	1486G
1134G	1134R	1042G	1421G	13LC24	1275G	1620G	1620R	1504G
1135G	1135R	1042G	1422G	1422R	1422G	1628G	13CC12	397G
1183G	1183R	1579G	1424G	1424R	1424G	1630G	1630R	1630G
1218G	1218R	1217G	1426G	1426R	1246G	1636G	1636R	1486G
1221G	1221R	1221G	1429G	1429R	1429G	1638G	1638R	1042G
1222G	1222R	1888G	1430G	1430R	1430G	1647G	1647R	1641G
1232G	1232R	1010G	1434G	13CC6	1089G	1651G	1651R	1486G
1233G	1233R	1010G	1438G	1438R	1439G	1652G	1652R	1534G
1234G	1234R	1010G	1442G	1442R	1079G	1654G	1654R	1504G
1235G	1235R	1010G	1444G	1444R	1444G	1656G	1656R	1656G
1238G	1238R	1238G	1452G	1452R	1452G	1665G	13LC24	1439G
1248G	1248R	1300G	1455G	13LC24	1439G	1673G	1673R	1430G
1250G	1250R	1250G	1462G	1462R	1462G	1691G	1691R	1691G
1267G	1267R	1010G	1470G	1470R	1424G	1693G	1693R	1693G
1268G	1268R	1010G	1479G	13LC24	1479G	1697G	1697R	1691G
1274G	1274R	1406G	1485G	1485R	1486G	1703G	1703R	1703G
1275G	13LC24	1406G	1486G	1486R	1486G	1707G	1707R	1490G
1276G	1276R	1262G	1503G	1503R	1262G	1740G	1740R	1740G
1277G	1277R	1262G	1506G	1506R	1506G	1740G2	1740R2	1740G
1302G	1302R	1300G	1509G	1509R	997G	1747G	1747R	1740G
1304G	1304R	1063G	1510G	1510R	1510G	1748G	1748R	1246G
1315G	1315R	1315G	1512G	1512R	1486G	1749G	1749R	1246G
1321G	1321R	1320G	1518G	1518R	1486G	1751G	1751R	1750G
1323G	1323R	1273G	1526G	1526R	1262G	1780G	1780R	1042G
1338G	1338R	1262G	1530G	1530R	1528G	1789G	1789R	1042G
1342G	13CC12	1342G	1532G	1532R	1412G	1830G	1830R	1246G
1344G	13CC12	1342G	1534G	1534R	1534G	1831G	1831R	1246G
1366G	1366R	1262G	1542G	1542R	997G	1952G	1952R	1953G
1370G	1370R	868G	1550G	1550R	1528G	1953G	1953R	1953G
1372G	1372R	1262G	1553G	1553R	1553G	1962G	1962R	1962G
1373G	1373R	1262G	1554G	1554R	1490G	1990G	1990R	1042G
1376G	1376R	1262G	1555G	1555R	1490G	1992G	1992R	1273G
1377G	1377R	1262G	1572G	1572R	1246G	1994G	1994R	1732G
						2106G	2106R	1490G

① For setting key specifications, see the "Generator Specifications" table on page 660.

LOAD LIMITER SPECIFICATIONS

(Three element regulators)

Setting Key Type	Maximum Output, Amperes	Generator R. P. M.	Volts	Field Amperes	Minimum Battery Gravity	Point Gap, Inch	Armature Air Gap, Inch	Temperature Setting	Remarks
868G	30–31	1500	13–14	.8–.9	1.250	.015–.018	.015–.020⑥	Hot	①
1217G	50–52	2000	31.5	1.00–1.15	1.250	.025–.030	.050–.055⑥	Hot	③
1217G	50–52	2000	34	1.11	1.250	.025–.030	.027–.033⑥	Hot	④
1221G	70–72	2000	14.0–14.2	.9–1.1	1.110⑦	.027–.030	.045–.060⑥	Hot	⑤
1300G	40–41	2500	14.5–15.0	1.0–1.2	1.250	.015–.018	.015–.020⑥	Hot	①
1419G	40–41	1000	12.6–12.8	1.5–1.6	1.200⑧	.015–.018	.015–.020⑥	Hot	
1422G	36–38	2500	---------	.7–.8	1.250	.015–.018	.015–.020⑥	Hot	①
1429G	40–41	2500	15.4	.7–.8	1.250⑨	.015–.018	.015–.020⑥	Hot	①
1430G	40–41	2500	13.5–14.0	1.00–1.05	1.250	.015–.018	.015–.020⑥	Hot	②
1444G	40–41	2500	13–14	.55–.65	1.250	.015–.018	.013–.020⑥	Hot	①
1452G	50–51	2000	7.5–7.7	1.00–1.05	1.250	.015–.018	.015–.020⑥	Hot	②
1462G	25–26	2500	13–14	.7–.8	1.250	.015–.018	.015–.020⑥	Hot	②
1486G	40–41	2500	13.5–14.0	1.00–1.05	1.250	.015–.018	.015–.020⑥	Hot	②
1490G	30–31	1500	13–14	1.0–1.1	1.250	.015–.018	.015–.020⑥	Hot	②
1504G	50–51	2000	7.5–7.7	1.0–1.05	1.250	.015–.018	.015–.020⑥	Hot	②
1506G	40–41	2500	13–14	.55–.65	1.250	.015–.018	.013–.020⑥	Hot	②
1510G	30–31	2500	13.8–14.2	.80–.90	1.250	.015–.018	.015–.020⑥	Hot	②
1528G	25–26	2000	33–33.5	.65–.75	1.250	.025–.030	.023–.028⑥	Hot	③
1528G	25–26	2000	34	.70	1.250	.025–.030	.023–.028⑥	Hot	④
1534G	30–31	2500	13.0–13.5	.70–.80	1.250	.015–.018	.015–.018⑥	Hot	②
1553G	25–26	2000	24.5–25.0	.40–.42	1.250	.015–.018	.015–.020⑥	Hot	①
1579G	25–26	2500	13.0–14.0	.55–.65	1.250	.015–.018	.015–.020⑥	Hot	②
1582G	25–26	2500	13.0–14.0	.55–.65	1.250	.015–.018	.015–.020⑥	Hot	②
1602G	50–51	2500	13.0–14.0	.75–.90	1.250	.015–.018	.013–.020⑥	Hot	②
1630G	50–51	2500	13–14	.60–.70	1.250	.015–.018	.013–.020⑥	Hot	②
1641G	15–16	2500	13–14	.4–.5	1.250	.015–.018	.015–.020⑥	Hot	②
1656G	40–41	2500	13.5–14.0	1.00–1.05	1.250	.015–.018	.015–.020⑥	Hot	②
1691G	40–41	2500	13–14	1.2–1.3	1.250	.015–.018	.013–.020⑥	Hot	①
1693G	60–61	2500	13–14	1.30–1.40	1.250	.015–.018	.013–.020⑥	Hot	②
1703G	19–20	1500	14–14.5	1.0–1.1	1.250	.015–.018	.015–.020⑥	Hot	②
1750G	19–20	1500	14–14.5	1.0–1.1	1.250	.015–.018	.015–.020⑥	Hot	②
1888G	69–70	1500	12.1–12.3	1.70–1.91	1.200	.022–.025	.014–.015⑥	Hot	①

① Regulator points held closed.

② Upper regulator points held closed.

③ Set for 15 cells of battery. Regulator points held closed.

④ Set for 16 cells of battery. Regulator points held closed.

⑤ Hot after 1 hour at 50 amperes. Regulator points held closed. ⑥ Open. ⑦ To 1.200. ⑧ To 1.225. ⑨ To 1.275.

VOLTAGE REGULATOR SPECIFICATIONS

(Two and three element regulators)

Setting Key Type	Open Circuit Voltage	Generator R. P. M.①	Field Amperes	Point Gap, Inch	Armature Air Gap, Inch	Remarks
528G	14.4–14.6	2500	.27–.33	.020–.025	.021–.025	②
528G	14.7–14.9	2500	.27–.33	.020–.025	.021–.025	③
868G	14.0–14.2	2000	.25–.35	.018–.020⑥	.015–.020⑦	--
997G	28.4–28.6	2000	-------	.020–.025	.050–.055	②
1010G	14.4–14.6	2500	.40–.45	.020–.025	.021–.026⑩	②

① At generator speed shown, current output should be zero.

② Do not set cold.

③ Cold setting for checking only.

④ Set for 15 cells of battery.

⑤ Set for 16 cells of battery.

Continued on next page

Continued from previous page

VOLTAGE REGULATOR SPECIFICATIONS

(Two and three element regulators)

Setting Key Type	Open Circuit Voltage	Generator R. P. M.①	Field Amperes	Point Gap, Inch	Armature Air Gap, Inch	Remarks
1042G	35.5–36.0	2500	.20–.30	.020–.025	.062–.065⑩	⑬
1042G	38.0–38.5	2500	.2–.3	.020–.025	.062–.065⑩	⑭
1063G	7.5–7.7	2500	.4–.5	.020–.025	.021–.026⑩	②
1079G	14.0–14.2	2000	.45–.55	.018–.020⑥	.015–.020⑦	②
1217G	35.5–36.0	2500	.30–.35	.027–.030	.027–.033⑩	⑬
1217G	35.5–36.0	2500	.30–.35	.027–.030	.027–.033	⑤
1221G	14.5–14.7	2500	.10–.15	.020–.025	.027–.033⑩	②
1238G	7.4–7.6	1500	.22–.24	.020–.025	.021–.025⑩	②
1246G	14.4–14.6	2500	.35–.40	.020–.025	.021–.026⑩	②
1250G	14.4–14.6	2500	.9–1.0	.020–.025	.021–.026⑩	②
1262G	28.4–28.6	2500	.20–.25	.020–.025	.027–.033⑩	②
1273G	35.5–36.0	2500	.35–.40	.045–.051	.027–.033⑩	⑬
1273G	38.0–38.5	2500	.35–.40	.045–.051	.027–.033⑩	⑭
1300G	14.0–14.2	2000	.8–.9	.018–.020⑥	.015–.020⑦	②
1315G	14.4–14.6	2000	.60–.65	.020–.025	.027–.033⑩	②
1320G	35.5–36.0	2500	.35–.37	.020–.025	.027–.033⑩	②
1412G	28.4–28.6	2500	.20–.25	.020–.025	.027–.033⑩	②
1419G	14.4–14.6	2500	.30–.35	.020–.025	.027–.033⑩	②
1422G	14.5–14.7	3000	.35–.40	.020–.025	.027–.030⑩	②
1424G	7.4–7.6	2500	.45–.50	.020–.025	.021–.026⑩	②
1429G	14.5–14.7	3000	.45–.50	.020–.025	.027–.033⑩	②
1430G	14.0–14.2	2000	.35–.40	.018–.020⑥	.015–.020⑦	②
1444G	14.0–14.2	2000	.35–.40	.018–.020⑥	.015–.020⑦	②
1452G	7.4–7.5	2000	.20–.30	.018–.020⑥	.014–.015⑦	②
1462G	14.0–14.2	2000	.55–.65	.018–.020⑥	.015–.020⑦	②
1486G	14.0–14.2	2000	.35–.40	.018–.020⑥	.015–.020⑦	②
1490G	14.0–14.2	2000	.25–.30	.018–.020⑥	.015–.020⑦	②
1504G	7.4–7.5	2000	.20–.30	.018–.020⑥	.014–.015⑦	②
1506G	14.0–14.2	2000	.35–.40	.018–.020⑥	.015–.020⑦	②
1510G	14.0–14.2	2000	.75–.80	.018–.020⑥	.015–.020⑦	②
1528G	35.5–36.0	2500	.22–.27	.045–.051	.027–.033⑩	⑬
1528G	38.3–38.5	2500	.3	.045–.051	.027–.033⑩	⑭
1534G	14.0–14.2	2000	.43–.45	.018–.020⑥	.015–.020⑦	②
1553G	28.5–28.7	1500	------	.020–.025	.027–.033⑩	②
1579G	14.0–14.2	2000	.43–.45	.018–.020⑥	.015–.020⑦	②
1582G	14.0–14.2	2000	.43–.45	.018–.020⑥	.015–.020⑦	②
1602G	14.0–14.2	2000	.35–.40	.018–.020⑥	.015–.020⑦	②
1630G	14.0–14.2	2000	.60–.65	.018–.020⑥	.015–.020⑦	②
1641G	14.0–14.2	2000	.15–.20	.018–.020⑥	.015–.020⑦	②
1656G	14.0–14.2	2000	.35–.40	.018–.020⑥	.015–.020⑦	②
1691G	14.0–14.2	2000	.18–.20	.018–.020⑥	.015–.020⑦	②
1693G	14.0–14.2	2000	.35–.40	.018–.020⑥	.015–.020⑦	②
1703G	14.0–14.2	2000	.25–.30	.018–.020⑥	.015–.020⑦	②
1740G	14.4–14.6	2500	.40–.45	.020–.025	.021–.026⑩	②
1750G	14.0 14.2	2000	.25–.30	.018–.020⑥	.015–.020⑦	②
1888G	14.0–14.2	2000	.15–.20	.020–.022⑥	.032–.035⑦	②
1953G	14.0–14.2	2500	.22–.25	.018–.020⑥	.015–.020⑦	②
1962G	14.0–14.2	2000	.45–.55	.018–.020⑥	.015–.020⑦	②

⑥ Upper contacts. ⑦ Closed lower contacts.
⑧ Silver contacts. ⑨ Silver contacts held closed.
⑩ Open. ⑪ Closed.
⑫ Main contacts held closed.
⑬ Set for 15 cells of battery. Do not set cold.
⑭ Set for 16 cells of battery. Do not set cold.

CUTOUT RELAY SPECIFICATIONS

(Two and three element regulators)

Setting Key Type	Points Close at Volts	Points Open, Amperes Discharge	Point Gap, Inch	Armature Air Gap, Inch	Hinge Clearance, Inch	Temperature Setting	Remarks
1273G ⑮	---------	---	.035–.038	----------	----	----	⑬
1300G	12.0–12.3	4–8	.032–.037	.022–.025 ⑩	.005	Hot	①
1315G	12.0–12.3	5–10	.035–.045	.015–.020 ⑩	----	Hot	①
1320G ⑦	32.0–34.0	8–10	.078–.083	.016–.018 ⑩	.005	Hot	①
1320G ⑮	---------	---	.047–.052	----------	----	----	--
1412G ⑦	22.0–22.5	0–3	.070–.075	.018–.025 ⑧	.005	Hot	①
1412G ⑮	---------	---	.035–.038	----------	----	----	--
1419G	12.0–12.3	4–8	.032–.037	.022–.025 ⑩	.005	Hot	①
1422G	12.0–12.3	4–8	.032–.037	.022–.025 ⑩	.005	Hot	①
1424G	6.0–6.3	2–4	.025–.030	.015–.020 ⑩	.005	Hot	①
1429G	12.0–12.3	4–8	.032–.037	.022–.025 ⑩	.005	Hot	①
1430G	12.0–12.3	4–8	.032–.037	.022–.025 ⑩	.005	Hot	①
1444G ,	11.8–12.2	4–8	.032–.037	.022–.025 ⑩	.005	Hot	①
1452G	6.0–6.3	4–8	.032–.037	.022–.025 ⑩	.005	Hot	①
1462G	6.0–6.3	4–8	.032–.037	.020–.023 ⑩	.005	Hot	①
1486G	12.0–12.3	4–8	.032–.037	.022–.025 ⑩	.005	Hot	①
1490G	12.0–12.3	5–8	.032–.037	.020–.023 ⑩	.005	Hot	①
1504G	6.0–6.3	4–8	.032–.037	.022–.025 ⑩	.005	Hot	①
1506G	11.8–12.2	4–8	.032–.037	.022–.025 ⑩	.005	Hot	①
1510G	12.0–12.3	5–8	.032–.037	.020–.023 ⑩	.005	Hot	①
1528G	32–34	0–2	3/32–1/8	1/32–1/16 ⑩	.005	Hot	⑫
1528G ⑦	---------	---	5/32–3/16	----------	----	----	⑫
1528G	35–36	0–2	3/32–1/8	1/32–1/16 ⑩	.005	Hot	⑬
1528G ⑦	---------	---	5/32–3/16	----------	----	----	⑬
1534G	12.0–12.3	5–8	.032–.037	.020–.023 ⑩	.005	Hot	①
1553G ⑦	22.0–22.5	0–3	.070–.075	.018–.025 ⑧	.005	Hot	①
1553G ⑮	---------	---	.035–.038	----------	----	----	--
1579G	12.0–12.3	5–8	.032–.037	.020–.023 ⑩	.005	Hot	①
1582G	12.0–12.3	5–8	.032–.037	.020–.023 ⑩	.005	Hot	--
1602G	11.8–12.2	4–8	.032–.037 ⑤	.022–.025 ⑩	.005	Hot	①
1630G	11.8–12.2	4–8	.032–.037 ⑤	.022–.025 ⑩	.005	Hot	①
1641G	12.0–12.3	5–8	.032–.037 ⑤	.020–.023 ⑩	.005	Hot	①
1656G	12.0–12.3	4–8	.032–.037 ⑤	.022–.025 ⑩	.005	Hot	①
1691G	11.8–12.2	4–8	.032–.037 ⑤	.022–.025 ⑩	.005	Hot	①
1693G	11.8–12.2	4–8	.032–.037 ⑤	.022–.025 ⑩	.005	Hot	①
1703G	12.0–12.3	5–8	.032–.037 ⑤	.020–.023 ⑩	.005	Hot	①
1740G	12.5–13.0	2–4	.023–.026	.015–.020 ⑩	.005	Hot	①
1750G	12.0–12.3	5–8	.032–.037 ⑤	.020–.023 ⑩	.005	Hot	①
1888G	12.3–12.5	8–10	.032–.035	.022–.025 ⑩	----	Hot	①
1953G	12.2–12.5	2–5	.032–.035 ⑤	.018–.020 ⑩	.005	Hot	①
1962G	12.2–12.5	2–5	.032–.035 ⑤	.018–.020 ⑩	----	Hot	①

① Do not set cold.
② Cold setting for checking only.
③ Set for 15 cells of battery.
④ Set for 16 cells of battery.
⑤ Upper contacts.
⑥ Closed lower contacts.
⑦ Silver contacts.
⑧ Silver contacts held closed.
⑨ Open.
⑩ Closed.
⑪ Main contacts held closed.
⑫ Set for 15 cells of battery. Do not set cold.
⑬ Set for 16 cells of battery. Do not set cold.
⑭ Carbon contacts.
⑮ Auxiliary contacts.

CUTOUT RELAY SPECIFICATIONS

(Type used without voltage regulator)

Setting Key Type	Relay Part No.	Points Close at Volts	Points Open, Amperes Discharge	Temperature Setting	Point Gap, Inch	Armature Air Gap, Inch	Hinge Clearance, Inch	Voltage Rating	Ampere Rating
397G	13CC12	13–14	4–8	Cold	⑤	⑤	----	12–15	15
397G	13CC12	14–15	3–7	Hot	.030–.045	.025–.030	----	12–15	15
1089G	13CC6	6.5–7	3–5	Cold	⑤	⑤	----	6–7.5	20
1089G	13CC6	7.5–8	2–4	Hot	.030–.045	.020–.030	----	6–7.5	20
1275G	13CC24	27–28	0–2	Cold	.078–.083①	⑤	----	24–32	15
1275G	13CC24	28–29	0–2	Hot	.047–.052②	.026–.028	----	24–32	15
1342G	13CC12	13–14	4–8	Cold	⑤	⑤	----	12–15	15
1342G	13CC12	14–15	3–7	Hot	.030–.045	.025–.030	----	12–15	15
1406G	13LC24	22.0–22.5	½–3	Cold	.070–.075①	.018–.025	.005	24	15
1406G	13LC24	-----	---	-----	.035–.038③	④	----	24	15
1439G	15LC24	22.0–22.5	½–3	Cold	.070–.075①	.018–.025	.005	24	15
1439G	15LC24	-----	---	-----	.035–.038③	④	----	24	15
1479G	13CC24	27–28	0–2	Cold	.078–.083①	.026–.028	----	24–32	15
1479G	13CC24	28–29	0–2	Hot	.047–.053②	---------	----	24–32	15
1732G	15LC32	28.0–28.5	½–3	Cold	.070–.075①	.025–.027	.005	32	10
1732G	15LC32	-- --	--	-- --	.035–.038③	④	----	32	10

① Silver.
② Carbon.
③ Auxiliary.
④ Silver contacts held closed.
⑤ Adjust when hot.

CUTOUT RELAY SPECIFICATIONS

(Single element type)

Setting Key Type	Points Close at Volts	Points Open, Amperes Discharge	Point Gap, Inch	Armature Air Gap, Inch	Hinge Clearance, Inch	Temperature Setting	Remarks
528G	11.7–12.3	2–4	.025–.025	.021–.026⑨	----	Hot	①
528G	11.3–11.8	2–4		---------	----	Cold	--
868G	12.0–12.3	5–8	.032–.037	.020–.023	.005	Hot	--
997G⑦	22.0–22.5	0–3	.070–.075	.018–.025⑧	.005	Hot	--
997G⑭	---------	--	.035–.038	---------	-----	-----	--
1010G	12.5–13.0	2–5	.023–.026	.020–.025⑩	.005	Hot	①
1042G⑦	33–34	0–2	.078–.083	.020–.025⑩	----	Hot	⑫
1042G⑭		--	.047–.052	---------	----	----	⑫
1042G⑦	36–37	0–2	.078–.083	.020–.025⑩	----	Hot	⑬
1042G⑭	---------	--	.047–.052	---------			⑬
1063G	6–6.3	2–4	.025–.030	.015–.017⑩	.005	Hot	①
1079G	12.0–12.3	5–8	.032–.037	.020–.023⑩	.005	Hot	①
1217G⑦	28–29	½–2	.108–.112	.042–.047⑪	.030	Hot	⑫
1217G⑭	---------	--	.042–.047	---------	----	----	⑫
1217G⑦	28–29	½–2	.108–.112	.042–.047⑪	.030	Hot	⑬
1217G⑭	---------	--	.042–.047	---------	----	----	⑬
1221G⑦	13.5–13.8	10–12	.035–.045	.015–.020⑩	----	----	①
1238G	6.0–6.3	2–4	.028–.032	.015–.020⑩	.005	Hot	①
1246G	12.5–13.0	2–4	.023–.026	.015–.020⑩	.005	Hot	①
1250G	12.5–13.0	2–4	.023–.026	.015–.020⑩	.005	Hot	①

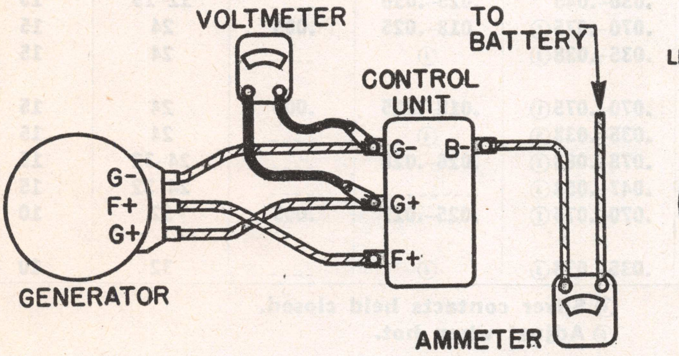
Continued on next page

Continued from previous page

CUTOUT RELAY SPECIFICATIONS

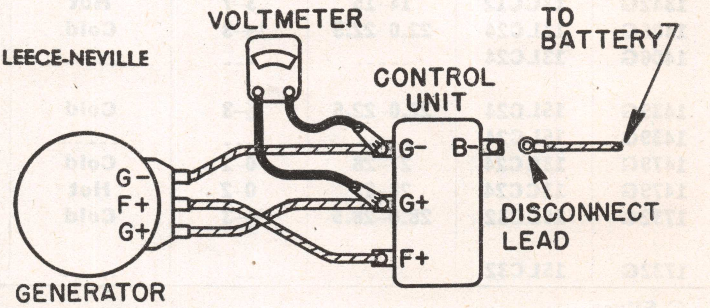
(Single element Type)

Setting Key Type	Points Close at Volts	Points Open, Amperes Discharge	Point Gap, Inch	Armature Air Gap, Inch	Hinge Clearance, Inch	Temperature Setting	Remarks
1262G⑦	27.0–27.5	0–2	.078–.083	.026–.028⑩	.010	Hot	①
1262G⑭	--------	--	.047–.052	----------	----	----	--
1273G⑦	32.0–34.0	0–2	5/32–3/16	1/32–1/16⑩	.005	Hot	㉒
1273G⑭	--------	--	3/32–1/8	----------	----	----	⑫
1273G⑦	29.0–30.0	0–4	.070–.075	.025–.027⑧	.005	Hot	⑬



BASIC METER CONNECTIONS TO CHECK CUT-OUT RELAY AND LOAD LIMITOR. MAKE METER CONNECTIONS ACCORDING TO TERMINAL MARKINGS. ON GROUNDED (ONE WIRE) SYSTEM, CONNECT ONE VOLTMETER LEAD TO GROUND.

LEECE-NEVILLE



BASIC METER CONNECTIONS TO CHECK VOLTAGE REGULATOR. MAKE METER CONNECTIONS ACCORDING TO TERMINAL MARKINGS. ON GROUNDED (ONE WIRE) SYSTEM, CONNECT ONE VOLTMETER LEAD TO GROUND.

LEECE-NEVILLE

GENERATOR OUTPUT REGULATORS

Leece-Neville generator output regulators may consist of two units, a cutout relay and voltage regulator, or three units, cutout relay, voltage regulator, and load limitor or current regulator. They are checked and adjusted as below.

Cutout Relay, Check & Adjust

The checking and adjusting procedure varies according to whether the cutout relay has single contacts, or main and auxiliary contacts. On the latter, the auxiliary contacts close first and open last, and consequently take the brunt of closing and opening the circuit between the generator and battery. The main contacts follow the auxiliary contacts in closing, and open before the auxiliary contacts.

On the single contact relay, proceed as follows:

Hinge gap is checked between the yoke and armature (ignoring the thin spring hinge) and is adjusted by loosening the armature bracket attaching screw and raising or lowering the armature bracket as required.

Contact gap is checked with the contacts open, and is adjusted by means of the upper armature stop.

Closing voltage is checked by connecting voltmeter across the generator (on generator side of relay) and slowly increasing generator speed to note relay closing voltage. Adjust by turning the adjusting nut to increase or lower the relay spiral spring tension. Increasing the tension raises the closing voltage, reducing the tension lowers it. Retest after each change of adjustment.

Reverse current to open contacts is checked by connecting a test ammeter into the charging circuit in series with the battery. After increasing generator speed until contacts close, reduce speed slowly and note reverse current at which the contacts open. Adjust, if necessary, by readjusting the closing voltage and also the gap between the core and armature when the contacts are closed. Increasing the core gap with the points closed reduces the reverse current.

On the relay with two sets of contacts, proceed as follows:

Hinge gap is checked and adjusted as for the single contact relay.

Main contact gap is checked between the main contacts when they are open. These are the contacts nearest the coil. Adjust by means of the armature stop.

Auxiliary contact gap is checked with the contacts open, and is adjusted by bending the thin spring contact carrier. Bend at a point near where it is attached, otherwise the contacts may not properly align. The auxiliary contacts close before the main contacts.

Core gap is measured when main contacts are closed, and provides a check on the armature and assembling of the stationary contact holder. If the hinge gap is correct, if the armature is not bent, and if stationary contact holder with its insulators has been properly assembled, the core gap will be correct.

Closing voltage and **reverse current to open contacts** are checked and adjusted as outlined for the single contact relay.

VOLTAGE REGULATOR CHECK & ADJUST

Some voltage regulators have a single set of contacts. Others are equipped with two sets, an outer set and an inner set. During the period of maximum voltage regulation, the regulator operates on the inner set

LEECE-NEVILLE GENERATOR REGULATORS

On the single contact voltage regulator, proceed as follows:

Core gap is measured between the armature and coil core with the contacts open. This gap is determined by the thickness of the head of the small brass pin in the armature, which should be filed to obtain the proper gap when a new armature is installed.

Contact gap is measured with the points held open, and is adjusted by loosening the lock nut and turning the contact screw.

Voltage setting is checked with the regulator operating on open circuit (lead from regulator to battery disconnected). Connect a voltmeter across the generator on the generator side of the regulator. Operate generator at specified speed and note voltage regulator setting. Adjust if necessary by turning the adjusting nut to increase or lower spiral spring tension. Increasing the spring tension increases the voltage setting. If there is a stop ring (which prevents change of setting during operation), the stop ring screw must be loosened before the adjusting nut can be turned. Put stop ring back in place and tighten screw after adjustment is completed. After each change of adjustment, open contacts momentarily before taking voltage reading. Regulator must be hot (operating temperature) and in operating position. As a final check on the setting, stop generator and then bring it back to speed.

On the double contact voltage regulator, proceed as follows:

Contact gap is measured between the outer contacts with the armature held down so the outer contacts are open.

Core gap is measured between the core and armature with the armature held down so the outer contacts are open. Both gaps are adjusted by loosening the screws which attach the inner stationary contact supporting bracket, and raising or lowering the bracket as required.

Voltage setting is checked with the regulator operating on open circuit, in the manner detailed above for the single contact voltage regulator. The regulator must be operating on the inner contacts during the voltage setting check and adjustment. After each change of adjustment, and before checking the voltage setting, stop generator and then bring it back to speed.

Load Limitor Check & Adjust

Core gap is measured between the armature and coil core with the contacts open. This gap is determined by the thickness of the head of the small brass pin in the armature, which should be filed to obtain the proper gap when a new armature is installed.

Contact gap is measured with contacts held open, and is adjusted by loosening the lock nut and turning the contact screw.

Current setting is checked with a test ammeter connected into the charging circuit in series with the battery. Operate generator at specified speed. Momentarily hold the voltage regulator contacts closed (outer points on double contact voltage regulator) so that voltage regulator cannot operate. The current will increase to the current setting of the load limitor. Adjust by turning the adjusting nut to increase or reduce the spiral spring tension. Increasing the spring tension increases the current setting. If there is a stop ring, the stop ring screw must be loosened before the adjusting nut can be turned. After adjustment is completed, stop ring should be put back in place and screw tightened.

BORG & BECK

MODELS 8A7, 9A3, 9A6, 9A7, 10A3, 10A4, 10A6, 10A7, 11A3, 11A5, 11A6

These models are of the single plate, dry disc type with no internal provision for adjustment for wear. However, each release lever is adjusted individually to the correct height, and no attempt should be made to adjust these levers unless the clutch is to be dismantled for overhaul.

As the clutch facings wear, the pressure plate moves closer to the flywheel face, and the outer ends of the release levers follow. This causes the inner ends of the levers to travel farther toward the transmission and decreases the clearance between the release levers and the release bearing. This will decrease the clutch pedal free travel, which must be maintained in order to prevent the clutch pedal from riding on the toe board, causing the clutch to slip. The clearance between the toe board and the point where the release levers contact the release bearing should be maintained according to the vehicle manufacturers' specifications, but if these are not available, allow from 1" to 1½" free travel.

CLUTCH, OVERHAUL

Remove the clutch assembly from the chassis, being sure that the flywheel and clutch cover are marked so that assembly may be made correctly and the original balance maintained.

NOTE—If the same pressure plate and clutch cover are to be re-installed, be sure to punch-mark these parts so that assembly may be made in the same relative position. When disassembling the unit, note carefully the position of the various parts so that assembly may be made correctly.

DISASSEMBLE: To disassemble the unit, place the cover assembly on the bed of a press with a block under the pressure plate, so arranged that the cover is left free to move down. Place a block across the top of the cover, resting on the spring bosses.

Compress the cover with the spindle of the press and, holding it under compression, remove the adjusting nuts and then, slowly release the pressure to prevent the springs from flying out. The cover can then be lifted off and all the parts will be available for inspection.

To remove the release levers, grasp the lever and eyebolt between the thumb and fingers so that the inner end of the lever and the upper end of the eyebolt are as near together as possible, keeping the eyebolt pin seated in its socket in the lever. The strut can then be lifted over the ridge on the end of the lever, making it possible to lift the lever and eyebolt off of the pressure plate.

INSPECTION: Inspect the pressure plate springs and replace if they show signs of overheating due to clutch slippage. If the springs have been overheated, they will show a pronounced blue color, indicating that the temper has been drawn, or else the paint will be burned off the springs.

NOTE—The following table may be used as a guide to test the spring compression pressure, and if the weight checks lower than indicated in the table, the springs should be replaced.

Color	Weight, Pounds	Height, Inches
No Color	150	1 11/16
Black	160	1 11/16
White	160	1 11/16
Brown	140	1 11/16
Red	180	1 11/16
Light Blue	160	1 11/16
Blue	180	1 11/16
Pink	200	1 11/16
Grey	200	1 11/16
Purple	130	1 11/16
Light Green	170	1 11/16
Green	105	1 11/16
Tan	155	1 ½
Orange	165	1 ½
Lavender	145	1 ½
*Yellow	135	1 ½
**Yellow	140	1 11/16

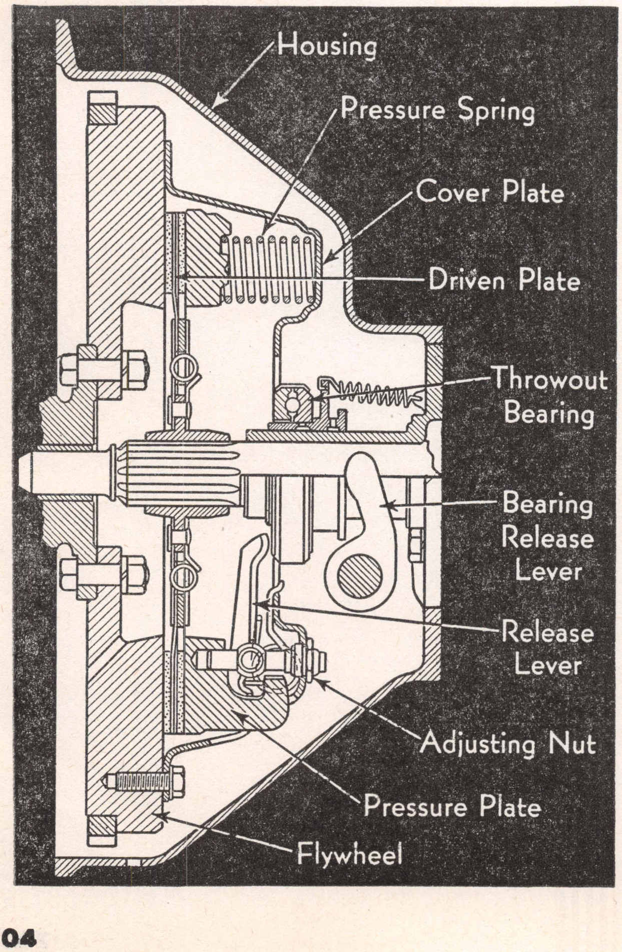
* Borg & Beck Spring No. 4331.

** Borg & Beck Spring No. 2994.

ASSEMBLE: When assembling the struts and release levers, apply a thin film of Lubriplate to the working edges of the struts, as well as to each side of the ears on the pressure plate where they extend through the clutch cover.

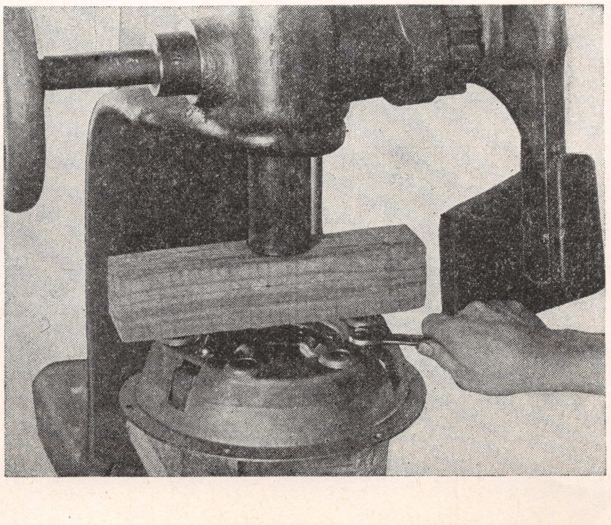
On clutches equipped with a baffle plate, install the baffle before the levers are installed. When installing the baffle plate, note that adjacent to each hooked lug on the pressure plate, one of the spring seat lugs is lower than the others. The flanged edge of the baffle plate is formed to fit depressions in the pressure plate casting at the base of each lug, and ears are also formed, which rest on the low ribs already mentioned. Springs, which seat on these ears, hold the baffle plate in position.

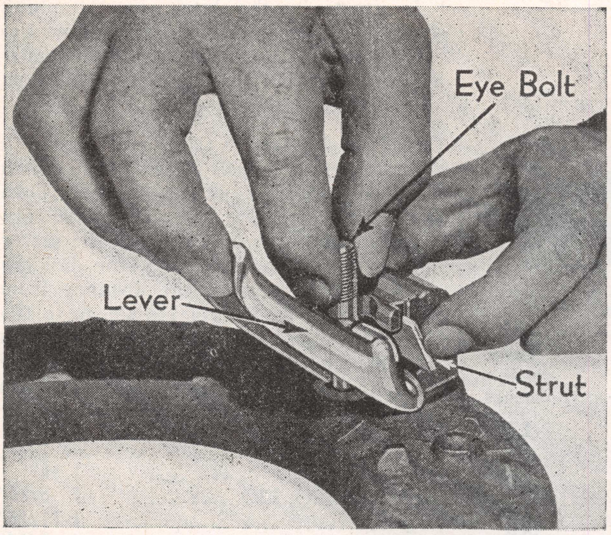
NOTE—On the 9 and 10 inch size clutches, the ears must be located on the spring seats adjacent to the lugs, in a counter-clockwise



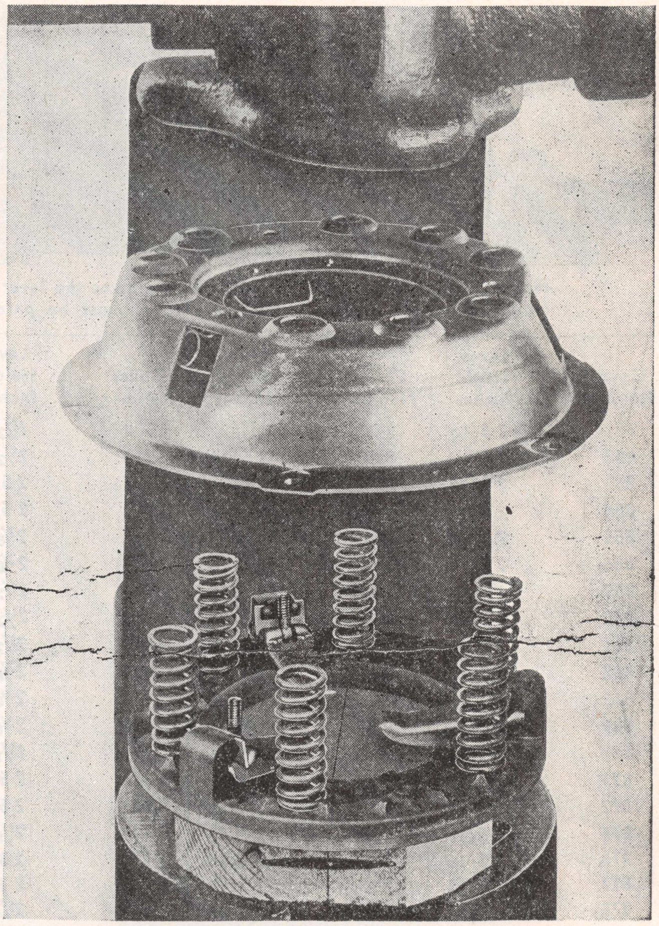
BORG & BECK.
Typical design.

BORG & BECK.
Method of Disassembly.





BORG & BECK. Method of Removing Release Levers.



BORG & BECK. Method of Assembly.

direction. On the 11 inch size clutch, the ears must be located on the spring seats adjacent to the lugs in a clockwise direction. Particular attention must be paid to the correct assembly of these baffle plates as this is the only position in which the baffle plate will seat properly in the pressure plate. If the ears of the baffle plate have been bent in handling, be sure that they are straightened so that they will lie flat on the spring seat ribs and, at the same time, the baffle plate must fit fully into the machined recess of the pressure plate.

LEVERS, ASSEMBLE: Assemble the lever, eyebolt and eyebolt pin, holding the threaded end of the eyebolt between the thumb and index finger, allowing the end of the lever to rest on the second finger. Hold the end of the lever and the end of the eyebolt as close together as possible. Grasp the strut with the other hand, between the thumb and first finger, and insert the strut in the slots of the pressure plate lug. Drop the strut slightly and tilt its edge until it touches the vertical milled surface of the lug. Insert the lower end of the eyebolt in the hole in the pressure plate, which will place the short end of the lever under the hook of the pressure plate, and near the strut. Slide the strut upward in the slots of the lug, lift it over the ridge on the short end of the lever and drop it into its groove in the lever.

COVER, ASSEMBLE: Place the springs on the pressure plate, and the lever return springs, or anti-rattle springs, in the cover. Lay the clutch cover on top of the pressure plate and assembled parts, being sure that the punch marks on the pressure plate and cover are matched. Also make certain that the lever return springs, or anti-rattle springs, remain in the correct position and that the tops of the pressure springs are directly under the embossed seats in the cover.

With a wood block laid across the cover and the assembly placed on the bed of the press, compress the cover slowly, being sure that the eyebolt and pressure plate lugs are guided through the proper holes in the cover. Hold the clutch under compression and screw down the adjusting nuts until they are flush with the tops of the eyebolts. The spindle on the press can then be released. Release the clutch several times so that all moving parts will settle into their working positions. This can be done with the press by applying the spindle to the inner ends of the levers.

RELEASE LEVERS, ADJUST: Satisfactory operation of the clutch is absolutely dependent upon the accuracy of the lever adjustment, since the pressure plate must be parallel with the flywheel. The method of checking the position of the levers depends upon the equipment available. Regardless of how the levers are measured, they must be uniform within .005".

Using an extra flywheel as a dummy, and the gauge plate in the position normally occupied by the driven plate, mount the cover assembly to the dummy flywheel, turning the cover screws a turn or two at a time when pulling against the spring pressure, otherwise, the cover may be sprung. Before the cover is tightened down, be sure the gauge is centered.

NOTE—If an extra flywheel is not available, remove the flywheel from the engine being worked on. The gauge being used, must be exactly the same thickness as the driven plate used in the unit being serviced.

Adjust the levers by screwing the adjusting nut on each lever until all levers are in the same plane within .005".

After the correct adjustment is obtained, engage and disengage the assembly several times to be sure all working parts are properly seated, and then re-check the adjustment. After the adjustment is completed, lock the nuts with a small chisel, peening portions of the nuts into the slots in the eyebolts.

When replacing the driven plate, be sure that the correct side is toward the flywheel, and, before tightening the clutch cover, insert an aligning tool, or a spare main drive gear, through the driven plate and into the crankshaft pilot bearing. Tighten the clutch cover to the flywheel gradually and evenly until all the bolts are secure before removing the aligning tool.

NOTE—If the correct gauge plate is not available, dimensions given in table on next page Figure A may be used as a guide to determine the lever height setting. The measurement is taken between the face of the flywheel and the contacting point of the lever. Cover assemblies are identified by the number which is stamped thereon. These measurements are to be used only for clutch rebuilding purposes. Lever settings on factory built covers should never be disturbed unless the levers are out of parallel more than .030".

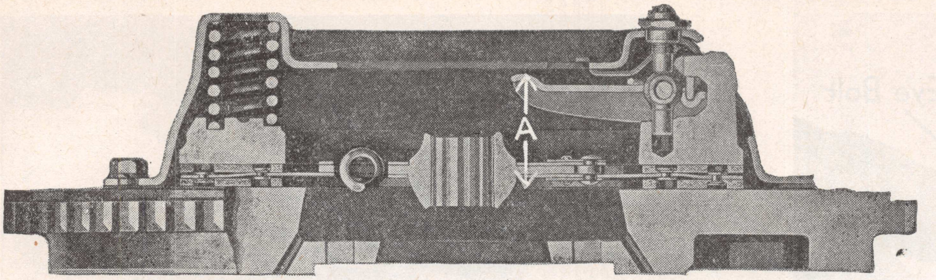


Figure A. BORG & BECK. The table below gives the lever height setting as indicated by the dimension "A". All levers must be parallel within .005".

Cover Number	Lever Height, Inches	Cover Number	Lever Height, Inches	Cover Number	Lever Height, Inches	Cover Number	Lever Height, Inches
851	2 5/16	879	1⅞	908	2½	930	2 3/16
852	1⅞	880	2 5/16	910	2½	931	2¼
853	2 5/16	882	1⅞	911	2 5/16	932	2 5/16
854	2 5/16	883	2 5/16	912	2 5/32	933	2 3/16
855	2 5/16	884	1⅞	913	2⅜	934	2⅜
856	2 5/16	886	2 5/16	914	2⅜	936	2¼
859	1⅞	890	2 5/16	915	2½	937	2 5/16
860	2 5/16	892	2 5/32	916	2½	938	2 3/16
861	1⅞	894	2 5/16	917	2½	939	2 3/16
862	2 5/16	898	2 5/16	918	2⅜	940	2 3/16
863	1⅞	899	2 5/16	919	2⅜	941	2¼
869	2 5/16	900	1⅞	920	2⅜	943	2 3/16
870	2 5/16	901	2 5/16	921	2½	944	2¼
871	1⅞	902	2 5/16	922	2 5/16	945	2¼
872	1⅞	903	2 5/32	923	2 5/16	946	2¼
874	2 5/16	904	2 5/16	925	2⅛	948	2 5/16
876	2 5/16	905	2 5/16	926	2 3/16	949	2 3/16
877	2 5/16	906	2 5/16	928	2 3/16	950	2 3/16
878	2 5/16	907	2 5/16	929	2¼	951	2 3/16

CAM TYPE

MODELS Q & QL. SIZES 8 TO 14

NOTE—Before removing the clutch from the flywheel, remove all attaching screws and clamps, which will permit the removal of the clutch cover assembly, after which, lift out the pressure plate. Then, use a pair of pliers to take out the dowel pins, and remove the driven plate assembly.

DISASSEMBLE: Place the cover assembly on the bed of a press with the clutch sleeve facing downward. Use a square block of wood, large enough to cover the cover hub, and compress the cover just enough to release the pressure from the lever pins. Drive out the three lever pins and remove the levers. Release the pressure from the cover gradually to prevent the springs from flying out.

ASSEMBLE: Lubricate the sleeve and place it on the press with the flange down. Force the large end of the spring into the cover recess, then turn the cover and spring assembly over and place the small end of the spring over the sleeve. (The foregoing applies to the Q models; on the QL models, a straight spring is used.)

Line up the key in the sleeve with the keyway in the cover, then place the wood block in position and compress the cover, at the same time, guiding the key into the keyway. Slip the ends of the levers into the sleeve slots and insert the lever pins, lubricating same with engine oil before doing so. Release the pressure and remove the wood block. Wipe away all excess lubricant from the end of the sleeve, and stake the lever pins securely in place with a round-nosed punch.

REPLACING IN VEHICLE: Lubricate the pilot bearing, using not more than one teaspoonful of grease. See that the pressure plate slides freely on the three dowel pins in the flywheel; if the ring sticks, do not file the slots. Turn the flat sides of the pins so that they are parallel with the slots in the pressure plate.

Install the driven plate in the flywheel, being sure the correct end of the hub is toward the outside, then line up the driven plate and pilot bearing with the clutch shaft before fastening the clutch cover attaching screws. Tighten all the holding screws before pulling out the shaft. Install the transmission to the engine and adjust the clutch and clutch pedal as follows:

CLUTCH, ADJUST: Loosen all the clutch cover attaching screws to permit the clutch cover to turn freely in the flywheel. Turn the clutch cover ½ inch in a counter-clockwise direction—as indicated by the arrow on the cover—and tighten the holding screws. Then measure the distance from the rear face of the release sleeve to the clutch cover, which should be as given in the following table. Bend a wire to the desired dimension given below, to obtain the necessary result (clutch model number shown on cover).

8Q, 9Q	1 ⅛"
10Q, 11Q, 12Q, 13Q	1 5/16"
14Q	1 11/16"
9QL	2 3/16"
10QL, 11QL, 12QL	2 ⅜"

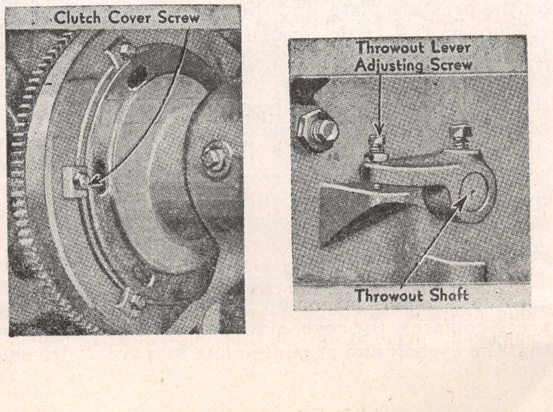
NOTE—If this dimension is more than the chart calls for, loosen the holding screws again and turn the cover in the same direction; if less than specified, turn the cover in the same direction as the flywheel rotates. When the desired results have been obtained, be sure to tighten the cover screws.

CLUTCH PEDAL, ADJUST: With the above operation completed, adjust the clutch pedal as required to permit the release sleeve to move toward the flywheel the dimension given in the following table:

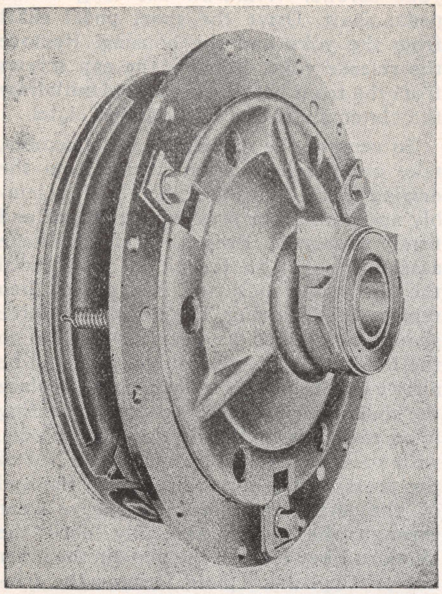
8Q, 9Q	¼"
10Q, 11Q	⅜"
12Q, 13Q	7/16"
14Q	9/16"
9QL	5/16"
10QL, 11QL	⅜"
12QL	7/16"

The above dimensions are necessary to obtain a clean release when the clutch sleeve is pushed toward the flywheel. If the sleeve does not travel the required distance, shift the pedal up, bearing in mind that the pedal pad must touch the toe board without springing the pedal.

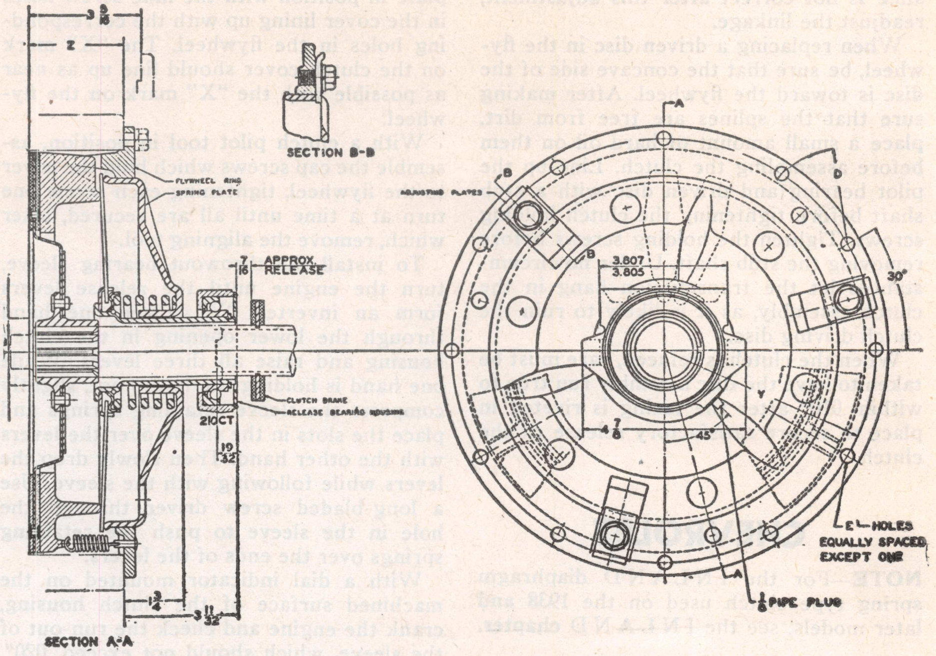
NOTE—With the clutch pedal adjusted according to the above limits, it should not be necessary to make any further changes because the clutch adjustment automatically restores the necessary toe board clearance



BORG & BECK. Models Q & QL, Cam Type.



Brown-Lipe single plate clutch.



Brown-Lipe single plate. Section B-B shows adjustment for wear.

BROWN-LIPE

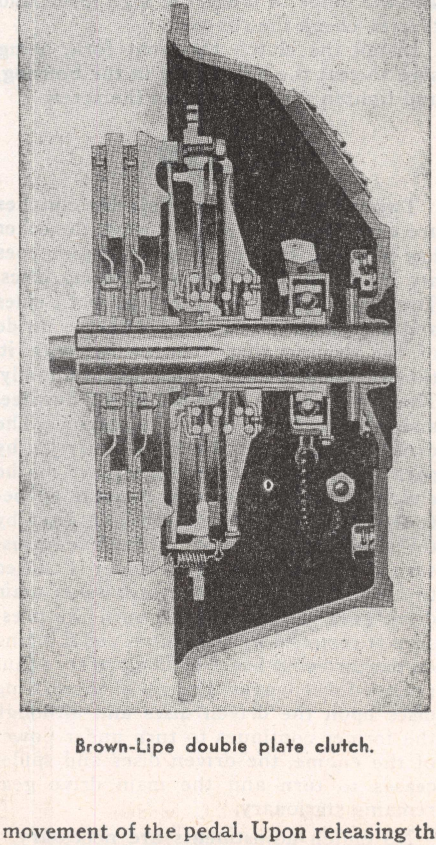
Brown-Lipe single and double plate clutches are designed to provide for rapid dissipation of heat resulting in maximum life of the friction discs. Multiple resilient levers transmit the force of a single or double coil spring uniformly to the entire face of the pressure and driven plates for smooth engagement. The large single or double coil springs are located at the inner end of the levers, approximately five inches from the pressure plate so that they are not affected by the heat generated in the clutch.

The clutch does not require removal from the chassis for making an adjustment but can be adjusted in the truck.

The correct amount of clutch release is controlled by the distance between the release bearing housing and the clutch brake and an adjustment of this dimension may be necessary. This distance should be 7/16" for the 12", 13" and 14" single plate clutch and ½" for the 13" and 14" two-plate clutch.

Adjustment of the 12" and 13" single plate clutch is accomplished by shims under the three adjusting plates on the flywheel ring or by changing the position of the three adjusting plates. Adjustment of the 14" single plate clutch and the 13" and 14" two-plate clutches is made by a large adjusting ring which can be screwed in or out of the flywheel ring with the clutch pedal depressed.

With the amount of clutch release correct the clutch pedal should be adjusted so that when it is fully depressed, the clearance between the under side of the pedal pad and the floor is approximately ¾". In this position the clutch brake should be engaged, preventing further downward movement of the pedal. Upon releasing the clutch pedal the distance between the upper end of the pedal shank and the bottom of the floor should be at least 1½" with the clutch completely engaged. When through natural wear of the clutch facings, this 1½" clearance under the floor board decreases to ½", the clutch should be adjusted.



Brown-Lipe double plate clutch.

12" AND 13" SINGLE PLATE CLUTCH

With the clutch partially depressed, the three adjusting plates which hold the spring plate in position should be removed. If no shims are used at this point, reassemble the adjusting plates in their reverse position with the turned edges pushing the spring plate forward. This completes the adjustment for this construction and should bring the clutch pedal back to approximately its original position with the clutch release bearing housing within about 7/16" of the brake washers.

If shims are used under the adjusting plates, they should be removed to make an adjustment for facing wear. The same number of shims should be removed from under each of the three adjusting plates. When replacing and tightening the adjusting plate screws, have the pedal depressed or the clutch in its released position. If a new or refaced drive plate is installed, the shims should be replaced beneath the adjusting plates, a total of six shims for each plate.

14" SINGLE PLATE, 13" AND 14" DOUBLE PLATE CLUTCH

With the clutch pedal partially depressed, the adjusting ring lock nut should be removed and the large adjusting ring turned clockwise until the 1½" pedal clearance under the floor board is back to its original distance. Replace the adjusting ring lock.

This completes the adjustment and should bring the clutch pedal back to approximately its original position with the clutch release bearing housing within about 7/16" of the brake washers for the 14" single plate clutch and ½" on the double plate clutches. If the pedal clearance is not correct after this adjustment, readjust the linkage.

When replacing a driven disc in the flywheel, be sure that the concave side of the disc is toward the flywheel. After making sure that the splines are free from dirt, place a small amount of hard oil on them before assembling the clutch. Line up the pilot bearing and driven disc with a stub shaft before tightening the clutch holding screws. Tighten the holding screws before removing the stub shaft. Under no circumstances let the transmission hang in the clutch assembly, as it is likely to ruin the clutch driving disc.

When the clutch is refaced, care must be taken to have the disc assembly run true to within .010" after the facing is riveted in place to secure satisfactory release of the clutch.

CHEVROLET

NOTE—For the INLAND diaphragm spring type clutch used on the 1938 and later models, see the INLAND chapter.

DISASSEMBLE: To remove the clutch assembly from the flywheel, remove every other screw and then relieve the spring tension by removing the other screws one turn at a time.

Mark the clutch cover and pressure plate so that assembly may be made in the same relative position, in order to maintain the original clutch balance. Remove the remaining cap screws which will permit the removal of the clutch cover from the pressure plate. Remove the clutch lever retaining springs and check the levers to see if they are binding, after which, the lever pins and levers may be removed.

INSPECTION: Check the fit of the lever pin in the lever and, if either pins or levers are worn, they must be replaced. Inspect the slots in the throwout bearing sleeve for wear, and also, check the ends of the levers in the slots to make sure they are free. See that the bearing surfaces of both the pressure plate and the flywheel are free from scores, grooves or heat checks. Install the cover over the pressure plate and check to make sure that the pressure plate bosses are not binding on the guides in the cover. Remove any burrs which are found along the edges of the broached guides in the cover. Check the pressure springs for even height. Also check the run-out of the transmission pilot hole in the clutch housing, which should be within .008" as measured with a dial indicator.

ASSEMBLE: Apply a light film of graphite grease to the lever pins and install the release levers, making sure that they operate freely. Install the pressure springs in the recesses of the pressure plate, and match the punch marks in the clutch cover and pressure plate. Assemble the lever plates, lock washers and bolts, tightening the bolts evenly and securely.

Assemble the clutch disc to the flywheel and place the clutch cover and pressure plate in position with the nine screw holes in the cover lining up with the corresponding holes in the flywheel. The "X" mark on the clutch cover should line up as near as possible with the "X" mark on the flywheel.

With a clutch pilot tool in position, assemble the cap screws which hold the cover to the flywheel, tightening each screw one turn at a time until all are secured, after which, remove the aligning tool.

To install the throwout bearing sleeve, turn the engine until the release levers form an inverted "Y". Place one hand through the lower opening in the clutch housing and raise all three levers. While one hand is holding the levers out, slightly compress the sleeve retaining springs and place the slots in the sleeve over the levers with the other hand. Then slowly drop the levers while following with the sleeve. Use a long-bladed screw driver through the hole in the sleeve to push the retaining springs over the ends of the levers.

With a dial indicator mounted on the machined surface of the clutch housing, crank the engine and check the run-out of the sleeve, which should not exceed .020". If the run-out is in excess of this, chalk-mark the high point. Remove the clutch lever plate that is in line with the high point and place a shim between the plate and the guide to lower the high lever, and then re-check the run-out.

Install the clutch throwout fork, being sure to seat the bolt firmly in the housing, and tighten the ball seat on the screw.

FULLER

Two types of Fuller multiple disc clutches are used. One has a single spring, the other has multiple springs. Both of these types are made up of driven and driving discs. The driving discs are faced on both sides and are notched or geared with the inside of the driving ring and revolve with it, though being free to slide longitudinally. The driving drum is bolted to the flywheel and always turns with the engine. The driven discs are saw steel plates carried by parallel pins which are solidly set in the clutch spider. Pressure is maintained between the driving and the driven discs by the clutch spring acting through the pressure plate. Thus the clutch spider is caused to revolve, turning the transmission main drive gear. This continues until the pressure is removed by the clutch pedal acting on the throwout bearing. The pressure thus removed disengages the grip of the driving discs upon the driven discs and although the former continues to turn under power of the engine, the driven discs and spider ceases to turn and the main drive gear remains stationary.

No clutch adjustments are necessary.

SINGLE SPRING TYPE

To remove the clutch shaft and clutch assembly, take off the inspection cover from the clutch housing. Remove the lock wire from the release yoke and loosen the yoke screws. Withdraw the long clutch pedal shaft. Drive the short pedal shaft from the yoke and the housing. Remove the release yoke. Remove the cap screws from the front bearing cover and withdraw the clutch shaft and its attached clutch.

To remove the driving flange assembly, take out the lubrication fitting from the driving flange pin. Place the clutch assembly under an arbor press with the gear end firmly supported. Press the driving flange assembly down on the clutch shaft until the half moon lock ring is exposed, then remove the lock ring. The downward force should be applied as near as possible to the hub of the flange and space should be allowed to remove the lock ring. Replace the clutch assembly in the press, supporting it on the ends of the driving flange pins, with the gear projecting below the bed of the press. Apply force directly to the end of the shaft and force the drive gear through the clutch assembly until the Woodruff key touches the plate in the inner hub of the pressure plate. Remove the driving flange assembly and clutch plates.

To remove the clutch pressure plate assembly, pull out the Woodruff key from the shaft. The clutch pressure plate assembly can now be slipped off the shaft.

To disassemble the pressure plate, force outward, from inside the release bearing sleeve, that portion of the locking ring which has been peened into the two holes. Unscrew the release bearing sleeve and remove the release bearing. Remove the cotter pin from the plate in the upper hub. From the release bearing end, insert a long bolt through the plate. The head of the bolt should be small enough to enter readily the bottom of the flange, and large enough to prevent its passage through the spring. Screw a nut down on the bolt against the spring retaining plate until the spring tension is taken from the pressure plate. Unscrew the spring retaining plate and remove the clutch spring still under pressure on the bolt. When no arbor press is available, the clutch driving flange assembly may be depressed by standing the assembly on end on a firm foundation and by driving the flange downward by the use of a lead hammer against a sleeve fitted over the end of the gear. The driving flange can be removed from the shaft with a puller, using the two ⅝" holes in the flange for the puller screws.

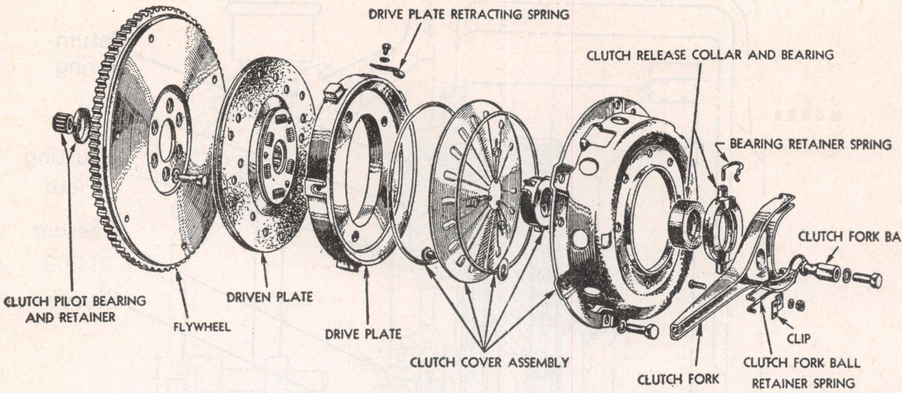
Reverse the order of the above procedure to assemble the clutch.

MULTIPLE SPRING TYPE

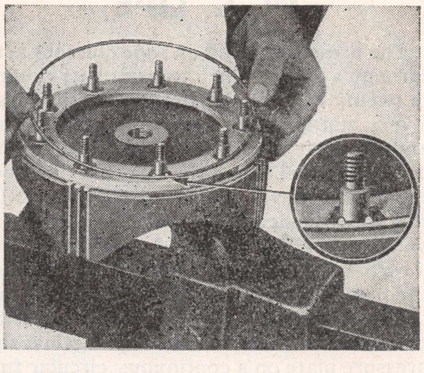
It is possible to remove the complete clutch pack assembly without removing the clutch shaft and drive gear. In addition, it is possible to replace the clutch plates without removing the complete clutch pack assembly.

To remove the clutch plates, take off the plate at the front end of the clutch by cutting the lock wire and by removing the six retaining screws. Remove clutch plates, both lined and unlined.

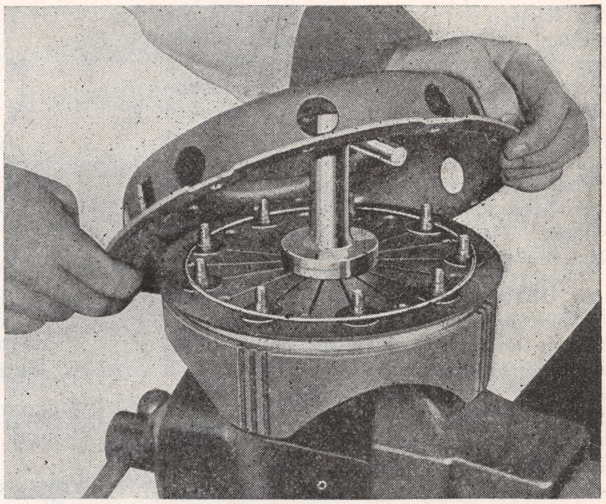
To remove the clutch pack assembly,


DRIVE PLATE RETRACTING SPRING
CLUTCH RELEASE COLLAR AND BEARING
BEARING RETAINER SPRING
CLUTCH FORK BALL
CLIP
CLUTCH FORK BALL RETAINER SPRING
CLUTCH FORK
CLUTCH COVER ASSEMBLY
DRIVE PLATE
DRIVEN PLATE
FLYWHEEL
CLUTCH PILOT BEARING AND RETAINER

INLAND. Diaphragm Spring Type.



INLAND. Assembling Pressure Plate.



INLAND. Remove Nuts and Lift Off Cover.

take out the clutch release yoke and shafts. Unscrew the oil fitting from the clutch shaft, working through the slot in the pressure plate. Remove the lock nut and washer from the clutch shaft. Remove the clutch pack by striking the end of the drive gear a sharp blow with a lead hammer.

To disassemble the clutch pack, remove the clutch plates as described above. Remove the cotter pins, nuts and springs from the studs in the order named. Separate the pressure plate and inner drum assembly. Remove the spring cups from the pressure plate.

To remove the clutch release bearing, disconnect the oil pipe assembly. Drive the two lock rivets from the bearing sleeve and pressure plate. Unscrew the clutch release bearing sleeve. Press or jar the bearing from the sleeve.

To remove the studs from the inner drum, grind or chop off with a chisel, that portion of the stud which has been peened. Unscrew the studs. It is recommended that the clutch shaft be greased slightly when the 8½" clutch is being reassembled. The grease will enable the pressure plate to slide freely.

NOTE—All Fuller multiple disc clutches are equipped with a master driving disc assembled next to the driving flange assembly. The letter H is stamped on one of the teeth for identification. Care should be taken that the master disc is in its proper place when the clutches are reassembled.

INLAND

DIAPHRAGM SPRING TYPE

This clutch is the single plate, dry disc type using a dished, or conical-shaped diaphragm spring in place of the coil pressure springs used in the conventional type units. The outer rim of the diaphragm spring acts as a spring, while, extending inward from it, are eighteen release fingers.

When the diaphragm spring is placed on the pressure plate, and the clutch cover is clamped tightly against it, the diaphragm spring forces the pressure plate firmly against the driven disc. The spring is fulcrumed on the clutch cover by two wire rings.

DISASSEMBLE: Before dismantling the unit, note the position of the various parts. Punch mark the clutch cover and pressure plate so that assembly may be made in the same relative position, in order to preserve the original clutch balance.

Use a suitable wrench to remove the three pressure plate retracting spring bolts, after which, the springs can be removed, which will release the pressure plate from the balance of the assembly.

If it is necessary to replace the diaphragm spring, and the unit which is being serviced employs bolts and nuts to hold the diaphragm spring in position, remove the nuts and washers, and take out the bolts and complete the disassembly operation.

If the assembly being serviced employs rivets to hold the diaphragm spring in place, remove the rivets by grinding the rivet ends from the top of the cover plate, after which, the disassembly may be completed.

ASSEMBLE: Place the cover plate upside down. Install the wire ring in position encircling the bolt or rivet holes. After coating the flat washers sparingly with graphite grease, place one washer over each bolt or rivet hole in the cover plate with one side resting on the wire ring. The projections on the wire ring should be adjacent to the bolt or rivet holes so that they will straddle the bolts.

Place the diaphragm spring in position with its convex side down, being careful not to disturb the ring and washers which are already in position. Coat the remaining flat washers lightly with graphite grease and place them on the diaphragm spring, one over each bolt or rivet hole, after which, the other wire ring should be placed on top of the washers with the projections located in the same straddling manner as the ring already in position.

Insert the bolts down through the assembly, making sure that they pass through both flat washers and both wire rings. Be sure that the three pairs of projections on the wire rings straddle the bolts. Turn the nuts and lock washers onto the bolts from underneath and tighten securely with suitable wrenches.

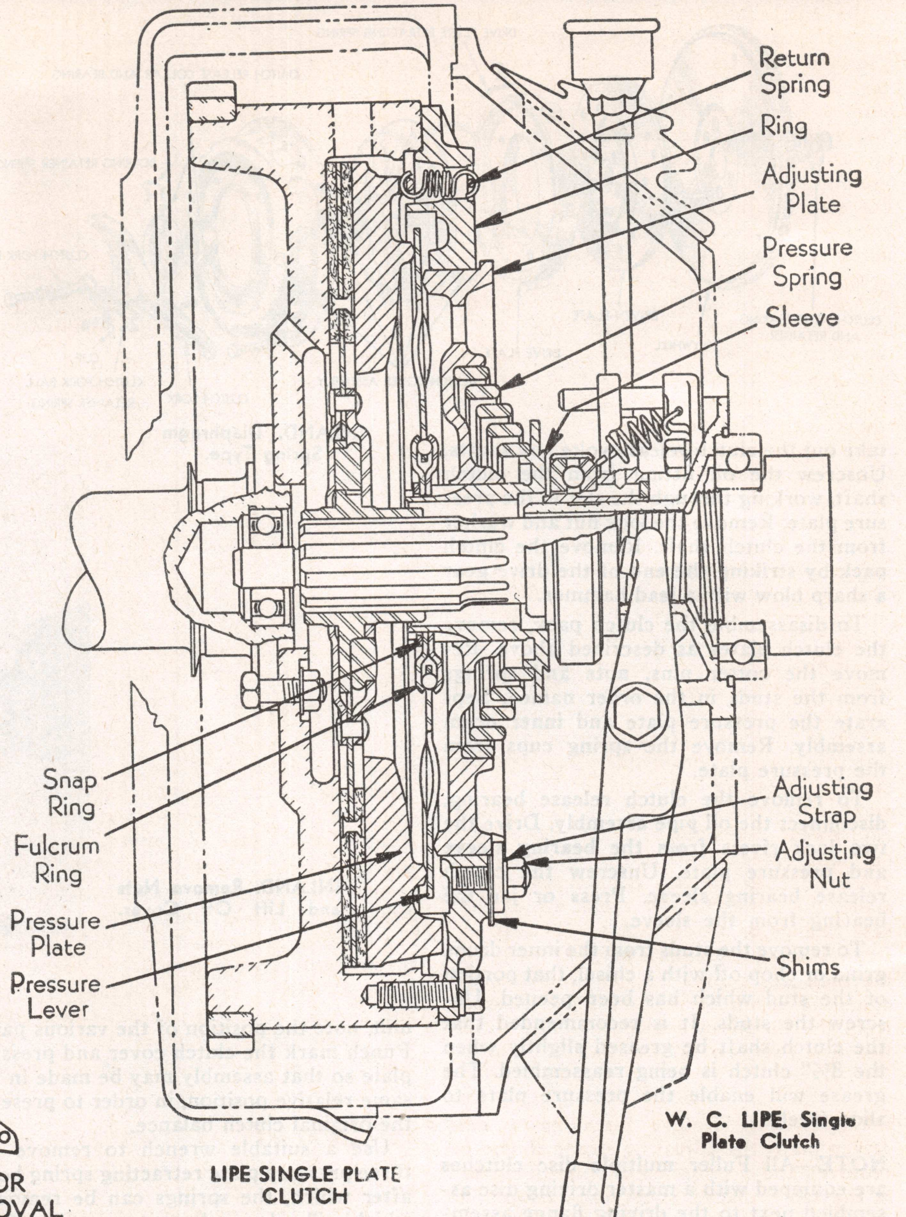
Place the cover and spring assembly on top of the pressure plate, lining up the drive slots in the cover plate with the drive lugs on the pressure plate. If the pressure plate has not been replaced, make sure that the punch marks, made before disassembling, are placed in the same relative position.

Install the pressure plate retractor springs through the holes in the top of the cover so that their hooked ends catch the top of the diaphragm spring. Fasten the retractor springs into position by means of the bolts through the holes in the side of the cover plate, being sure that lock washers are used.

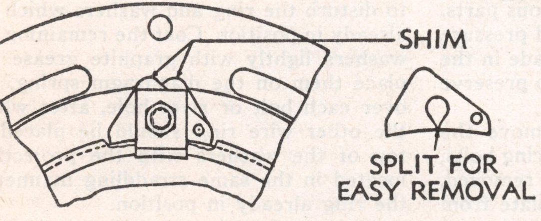
W. C. LIPE

The pressure spring on Lipe clutches acts through a sleeve which transmits its energy to twenty ball bearing, hinged levers. These levers multiply the pressure of the spring and transmit the increased pressure to the pressure plate. When the clutch is released, the sleeve moves toward the flywheel. In this way, the action on the hinged levers is opposite to the spring pressure on the levers, thus relieving the pressure against the pressure plate and by means of the retractor spring, preventing its contact with the driven plate. All levers bear against the pressure plate on a continuous, circular fulcrum which provides a uniform pressure toward the flywheel in a plane parallel to the friction face of the flywheel. As the clutch facings wear, the clutch sleeve moves toward the throwout bearing, thus reducing the clearance between the bearing and the sleeve when the clutch is in its engaged position. This reduced clearance results in a reduction of play in the clutch pedal. When the play in the clutch pedal is reduced to approximately ½", the clutch should be adjusted. Never wait until the clutch slips before adjusting it.

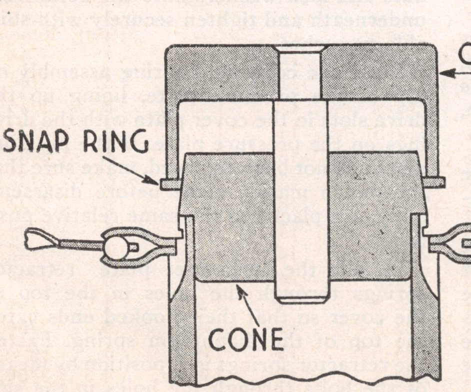
ADJUSTMENT: Do not adjust the pedal linkage before adjusting the clutch. To adjust the clutch, block the clutch pedal in its released position. Then back off each adjusting nut five full turns. Remove the block from the clutch pedal. This will permit the adjusting plate to move out of contact with the shims. Remove one shim from under each adjusting strap with sharp-nosed pliers or insert a cotter pin puller


Return Spring
Ring
Adjusting Plate
Pressure Spring
Sleeve
Snap Ring
Fulcrum Ring
Pressure Plate
Pressure Lever
Adjusting Strap
Adjusting Nut
Shims
LIPE SINGLE PLATE CLUTCH

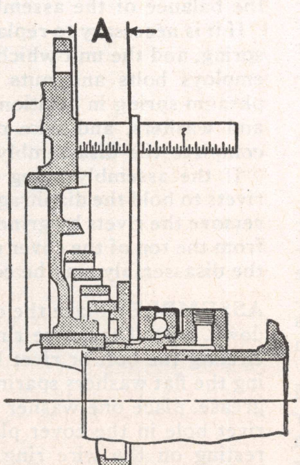
W. C. LIPE, Single Plate Clutch


SHIM
SPLIT FOR EASY REMOVAL

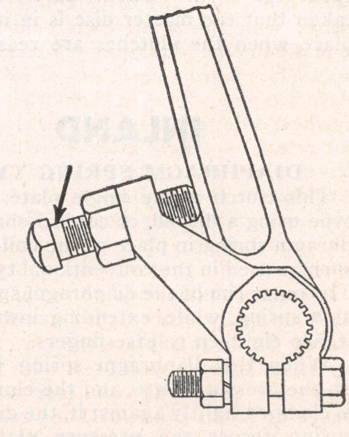
Shims are removed by pulling lip with sharp nosed pliers or by inserting cotter pin puller in hole.


CUP
SNAP RING
CONE

Cup and cone for installing snap ring to lock levers in position.



Distance "A" controls pedal play and is adjusted by shims at each bolt. Correct measurement for each model shown in table.



After all shims are removed, one pedal adjustment is possible by loosening lock nut and turning adjusting screw at clutch pedal shank.

in the small hole of the split shim and remove it. Be sure no portion of the shim is left between the adjusting plate and the ring and also that the same number of shims are removed from under each strap. It is good practice to check after making an adjustment to make sure that the same number of shims are left under each strap. The chart shows the change that is made when one shim is removed. Again block the clutch pedal in its released position and tighten each adjusting nut firmly.

Now measure the distance from the machined surface of the clutch ring, which supports the shims, to the clutch sleeve face against which the throwout bearing acts. This can be done with a straight edge and a scale, two scales or a special tool. Hold the straight edge firmly between the clutch sleeve and the throwout bearing by pushing the throwout bearing into contact with the straight edge so it will not drop into the case. The clutch should be in its engaged position for taking this dimension. This distance is indicated as dimension A on the chart. Its limits are plus 1/16" but minus 0. When this dimension is correct, check the distance between the throwout bearing and the clutch sleeve. This should not be less than ⅛" and not more than 5/32". It may be necessary to adjust the pedal linkage to obtain this clearance, because of wear or improper initial adjustment. After the last shim is removed, one adjustment of the clutch pedal linkage may be made before replacing or refacing the driven disc. While this adjustment can be made, the manufacturer recommends that new facings or a new disc be installed instead. If an adjustment is made at the pedal, the lock nut should be loosened and the adjusting screw turned until the distance from the throwout bearing and the clutch sleeve is between ⅛" and 5/32".

OVERHAUL: Before installing a new driven plate, the adjusting straps should be removed and the number of shims indicated in the table, placed under each strap. The use of a spare splined shaft for centering the driven plate while bolting the clutch in place is advised. The driven plates are furnished with the spline ends pointed so as to make the job of piloting the transmission easy. The pressure plate side of each driven plate has the spline ends pointed and the flywheel side left plain. If the clutch does not release properly after installing a new driven plate, either the pedal adjustment is insufficient, resulting in excessive lash or additional shims are needed. Bent driven plates and tight splines may also cause a drag.

If pressure plates are dished in excess of .015" or badly scored they should be replaced. To do this, place the clutch assembly on an arbor or drill press with the pressure plate down and compress the release sleeve as far as possible. Then remove the four pull back spring pins in the 12", 13" and 14" clutches. Turn the clutch over and place it on a bench with the release sleeve down. The pressure plate may then be removed. Driving lugs on the pressure plate must be free in the slots of the flywheel ring. Hook the pull back springs in the small holes provided for them in the pressure plate, then put the new pressure plate in place of the one removed. Be careful not to cramp the pull back springs or allow the release levers to overlap. Replace the clutch in the press with the pressure plate down and draw down the release sleeve before replacing the pull back spring pins. Caution must be maintained not to overstretch the pull back springs, which is the reason for compressing the clutch before replacing the pull back spring pins.

When replacing the pressure plate on 15" clutches, it is only necessary to back off the four castle nuts that retain the retractor springs in order to remove the old plate. Before the new pressure plate is assembled, the four driving lugs should be checked with the flywheel ring. A looseness of from .004" to .006" should be provided between the lugs and their slots in the flywheel ring. When replacing the castle nuts that retain the retractor spring, they should be turned down just enough to permit assembling the cotter pin.

COVER PLATE, DISASSEMBLE: Remove the pressure plate as already described. Place the assembly on an arbor or drill press with the assembly resting on the clutch sleeve. Place two substantial blocks, approximately 5" long, on the flywheel ring so that they rest over the driving lug slots. Arrange a strong bar on top of these blocks and compress the assembly. Lock the press in this position. Remove the snap ring. A special tool is available for this purpose. Remove the fulcrum rings, levers and balls. Slowly release the assembly which will permit removal of the spring, sleeve and other parts.

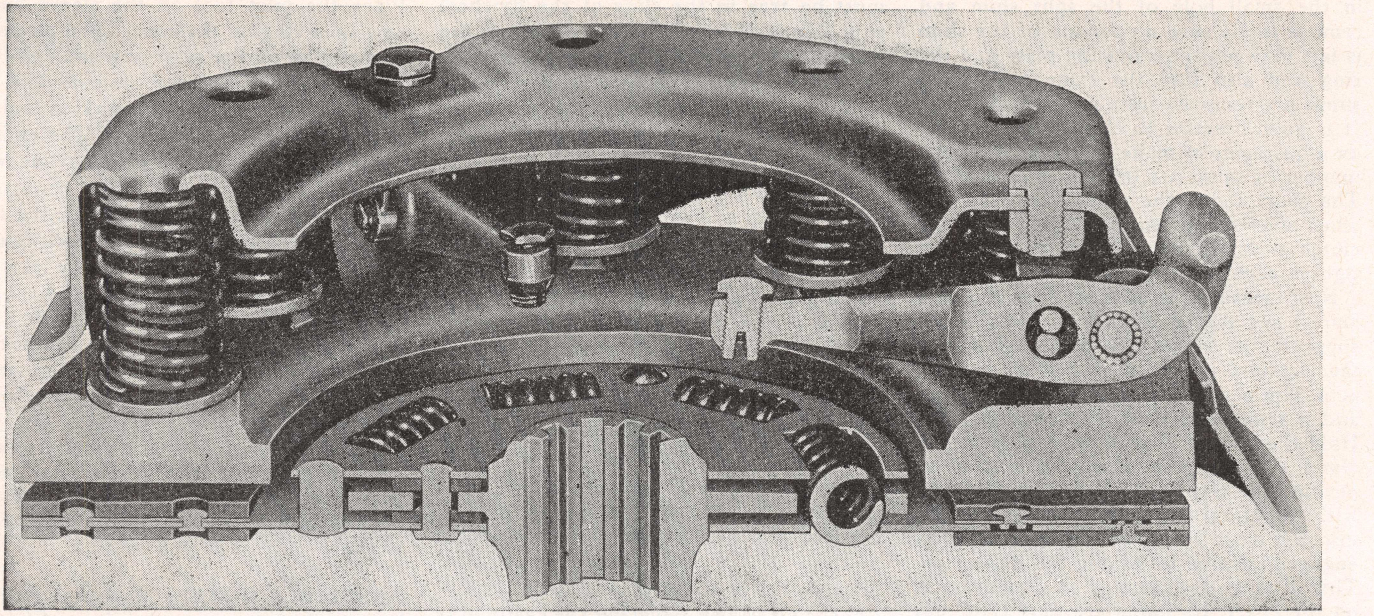
COVER PLATE, ASSEMBLE: Place the sleeve on an arbor or drill press table. Insert a special pilot tool in the sleeve to act as a guide in assembling the sleeve in the adjusting plate. With the large end of the pressure spring abutting the small boss in the adjusting plate, place the flywheel ring, adjusting plate and spring above the sleeve. Arrange the two blocks and a bar on the assembly as described for removing the cover plate. Compress the assembly, lock the press and remove the pilot tool from the sleeve. Check the fulcrum rings for flatness, or excessive wear. Select two good fulcrum rings and place one of them, cupped side up, over the sleeve. If new levers are not being installed, make sure that they are straight and not worn. Arrange the twenty levers on the fulcrum ring so that the end of the levers nest just inside the retaining rim of the flywheel ring. Place one ball in each of the holes in the small end of the levers. Assemble the remaining fulcrum ring firmly and carefully over the sleeve.

Be sure when you are reassembling that no ball bearings become displaced, and see that the levers do not overlap each other. Place the pilot tool on the sleeve and a new snap ring on the cone. Then place the cupped tool on the snap ring and drive the ring to its seat. Remove the cone and cup from the sleeve and with a staking tool tap the snap ring into its groove. The ends of the snap ring should not be in line with the keyways in the sleeve. Best results are obtained if staking starts opposite the snap ring ends and from this point work toward the ends. Test each of the twenty levers to see that they are locked in place by a ball bearing. Then assemble the pressure plate in the four driving slots of the flywheel. If an old plate is used, the driving lug marked 0 should be in the driving slot marked 0. Assemble retractor springs. On 15" clutches, be sure to draw the nuts down just far enough to permit the assembling of the cotter pins. The 12", 13" and 14" clutches use a retainer pin for holding the springs.

ASSEMBLY NOTES: Make sure that the large coil of the spring has its end located at the left of the small boss on the adjusting plate. Remove any burrs in the bore of the adjusting plate or on the release sleeve. The sleeve must be a "free fit" in the adjusting plate. When assembling the ball bearings in the levers, be sure that a ¼" diameter ball is used in 12", 13" and 14" standard clutches and a 9/32" ball is used in 14" heavy duty and 15" clutches. Before using old fulcrum rings, test them on a flat surface, and if warped or badly worn, use new rings. Always use a new snap ring and be sure it is firmly seated in its slot. Test each lever after assembly to make sure it has a ball bearing locking it in the fulcrum rings. Use new pull back springs if old ones are stretched. The pressure plate must be free in slots of the flywheel rings; approximately .004" to .006" clearance must be provided. If the old plate is used, assemble the lug marked 0 in the slot of the flywheel ring marked 0. If new facings have been assembled to the driven plate or a new plate installed, make sure the required number of shims are installed under each adjusting strap. If the face of the clutch sleeve is scored, use a new sleeve.

LIPE ADJUSTMENT CHART

Model Number	Size	Dimension "A" Inches	Number of Shims	One Shim Changes "A" Inches
Z22-S	12	1	6	5/64
Z34-S	12	1 1/16	4	5/64
Z43-S	12	1	6	5/64
Z27-S	13	1 1/16	6	3/32
Z30-S	13	1	6	3/32
Z35	13	2⅛	6	3/32
Z25-S	14	1⅜	6	3/32
Z28-S	14	1⅛	6	5/64
Z29-S	14	1⅛	6	3/32
Z31-S	14	1¼	6	7/64
Z32-S	14	1 1/16	6	7/64
Z33-S	15	1⅜	6	7/64
Z33-SX	15	1⅜	6	⅛
Z40-S	15	1⅛	8	7/64
Z42-S	15	1⅛	8	7/64
Z42-SX	15	1⅛	8	⅛



LONG. Model CF. Semi-Centrifugal Type.

LONG

MODEL CF SEMI-CENTRIFUGAL SIZES 9, 9½, 10, 11

This clutch is a single plate, dry disc type which uses a pressure plate having centrifugal levers which add to the disc pressure as engine speeds are increased.

The unit is of the open and truss design allowing maximum ventilation and rigidity, and is attached directly to the flywheel surface by means of six pilot cap screws.

The release levers are made of forged steel, mounted on needle roller bearings which are centrifugally out of balance, due to weights at the outer end. The faster the clutch revolves, the more the levers try to throw out and the greater the pressure they exert on the pressure plate.

At zero speed, the load in the pressure plate is only that which is created by the pressure springs, but as the engine is started and the speed increased, the load increases slowly at first, but more rapidly as the speed increases to a higher range, until at high engine R.P.M., the total load is exerted.

The pedal operating pressure at normal speeds is lighter with this type clutch, and the amount of pedal travel which is necessary to release the clutch is less than on clutches of the non-centrifugal design. Failure to maintain correct clutch pedal free play may result in excessive wear of the release lever adjusting screws and premature failure of the release bearing.

Since the centrifugal clutch action reduces the play at high speed, very often a clutch which seems to have sufficient pedal play with the engine idling, does not have any pedal play with the engine operating at higher speeds, which results in clutch slippage and excessive wear. Therefore, always check the clutch pedal free play with the engine operating at high speed.

DISASSEMBLE: Place the assembly on the bed of a press with a block under the pressure plate so arranged that the cover is free to move down. Place a block across the top of the cover, resting it on the spring bosses, and apply pressure to the assembly.

Mark the cover and pressure plate so that assembly may be made in the same relative position. Remove the screws from the assembly and release the pressure, after which, the cover may be lifted off.

NOTE—Before disturbing the position of any parts, note carefully their exact position so that assembly may be made accordingly.

INSPECTION: Examine all parts carefully and replace any that are doubtful. If the pressure springs have been overheated, they will show a pronounced blue color, indicating that the temper has been drawn, or else the paint will be burned off the springs. If the overheating has been continued long enough, the springs will show a dark grey color, indicating that the temper has been entirely drawn from them. If any of these conditions are evident, it is recommended that the complete set of springs be replaced.

NOTE—(See Figure C) If, when disassembling the pressure plate, washers are found between the clutch cover and the release lever yokes, be sure to replace them if the same pressure plate is used. If a new pressure plate is being installed, do not re-use these spacer washers.

With this type cover assembly, it is impossible to re-grind the pressure plate without throwing the levers out of adjustment. After the pressure plate has been ground or turned down, it is necessary that a spacer washer be used to compensate for the material removed. It is recommended that when .020″ is removed from the surface of the pressure plate, spacer washers .015″ thick be used between the clutch cover and the release lever yokes. These washers should be approximately the same size as the top of the release lever yoke.

If the cover is bent or twisted, it is impossible to set the levers correctly. To check the cover, use a spare flywheel, lining up the cap screw holes in the cover with the corresponding holes in the flywheel. If the cover is bent or twisted, the holes will not line up properly and no amount of hammering will correct the trouble. Therefore, it will be necessary to replace the entire cover assembly.

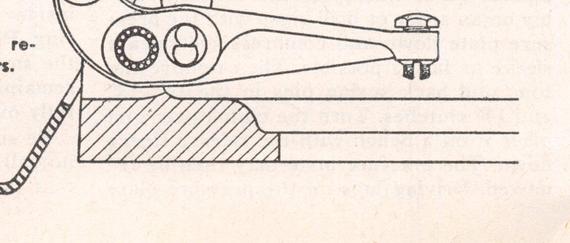


Figure C. LONG. See text regarding the use of washers.

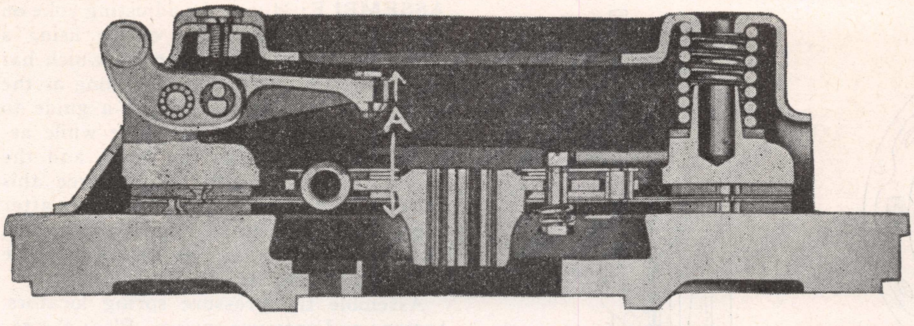


Figure B. LONG. Model CF. The table below gives the lever height setting as indicated by the dimension "A". All levers must be parallel within .005".

Clutch Model	Cover Number	Lever Height, Inches	Clutch Model	Cover Number	Lever Height, Inches
9CF	BL3538	2 3/32	10CF	BL5470	1¾
9CF	BL4235	2 3/32	11CF	BL1440	2 7/32
9CF	BL5102	2 3/32	11CF	BL1478	2 7/32
9CF	BL5448	1 15/16	11CF	BL3607	2 7/32
9½CF	ALL	2	11CF	BL3800	2 7/32
10CF	BL3555	2⅛	11CF	BL3890	2 3/16
10CF	BL3817	2⅛	11CF	BL4525	2 7/32
10CF	BL4395	2⅛	11CF	BL5004	1⅞
10CF	BL4671	2⅛	11CF	BL5013	1⅞
10CF	BL4898	2	11CF	BL5143	1 15/16
10CF	BL5034	1 15/16	11CF	BL5152	1⅞
10CF	BL5078	2	11CF	BL5167	1⅞
10CF	BL5148	2⅛	11CF	BL5300	2 7/32
10CF	BL5222	1¾	11CF	BL5305	2 7/32
10CF	BL5389	2⅛	11CF	BL5391	2 7/32
10CF	BL5392	2⅛	11CF	BL5393	2 7/32

ASSEMBLE: When mounting the lever on the yoke, make certain that the roller is placed on the correct side of the flat-sided pin. When assembling the lever to the pressure plate, use a pin which has been sawed off so that it is as long as the lever is wide. Use this pin as a guide to hold the needle bearings in position. Force the sawed-off pin out with the regular pin after the lever is in place and lock the pins in position with cotter pins. Screw the lever adjusting screw in position into the tip of the lever and turn it down all the way.

After the levers have been installed assemble the pressure springs and locators. Set the yokes so that they are vertical to the pressure plate. Mount the cover over the pressure springs, making certain that all parts are properly located. The marks which were previously made on the cover and pressure plate should line up.

Compress the cover slowly, guiding the pressure plate lugs through the holes in the cover, making sure that the pressure springs are seated properly. After the assembly is completed, apply pressure to the levers, compressing and releasing the assembly several times to make sure that all moving parts are in their proper working positions, then, adjust the levers.

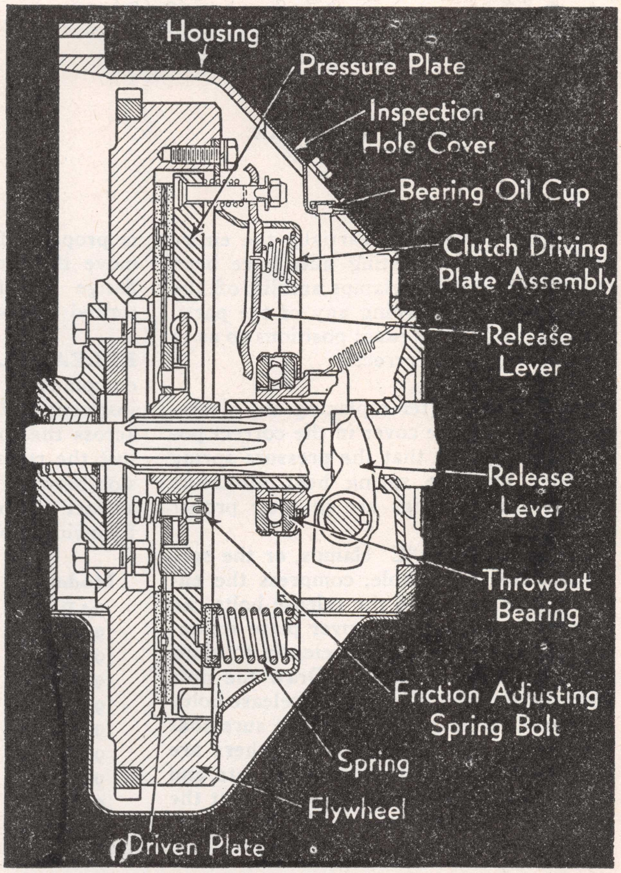
RELEASE LEVERS, ADJUST: Satisfactory operation of the clutch is absolutely dependent upon the accuracy of the lever adjustment, since the pressure plate must be parallel with the flywheel. The method of checking the position of the levers depends upon the equipment available. However, regardless of how the levers are measured, they must be uniform.

Using an extra flywheel as a dummy, and the correct lever height gauge plate in the position normally occupied by the driven plate, mount the assembly to the dummy flywheel, turning the cover screws a turn or two at a time to prevent springing the cover. Be sure the gauge is centered properly.

NOTE—If an extra flywheel is not available, remove the flywheel from the engine being worked on. The gauge being used must be exactly the same thickness as the driven plate used in the unit being serviced.

To make the adjustment, turn the adjusting screw in the end of the lever as far as it will go. Make sure that the yoke fastening screws are tight. Turn the adjusting screw in the end of the lever until the distance from the surface of the flywheel to the tip of the adjusting screw is as given in the LEVER SETTING table.

NOTE—If the correct gauge plate is not available, the dimensions given in the caption under Figure B may be used as a guide to determine the lever height setting. This measurement is taken between the face of the flywheel and the contacting point of the lever adjusting screw head. These measurements are to be used for clutch rebuilding purposes only. Lever settings on factory built covers should never be disturbed unless the levers are out of parallel more than .030".



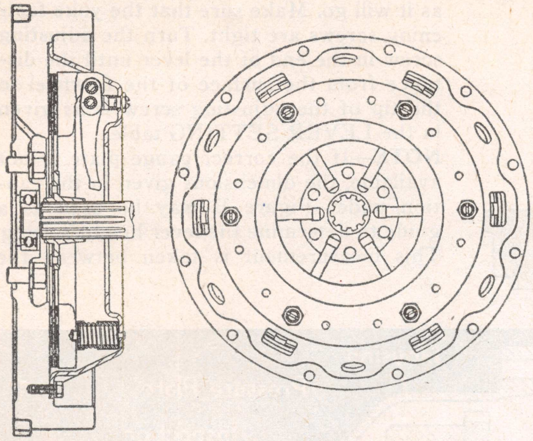
LONG. Models 9AB and 11AB.

After the adjustment is correct on all the levers, turn the pressure plate over and rest the head of the screw on some metal surface. With a staking chisel or screw driver, peen a portion of the lever into the slot of the adjusting screw.

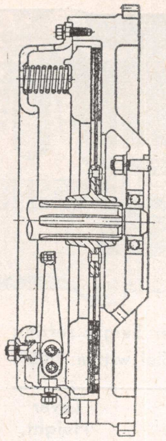
MODEL 9AB, 11AB

DISASSEMBLE: Before disassembling the unit, a hacksaw should be used to break the seals of the release lever adjusting nuts. By removing the metal of the adjusting nut upset into the slot in the release bolt, the removal of the adjusting nuts will be greatly aided.

To disassemble the unit, use three hand "C" clamps, if a regular fixture is not



LONG. Model 12CB.



LONG. Models 13 and 15.

available, to compress partially the entire unit. After the adjusting nuts have been removed, loosen the clamps and lift off the cover. Before disturbing any of the parts, note carefully their exact positions so as to assemble the unit correctly.

ASSEMBLE: After replacing any necessary parts, set the cover in the correct position, being sure that the pressure spring locators, pressure spring heat insulators and pressure springs are in their proper location.

Using the three "C" clamps, or the special fixture if available, compress the entire unit evenly until the release bolts can be pushed through the cover plate stamping and release levers sufficiently to allow the nuts to be assembled. Draw the nuts down flush with the top of the release bolts, but leave them unlocked. Make sure that the release bolt springs and washers are assembled between the pressure plate and the release levers, with the washers at the top of the springs next to the levers, before the release bolts are installed.

NOTE—If, when attempting to compress the entire unit with the hand clamps, the driving blocks do not quite enter the slots in the pressure plate, do not drive or pry on the driving blocks to bring them into position, but use a small diameter brass drift at one end of the pressure spring holes in the top of the cover and, with light hammer blows, shift the cover in the desired direction until the driving blocks are directly over the slots in the pressure plate.

After the adjusting nuts have been drawn down flush with the threaded end of the release bolts, install the entire assembly together with the driven plate to the flywheel.

NOTE—Before installing the cover assembly to the flywheel, compress the assembly and insert 1/4" tapered wooden blocks between the inside edge of the cover and the top of the levers, which will prevent the cover flange from bending when installing the cover. When the cover is properly fastened to the flywheel, remove the blocks, and be sure the cover flange fits freely and evenly into the turned recess of the flywheel.

RELEASE LEVERS, ADJUST: If special equipment is not available to make the adjustment of the levers, use a straight edge across the top of the cover plate and adjust the release levers so that the dimension between the tips of the levers and the surface of the flywheel is as given in the following table:

Model	Cover	Setting, Inches
9AB	BL1523	1 19/32
9AB	BL1524	1 5/8
9AB	BL1578	1 5/8
9AB	BL2122	1 17/32
9AB	BL2132	1 17/32
9AB	BL2224	1 17/32
9AB	BL2483	1 17/32
9AB	BL2495	1 17/32
9AB	BL2984	1 17/32
9AB	BL3343	1 17/32
11AB	BL2273	1 23/32

Make sure all levers are set uniformly, and when the adjustment is completed, lock the adjusting nuts with a staking chisel and re-check the adjustment. If possible, use a dial indicator for the final check.

MODEL 12 CB

DISASSEMBLE: Place the assembly on the bed of a press with a block under the pressure plate so arranged that the cover is free to move down. Place a block across the top of the cover, resting it on the spring bosses, and apply pressure to the assembly.

Mark the cover and pressure plate so that assembly may be made in the same relative position. Remove the screws from the assembly and release the pressure, after which, the cover may be lifted off.

Before disturbing any of the parts, note carefully their exact position so that assembly may be made accordingly. Examine all parts carefully and replace any that are doubtful.

ASSEMBLE: Mount the adjusting yoke on each lever and fasten it on by using a short lever pin. Use a lever pin which has been sawed off so that it is as long as the lever is wide. Use this pin as a guide to hold the needle rollers in place while assembling the yoke to the lever, and the lever to the pressure plate. Force this sawed off pin out with the regular pin after the yoke is in position. Repeat this operation to assemble the lever to the pressure plate, using long lever pins.

Assemble the pressure spring locators, buttons and pressure springs. Place the release lever tension washers over the yoke bolt and set so that the bolt part of the yoke is vertical to the pressure plate. Mount the clutch cover over the pressure springs, making certain that every part is properly located. The marks on the cover and pressure plate which were made before dismantling must line up during assembly.

With the assembly in position on the press, compress the cover slowly, guiding the pressure plate lugs through the holes in the cover, making sure that the pressure springs are properly located. After the assembly is completed, apply pressure to the levers, compressing and releasing the assembly several times to make sure that all moving parts are in their proper working positions. Assemble the release lever adjusting nuts, turning them down until their tops are flush with the tops of the bolts.

NOTE—Care must be exercised when assembling the levers to the pressure plate to see that all the needle roller bearings are in place correctly and the lever pins are locked with cotter pins.

NOTE—If the unit being serviced is equipped with lever pins using a hairpin lock wire at either end to hold the pin in place, replace with the new type pin using a head on one end and a cotter pin on the other end.

RELEASE LEVERS, ADJUST: Using an extra flywheel as a dummy, and the correct lever adjusting gauge plate in the position normally occupied by the driven disc, mount the assembly on the dummy flywheel, turning the cover screws a turn or two at a time to avoid springing the cover. Be sure the gauge is seated properly.

NOTE—If an extra flywheel is not available, remove the flywheel from the engine being worked on. The gauge being used, must be exactly the same thickness as the combined thickness of the driven disc used in the unit being serviced.

To make the adjustment, set each lever by turning the adjusting bolt nut so as to bring each lever 2 13/32" from the surface of the flywheel to the contacting portion of the lever. Lock the nuts with a staking chisel and recheck the lever setting.

MODELS 13 AND 15

DISASSEMBLE: Place the assembly on the bed of a press with a block under the pressure plate so arranged that the cover is free to move down. Place a block across the top of the cover and apply pressure to the assembly.

Mark the cover and pressure plate so that assembly may be made in the same relative position. Remove the six lever adjusting nuts from the assembly and release the pressure, after which, the cover may be lifted off.

Before disturbing any of the parts, note carefully their exact position so that assembly may be made accordingly. Examine all parts carefully and replace any that are doubtful.

NOTE—Do not loosen the driven block nuts unless the blocks are badly worn. If worn, loosen the nuts and turn the blocks 90 degrees so that the other two sides of the blocks will present a bearing contact. Before tightening the nuts, be sure the blocks are positioned properly, otherwise they may cause a bind or an uneven contact with the pressure plate lugs. When the nuts are tightened, the pressure plate should move freely on the blocks.

ASSEMBLE: Mount the adjusting yoke on each lever and fasten it on by using a short lever pin. Use a lever pin which has been sawed off so that it is as long as the lever is wide. Use this pin as a guide to hold the needle rollers in place while assembling the yoke to the lever, and the lever to the pressure plate. Force this sawed off pin out with the regular pin after the yoke is in position. Repeat this operation to assemble the lever to the pressure plate, using long lever pins.

Assemble the pressure spring locators, buttons (if used) and pressure springs. Place the release lever tension washers over the yoke bolt and set so that the bolt part of the yoke is vertical to the pressure plate. Mount the clutch cover over the pressure springs, making certain that every part is properly located. The marks on the cover and pressure plate which were made before dismantling must line up during assembly. Be sure the driving blocks are in line with the pressure plate slots.

With the assembly in position on the press, compress the cover slowly, guiding the pressure plate lugs and driving blocks through the holes in the cover, making sure that the pressure springs are properly located. After the assembly is completed, apply pressure to the levers, compressing and releasing the assembly several times to make sure that all moving parts are in their proper working positions. Assemble the release lever adjusting nuts, turning them down until their tops are flush with the tops of the bolts.

NOTE—Care must be exercised when assembling the levers to the pressure plate to see that all the needle roller bearings are in place correctly and the lever pins are locked with cotter pins.

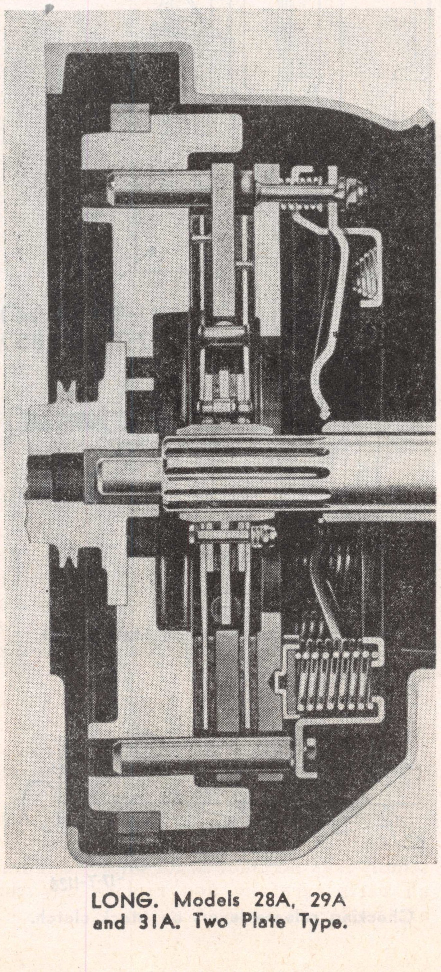
RELEASE LEVERS, ADJUST: Mount the entire clutch assembly to the engine flywheel in the regular way and adjust the levers until their tips are the distance given below to the top flat surface of the clutch cover. This adjustment may be obtained by laying a straight edge across the top of the cover and measuring down to the tips of the levers. A suitable aligning shaft can be made from a main drive gear when installing these clutches.

The distance between the tips of the levers and the top of the cover should be 15/16" on model 13, cover number BL3356; 1 1/16" on model 13, cover number BL5087, and 1⅛" on all model 15 covers.

DOUBLE PLATE TYPE MODELS 14B, 28A, 29A, 31A, 31AD, 34A, 34BD

DISASSEMBLE: After removing the clutch assembly from the flywheel, remove the three center drive plate adjusting screws. Run a hacksaw through the slots in the release bolts to break the seals. Use three hand clamps or a press to compress the cover while the nuts on the release bolts are removed. Before removing the cover, punch-mark its location with relation to the pressure plate so that assembly may be made in the same position. Before removing any parts, note carefully their position and assemble accordingly.

ASSEMBLE: Insert the release bolts in the pressure plate and lay the front side of the plate on a piece of heavy cardboard which is larger than the pressure plate diameter. Install the pressure spring locating cups and place an insulator button in each one. Put the pressure springs in place and lay the clutch cover over the assembly, aligning the driving plate adjusting screw holes in the cover with the corresponding holes in the pressure plate. Compress the cover about halfway down and assemble the release levers.



LONG. Models 28A, 29A and 31A. Two Plate Type.

NOTE—When installing the cover over the pressure springs on Models 28A, 29A and 31A, compress the cover down about halfway, but before entering the release bolts through the levers, install the flat washers on top of the release bolt springs. Any attempt to install these washers at any other time will result in interference with the cover as it is being pressed down, which will very likely cause the edge of the cover to bend.

NOTE—On Model 31AD covers, the release lever studs protrude from the surface of the pressure plate, and when assembling these units, use a suitable surface plate having slots to accommodate these studs, otherwise an accurate lever height adjustment will not be obtained.

On all models, increase the pressure on the cover until the washers and nuts can be installed on the release bolts and tighten the nuts until flush with the top of the bolts.

RELEASE LEVERS, ADJUST: The method of checking the position of the levers depends on the equipment available. However, regardless of how the levers are measured, they must be of uniform height.

Using an extra flywheel as a dummy, adjust the levers so that the distance between the face of the flywheel and the contacting point of the levers is as given in the following table.

Model	Cover No.	Height, Inches
28A	ALL	1⅜
29A	BL2847	1½
29A	BL2905	1½
29A	Others	1⅜
31A	BL2563	1 9/16
31A	Others	1½
31AD	BL2730	1 9/32
31AD	BL2796	1 9/32
31AD	BL2771	1¼
31AD	BL2868	1⅝

NOTE—On the 31AD model, be sure the heads of the release bolts are properly placed in the recesses of the pressure plate before adjusting the levers.

NOTE—On models 14B, 34A and 34BD, if a dummy flywheel is not available, mount the entire clutch assembly to the engine flywheel in the regular way and adjust the levers until their tips are exactly the distance given in the following table, to the top of the flat surface of the clutch cover.

This adjustment may be obtained by laying a straight edge across the top of the cover and measuring down to the tip of the levers.

Model	Cover No.	Height, Inch
14B	BL4750	⅞
34A	ALL	15/16
34BD	BL2900	13/16
34BD	BL2924	13/16
34BD	BL3376	27/32
34BD	BL5228	27/32

NOTE—Model 34BD clutches using cover assembly numbers BL2900 and BL2924, the above measurement is taken from the flat cover stamping. If equipped with a ribbed cover stamping, the dimension is 31/32 inch.

A suitable aligning shaft can be made from a transmission main drive gear when installing these clutches, and after a satisfactory lever adjustment is obtained, stake the release bolt nuts in place with a chisel —if they are not of the self-locking type.

On all models, after the assembly is bolted to the flywheel, depress the pedal a few times to be sure the center driving plate is not binding on the pins. Engage the clutch and screw the three center plate adjusting screws in until they butt against the center plate, then back off three notches, each notch indicated by a clicking sound. Check the clutch release and if insufficient, back off each screw another notch until the center plate is equally spaced between the two driven discs. Depress the pedal a few times to make sure the plate is not binding on the pins.

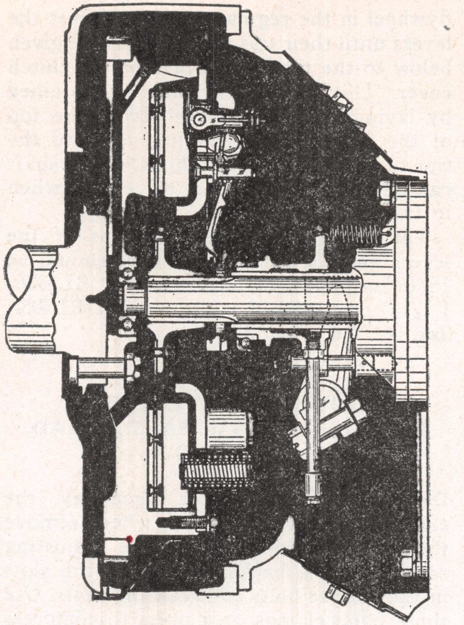
MACK

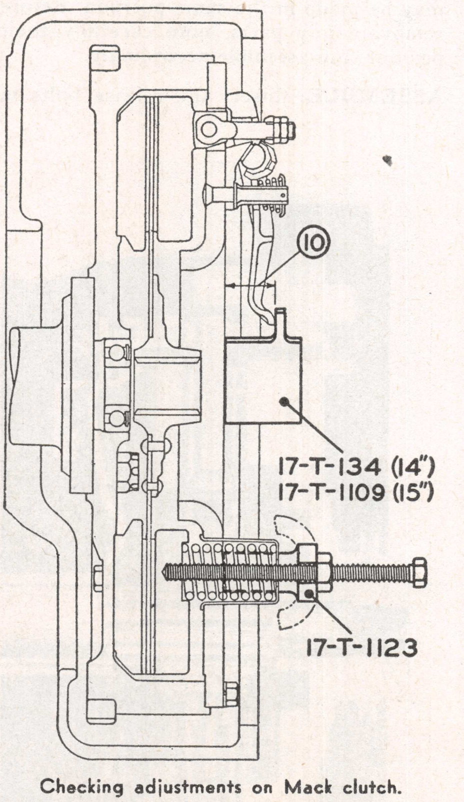
The Mack clutch is the single plate type. Models CL 20 and CL 40 are 14" in diameter and have 18 coil springs while Model CL 28 is 15" in diameter and has 36 coil springs in the pressure plate. Disengagement of the clutch is through action of six ball pivoted fingers on the clutch pulling the pressure plate away from the driven disc when the fingers are contacted and pushed toward the flywheel by the forward movement of the clutch release bearing.

The release bearing clearance or gap should be 5/32". As the facings wear, this gap decreases and when it reaches 1/16", an adjustment should be made to restore the gap to its original dimension of 5/32".

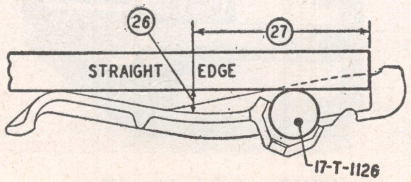
CLUTCH PEDAL ADJUSTMENT

When the release bearing gap is less than 5/32", the clutch release lever on the outside of the clutch should be adjusted so that there is ⅜" clearance between the roller and the cam, which will give approximately a 2" travel of the clutch pedal pad. When no further adjustment is possible between the roller and the cam, remove the clutch release lever from the serrated shaft and turn it slightly. Then replace it on the shaft. This permits more adjustments so that the ⅜" clearance can again be obtained.


Mack single plate clutch.



Checking adjustments on Mack clutch.



Checking release levers on Mack clutch.

Check the setting of the clutch fingers to determine if all permissible wear of the clutch driven disc facing has been obtained. Gauges are available for this. With the proper gauge held against the clutch cover, as shown, the facings are worn to the point where they should be renewed if the clutch fingers come to within 1/32" of the tongue of the gauge. If the finger pivots should become worn so that repairs are necessary, it is recommended that the assembly be exchanged for a reconditioned one.

REMOVAL

Before removing the clutch, first mark the cover and the flywheel to insure assembly in the same position. Then attach three assembly tools, if they are available, making sure that the screws bottom in the tapped holes in the pressure plate. Set the nuts snugly against the bracket but do not force it. Then remove the clutch cover screws after which the clutch assembly may be lifted out.

DRIVEN DISC REPLACEMENT

If the plate is torn or cracked, do not service it, but replace it with a new assembly. Inspect the splines in the hub and remove any burrs. After riveting on the new facings, test for runout and straighten if more than .025" out.

DISASSEMBLY

Mark the cover and pressure plate for reassembly in their original position. Remove the nuts and fulcrums from each of the eye-bolts. Back off the nuts of the assembly tool equally and alternately, one turn at a time, holding the screws from turning while doing so. When the spring pressure is entirely relieved, back out the three assembly tools and lift off the cover. To remove the fingers, first mark the fingers and cover and then compress the finger spring with washer and remove the pin.

INSPECTION

Check the fingers with a straight edge and steel ball, as illustrated. If the lever is bent so that dimension 26 is more than 11/32" when measured at a point 2½" from the end of the straight edge, 27 in illustration, the lever should be replaced. Inspect the bushings for cracks and crumbling. With the finger resting on a ¾" to 1" block to support it, fill the socket with oil and let it stand to absorb the oil until ready to reassemble it.

Test all springs and reject those not meeting the specifications shown in the table below:

Outside Diameter	Color	Minimum Pressure, pounds	At Length, inches
1	Green	63	2¼
1	Yellow	43	2¼
1⅛	Red	120	2 5/16
1⅛	Blue	112	2 5/16
1⅛	Green	98	2 5/16
1½	Yellow	108	2¼
1½	Black	75	2¼
1½	Red & Black	124	2¼

Clutch spring tension may decrease when the flywheel or the pressure plate are faced. Washers are available to insert in the spring cups to compensate for this loss of clutch spring pressure, but this compensation must never exceed 3/16".

Insert fitting in pilot bearing lubricating hole in the flywheel rim and pump in lubricant to clear possible clogged passage. Inspect the flywheel insert, when used, and the clutch pressure plate for scores and checks. If necessary to reface these parts, remove only sufficient metal to obtain a smooth flat surface. Finish with a light cut and polish with emery cloth. Do not machine the recess in the flywheel in which the cover seats. Excessively worn plates should be renewed.

When plates are refaced, the compressed length of the springs is increased, which decreases the effective spring pressure. Consequently to compensate for this, metal washers must be placed in the bottom of the spring cups. Washers should be centered in the cups through the ventilating holes and may be held in place with a touch of shellac.

Due to refacing of plates, longer eye-bolts may be required, the increase in length being equal to the thickness of the compensating washers. In order to avoid breaking off the lugs on the pressure plate when replacing eye-bolts, use a pin remover tool. New pins should be pressed in between vise jaws or with a press and finally set, with the remover, so that the ends do not project beyond the sides of the lugs.

REASSEMBLY

In reassembling the clutch, make sure that each spring pocket in the pressure plate has an insulating washer and that the marks on the cover and pressure plate line up. Apply the three assembly tools, bottoming the screws in the tapped holes. Thread down the nuts equally and alternately one turn at a time until the cover is 1 3/32" from the friction face of the pressure plate.

MOUNTING

Pack the pilot bearing in the flywheel with grease and replace it with the shield toward the clutch. Center the driven disc with an aligning mandrel. Place the clutch assembly on the flywheel, lining up the marks on the wheel and cover. Make sure that the cover is firmly seated in the recess and attach with the cover screws. Then remove the assembly tools and aligning mandrel.

ASSEMBLING FINGERS

Assemble the fingers, springs, washers and pins, matching the marks on the covers and the fingers. Grease the contact edges of fulcrums, assemble them and the lock nuts onto the eye-bolts. Turn down the nuts until the fingers are 15/32" from the clutch cover. Pull out the fingers once or twice, allowing them to snap back and recheck. This setting should be done very accurately so that the contact faces of all six levers will be in line. Securely lock the two nuts against each other. This is important.

Assembly is now completed, but before attaching the transmission, inspect the release sleeve shoes and yoke for excessive wear, and release bearings for lubrication. If longer eye-bolts have been installed, make sure they do not strike the transmission case in any way.

NOTE—When setting the fingers, the faced driven disc is preferably replaced by a true steel disc 15/32" thick, thus avoiding improper adjustment due to high spots of clutch facings. After setting the fingers and locking them securely, substitute the faced driven disc for the steel gauge. Do not alter finger setting as made with the steel dummy.

ROCKFORD

MODELS HH, II, LL, RM, RR, TT

DISASSEMBLE: Compress the assembly in a press and remove the lever pins and release levers. Release the pressure and lift off the cover.

Examine all parts and replace any that appear to be doubtful. Inspect the release levers for wear. Replace pressure springs that have seen considerable service and have lost their original tension. If the pressure plate is warped, grooved or heat checked, it must be replaced. Replace worn lever pins.

ASSEMBLE: Position the pressure springs on the pressure plate, and the spring cups over the pressure springs. Install the cover over the spring cups, lining up the square holes in the cover with the lever or drive studs in the pressure plate. Compress the cover and fasten it to the pressure plate.

With the adjusting screw partially turned down into the lever, insert the lever spring through the hole in the lever so that it extends upward against the head of the adjusting screw. Hook the curved end of the lever spring under the rim of the cover plate and force the rear end of the release lever into position in the slot of the lever stud to a point where the lever pin can be inserted through the stud and lever, after which, lock the lever pin with a cotter pin.

RELEASE LEVERS, ADJUST: If a special fixture is not available to make the adjustment, install the clutch assembly to the flywheel. The installation is made easier by placing a short nail or steel pin 1/8" in diameter in the lever stud slot directly under the rear end of the lever. Be sure to remove these pins after the assembly is bolted to the flywheel.

To make the adjustment, turn the adjusting screw in each of the release levers so that when the clutch pedal is released and the clutch engaged, there should be approximately 1/16" clearance between the

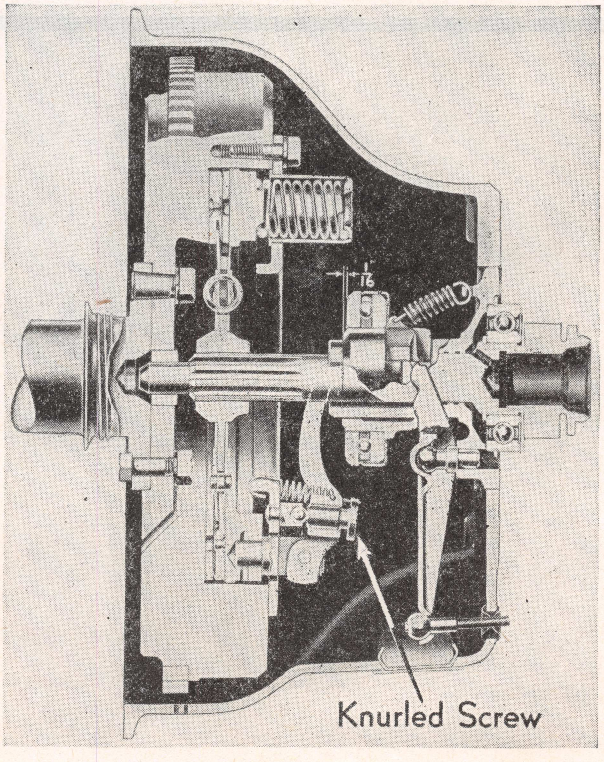


Figure D. ROCKFORD. Showing clearance between release bearing and tips of levers.

Model	Cover No.	Height, Inches
HH	UCLA-949	1 29/32
HH	UCLA-1-949	1 29/32
HH	UCLA-2-949	1 23/32
II	UCLA-1062	2 5/32
II	UCLA-1062-1	2⅜
II	UCLA-1-1062	1 31/32
II	UCLA-6-1062	2 5/16*
II	UCLA-10-1062	1 13/16
II	UCLA-9-1098	2 7/32
II	UCLA-13-1098	2 7/32
II	UCLA-1-1471	2⅜
II	UCLA-3365	2½
LL	UCLA-4-1062	2 5/32
LL	UCLA-8-1062	2 3/32
LL	UCLA-9-1062	2 5/32
LL	UCLA-1-1428	1 29/32
LL	UCLA-3-1428	2 3/32
LL	UCLA-4-1428	2 5/32
LL	UCLA-6-1428	1 29/32
RM	UCLA-4409	2½ *
RM	UCLA-4259	2 7/32
RM	UCLA-4665	1 31/32*
RM	UCLA-4534	2 11/32
RM	UCLA-4259-1	2 7/32
RM	UCLA-4596	2¾
RR	UCLA-1534	2 5/16*
RR	UCLA-1534-2	2 3/32
RR	UCLA-1716-2	2¼
RR	UCLA-1-1716	2 5/32
RR	BW-571	1¾
RR	BW-572	1¾
RR	BW-573	1¾
TT	UCLA-2-3271	2 *
TT	UCLA-3271	2 *
TT	UCLA-3280	2 *
TT	UCLA-4-3280	2 *
TT	UCLA-2334	2 5/32
TT	UCLA-2334-1	2 5/32
TT	UCLA-1-3688	2 1/32
TT	UCLA-3703	1 15/16
TT	UCLA-1-3703	1 15/16
TT	UCLA-3706	2⅜ *
TT	UCLA-3706-1	2⅜ *

*See note next page.

front face of the release bearing and the end of the release levers (See Figure D).

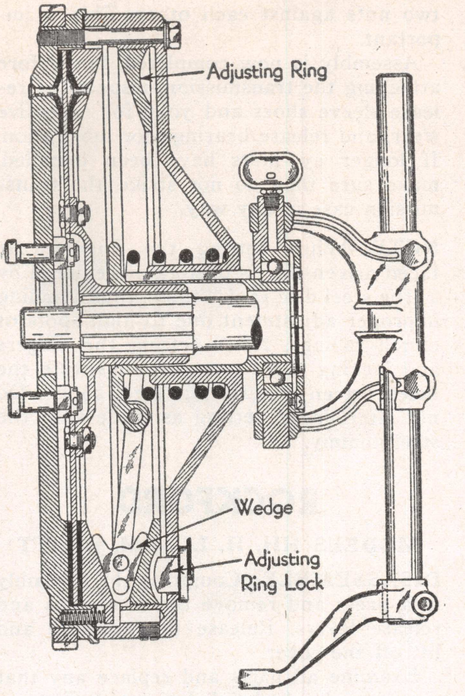
NOTE—If a clutch rebuilding fixture is used, the lever setting table may be used as a guide to determine the correct lever height. The dimension shown is the distance between the surface of the pressure plate and the contacting tip of the lever. Where a dimension is followed by an asterisk (*), the measurement is taken from the face of the flywheel and the contacting tip of the lever.

WHITE

SINGLE PLATE WEDGE TYPE

This clutch is of the single plate design, operating in oil, with the mechanism entirely enclosed. Clutch engagement is accomplished by the pressure of a heavy coil spring, acting through a flanged sleeve, which moves six wedges radially—through suitable linkage—between the pressure plate and the clutch plate adjusting ring. The clutch is disengaged by the throwout yoke compressing the coil spring, thereby causing the wedges to release the pressure plate.

ADJUSTMENT: The clutch may be adjusted by rotating an adjusting ring which is threaded inside the clutch case. To make an adjustment, remove the hand hole cover from the bell housing and turn the flywheel until the adjusting ring lock is visible. Remove the ring lock and press the clutch pedal down all the way. The clutch may then be tightened by moving the notched ring in a clockwise direction, using a screwdriver for the purpose.



WHITE. Single Plate Wedge Type.

NOTE—The space between the flywheel cover and the clutch pull-out shoe should be ¼" and never more than 5/16". The only time the 5/16" dimension should be used is when new facings are installed. When replacing the lock plate, be sure its tongue registers with the groove in the adjusting ring before tightening the cap screws.

When the clutch is properly adjusted and fully engaged, the clutch pedal lever should be ½" from the underside of the floor board. If an adjustment is required, turn the yoke ends on the clutch pedal connecting rod.

LUBRICATION: After the first 500 miles and each 2000 miles thereafter, the clutch should be drained and refilled with fresh oil. Unscrew the plug from the underside of the flywheel housing. Remove the floor board cover over the bell housing hand hole and the plate from the transmission housing. Turn over the engine until the brass plug in the flywheel clears at the opening in the housing. Remove this plug and turn the flywheel ½ turn to permit the oil to drain.

When completely drained, turn the flywheel until the hole is again facing upward and pour in one pint of kerosene. Replace the plug and operate the engine at a moderate speed for about a minute, and at the same time, engage and release the clutch several times to permit the kerosene to clean the clutch thoroughly, after which, remove the plug and drain off the kerosene.

Refill the clutch with a half pint (no more) of oil of the specified grade and type. This oil should be a light engine oil of a low cold test, or a mixture of ¼ pint of medium engine oil and ¼ pint of kerosene.

OVERHAUL: Disassembly of this type clutch is accomplished by simply mounting the unit on the bed of a press and removing the cap screws which fasten the clutch case to the pressure plate. With all cap screws removed, release the pressure gradually until the clutch spring pressure is relieved, after which all parts can be removed.

TRANSMISSIONS

INDEX

Make and Model	Number Speeds and Type Gears	Oil Capacity, Pints	Lubricant Recommended, SAE Number		Page Number
			Above 32° F.	Below 32 F.	
AUTOCAR					
RL-4		10⑤	140	90	719
URL-4		10⑤	140	90	719
RL-5	5-SG	10⑤	140	90	719
URL-5	5-SG	10⑤	140	90	719
DF-5	5-CM	10⑤	140	90	719
UDF-5	5-CM	10⑤	140	90	719
TF-5		14⑤	140	90	719
UTF-5		14⑤	140	90	719
BROWN-LIPE					
224	4-CM	8③	140	90	722
234	4-SG	8③	140	90	723
703	3 Aux.	8½	140	90	720
2252	5-CM	8⑦	140	90	727
2253	5-CM	8⑦	140	90	727
2321	2 Aux.	4	140	90	720
2323	2 Aux.	4	140	90	720
2341	4-CM	5½	140	90	723
2352	5-CM	10	140	90	727
2353	5-CM	10	140	90	727
2441	4-CM	6	140	90	724
3221	2 Aux.	7	140	90	720
3222	2 Aux.	7	140	90	720
3241	4-CM	8½	140	90	725
3341	4-CM	8½	140	90	725
3352	5-CM	10	140	90	727
3353	5-CM	10	140	90	727
3440	4-CM	8½	140	90	725
3481	8-CM	11⑥	140	90	730
4452	5-SM	11	50	50	733
4453	5-SM	11	50	50	733
5222	2 Aux.	8	140	90	720
5331	3-CM	9	140	90	721
5341	4-CM	10	140	90	725
5351	5-CM	12⑧	140	90	727
5352	5-CM	12⑧	140	90	728
5531	3 Aux.	6	140	90	731
5552	5-SM	11	50	50	733
5553	5-SM	11	50	50	733
6031(A)	3 Aux.	7④	140	90	732
6241	4-CM	11	140	90	725
6440	4-CM	11	140	90	725
7131	3-CM	20	140	90	722
7341	4-CM	18	140	90	725
7441	4-CM	18	140	90	725
7451	5-CM	26	140	90	729
7481	8-CM	26	140	90	730
7640	4-CM	18	140	90	725
7641	4-CM	18	140	90	725
7651	5-CM	26	140	90	729
CHEVROLET					
1933–36	3-SM	2½	90	90	734
1937–46	3-SM	1½	90	90	735
1932–46	4-SG	⑨	90	90	737
CLARK					
140 T	3-CM	3½	140	90	739
141 T	3-CM	3½	140	90	739
142 T	3-CM	3½	140	90	739
170 FS	4-SG	8	140	90	739
185 F	4-CM	8	140	90	739
200 V & VO	5-CM	12	140	90	740
202 V & VO	5-CM	12	140	90	740
204 V & VO	5-CM	12	140	90	740
205 V & VO	5-CM	12	140	90	740
CLARK					
230 F	4-CM	11	140	90	740
231 F	4-CM	11	140	90	740
270 V & VO	5-CM	20	140	90	741
272 V & VO	5-CM	20	140	90	741
326 V & VO	5-CM	24	140	90	741
FORD					
1932–46	3-SM	2½	140	90	742
1932–46	4-SG	5	140	90	743
FULLER					
AR	RE.	8	140	90	744
AR-163	2 Aux.	8	140	90	744
H	4-SG	13½	140	90	745
HU	4-SG	13½	140	90	745
HOG	4-SG	13½	140	90	745
HUOG	4-SG	13½	140	90	745
MG	4-SG	8	140	90	745
MGOG	4-SG	8	140	90	745
MGU	4-SG	8	140	90	745
MH	4-SG	12	140	90	745
MHU	4-SG	12	140	90	745
MHOG	4-SG	12	140	90	745
MHUOG	4-SG	14	140	90	745
MKU	4-SG	7	140	90	745
MLU	4-SG	8	140	90	745
MR	4-SG	12	140	90	745
MRU	4-SG	12	140	90	745
UR	RE.	8	140	90	744
UR-163	2 Aux.	8	140	90	744
WO	4-SG	4	140	90	745
2-A-53	2 Aux.	8	140	90	744
2-B-53	2 Aux.	8	140	90	744
2-A-62	2 Aux.	8	140	90	744
2-B-62	2 Aux.	8	140	90	744
2-A-86	2 Aux.	12	140	90	744
2-B-86	2 Aux.	12	140	90	744
3-AY	3 Aux.	17	140	90	744
3-A-86	3 Aux.	17	140	90	744
3-B-86	3 Aux.	17	140	90	744
3-C-86	3 Aux.	17	140	90	744
4-A-86	4-CM	18	140	90	745
4-B-86	4-CM	18	140	90	745
4-AM-86	4-CM	18	140	90	745
4-BM-86	4-CM	18	140	90	745
4-A-860	4-CM	18	140	90	745
4-B-860	4-CM	18	140	90	745
4-AM-860	4-CM	18	140	90	745
4-BM-860	4-CM	18	140	90	745
5-A-29	5-CM	11	140	90	746
5-B-29	5-CM	11	140	90	746
5-C-29	5-CM	11	140	90	746
5-A-33	5-CM	12	140	90	746
5-B-33	5-CM	12	140	90	746
5-F-33	5-CM	12	140	90	746
5-G-33	5-CM	12	140	90	746
5-M-33	5-CM	12	140	90	746
5-A-38	5-CM	24	140	90	746
5-A-43	5-CM	16	140	90	746
5-F-43	5-CM	16	140	90	746
5-M-43	5-CM	16	140	90	746
5-A-53	5-CM	30	140	90	746
5-A-62	5-CM	24	140	90	746
5-F-62	5-CM	24	140	90	746
5-M-62	5-CM	24	140	90	746
5-A-290	5-CM	11	140	90	746

TRANSMISSIONS

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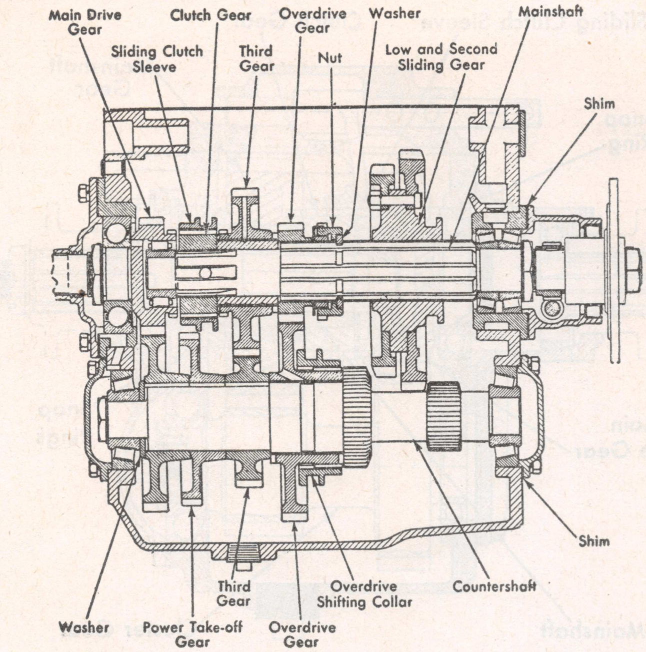
Make and Model	Number Speeds and Type Gears	Oil Capacity, Pints	Lubricant Recommended, SAE Number		Page Number
			Above 32° F.	Below 32° F.	
FULLER					
5-B-290	5-CM	11	140	90	746
5-C-290	5-CM	11	140	90	746
5-A-330	5-CM	12	140	90	746
5-B-330	5-CM	12	140	90	746
5-F-330	5-CM	12	140	90	746
5-G-330	5-CM	12	140	90	746
5-M-330	5-CM	12	140	90	746
5-A-380	5-CM	24	140	90	746
5-A-430	5-CM	16	140	90	746
5-F-430	5-CM	16	140	90	746
5-M-430	5-CM	16	140	90	746
5-A-530	5-CM	30	140	90	746
5-A-620	5-CM	24	140	90	746
5-F-620	5-CM	24	140	90	746
5-M-620	5-CM	24	140	90	746
8-A-86	8-CM	30	140	90	747
8-B-86	8-CM	30	140	90	747
8-C-86	8-CM	30	140	90	747
8-D-86	8-CM	30	140	90	747
8-AM-86	8-CM	30	140	90	747
8-BM-86	8-CM	30	140	90	747
8-CM-86	8-CM	30	140	90	747
8-DM-86	8-CM	30	140	90	747
8-A-860	8-CM	30	140	90	747
8-B-860	8-CM	30	140	90	747
8-C-860	8-CM	30	140	90	747
8-D-860	8-CM	30	140	90	747
8-AM-860	8-CM	30	140	90	747
8-BM-860	8-CM	30	140	90	747
8-CM-860	8-CM	30	140	90	747
8-DM-860	8-CM	30	140	90	747
FWD					
M	10-CM				
GMC					
①	3-SM	1¾	90	90	000
②	3-SM	1¾	90	90	000
NTERNATIONAL					
FPP-45	2 Aux.	15	140	90	751
HDS	3-SM	3	140	90	751
H-41	4-SG	5½	140	90	753
H-42	4-SG	5½	140	90	753
H-7	5-CM	48	140	90	754
F-51	5-CM	11	140	90	754
F-52	5-CM	18	140	90	754
F-54	5-CM	26	140	90	754
MACK					
TR-11	4-SG	6	●	●	754
TR-12	5-CM	28	●	●	755
TRD-12	10-CM	36	●	●	756
TR-15	5-CM	28	●	●	755
TRD-15	10-CM	36	●	●	756
TR-17	5-CM	28	●	●	755
MACK					
TRD-17	10-CM	36	●	●	756
TR-27	3-CM	4	●	●	754
TR-28	4-SG	6	●	●	754
TR-30	5-CM	18	●	●	755
TR-31	5-CM	22	●	●	755
TDF-31	10-CM	25	●	●	756
TR-32	5-CM	21	●	●	755
TRD-32	10-CM	36	●	●	756
TR-37	5-CM	28	●	●	755
TRD-37	10-CM	36	●	●	756
MACK JR.	4-SG		160	90	757
NEW PROCESS	3-CM	3½	140	90	758
PAK-AGE-CAR					
Stutz	3-SM	5	140EP	90EP	759
Diamond T	3-SM	5	140EP	90EP	760
REO	4-SG		160	90	756
WARNER					
T84	3-SM	1¼	140	90	761
T86	3-SM	2	140	90	761
T88	3-SM	2	140	90	761
T9	4-SG	6	140	90	762
T9A	4-SG	6	140	90	762
WHITE					
3B	4-SG	8	140	90	763
4B	4-SG	8	140	90	763
5B	4-SG	8	140	90	763
18A, B, BA	4-SG	6	140	90	762
20B	5-CM	30	140	90	746
27B	4-CM	5½	140	90	723
28B	4-CM	5½	140	90	723
36B	5-CM	26	140	90	746
37B	5-CM	26	140	90	746
41B	5-CM	12	140	90	740
42B	5-CM	12	140	90	740
43B	4-CM	10	140	90	740
44B	4-CM	8	140	90	739
45B	4-SG	7	140	90	762
46B	4-SG	7	140	90	762
50B	5-CM	20	140	90	741
51B	5-CM	20	140	90	741
54B	5-CM	12	140	90	740
55B	5-CM	12	140	90	740
58B	5-CM	24	140	90	741
59B	5-CM	24	140	90	741
60B	3-SG	8	140	90	764
63B	4-SG	8	140	90	731
401B	4-CM	5½	140	90	723
551B	5-CM	20	140	90	741
552B	5-CM	13	140	90	740
WHITE HORSE	3-CM	3	140	90	764

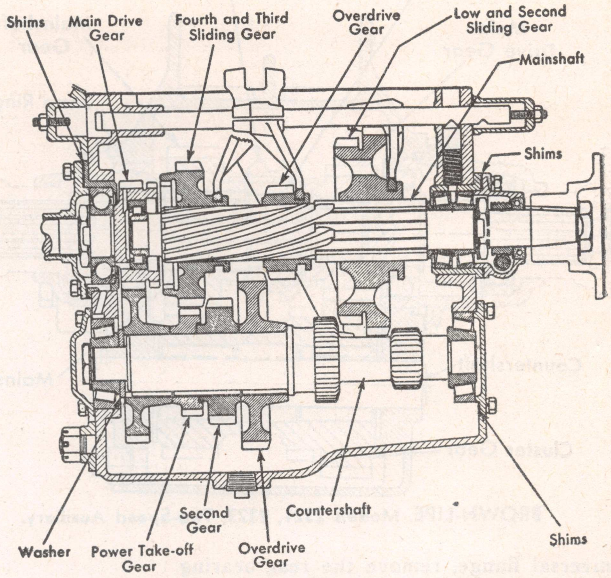
Abbreviations: S—Summer. W—Winter. CM—Constant Mesh. SG—Sliding Gears. SM—Synchronized Mesh. RE—Reversing Unit. AUX—Auxiliary Unit.

①—Three-speed synchromesh with standard floor shift control. ②—Three-speed synchromesh with remote control gearshift. ③—Add 2 pints for winter operation. ④—Add 3 pints for winter operation. ⑤—Add 4 pints for winter operation. ⑥—Add 4½ pints for winter operation. ⑦—Add 5 pints for winter operation. ⑧—Add 6 pints for winter operation. ⑨–1932-39, 6½ pints; 1940-42, 5½ pints.

● – The Mack Company attaches a metal tag to the transmission specifying the type lubricant to be used. Use the following SAE number lubricant against the builder's recommendations on the metal tag: Mack No. 1, use 140EP. Mack No. 2, use 140. Mack No. 3, use 90EP. Mack No. 4, use 90.



AUTOCAR. Models UDF-5, UTF-5. This unit without overdrive is UDF-4 and UTF-4. Typical of DF and TF models.



AUTOCAR. Model URL-5. This unit without overdrive is URL-4. Typical of RL models.

AUTOCAR

MODELS DF, UDF, TF, UTF

Four or Five Speeds Forward and One Reverse with Direct on Fourth and Overdrive on Fifth.

Disassemble: Take off shift lever housing assembly and bell housing. Remove the transmission top cover on model UDF and the side cover from the DF model. Loosen the shift fork lock screws and pull out the shift rails, holding a hand over the lock ball holes to prevent the balls and springs from flying out.

CAUTION—As each rail is removed, it should be tagged to assure correct assembly; lift out the loose forks and tag them also.

On the DF model, reach into the transmission side cover hole, loosen the fork lock screws and pull out the overdrive and reverse shift rails, after which, take out the forks.

On both units, remove the speedometer driven gear. Lock the transmission in two gears to prevent the mainshaft from turning and unscrew the universal flange nut. Pull off the universal flange and speedometer drive gear. Remove the mainshaft rear bearing cover, the main drive gear cover and the front and rear countershaft covers.

CAUTION—Be sure to collect the shims from the rear of the mainshaft and countershaft. Unscrew the nut from the rear of the mainshaft and remove the bearings and sleeve.

Pull the main drive gear, its bearing and sleeve out through the front; the bearing and drive gear can be separated after removing the bearing lock nut. Lift the mainshaft assembly out through the top by its front end.

Unscrew the nut from the front end of the countershaft, push the shaft to the rear, remove the rear bearing and lift the assembly out of the case by its front end. Pull the reverse gear shaft out of the case and lift out the gear assembly.

To disassemble the mainshaft, pull the sliding gears from the shaft. Remove the lock pin which retains the third and fourth speed sliding clutch gear to the mainshaft, then pull off the clutch gear and third speed gear assembly. Rotate the splined washer to align its teeth with the mainshaft splines and slip it from the shaft. Straighten the tab on the washer which holds the mainshaft overdrive gear retaining nut in place and unscrew the nut from the overdrive gear; the gear, washer and nut can then be removed from the shaft.

To disassemble the countershaft, press the fourth speed gear, power take-off gear and third speed gear from the shaft one at a time, after which, the overdrive gear and shifting collar may be removed.

NOTE—When installing the gears, be sure the keys are a tight fit, and see that the oil groove for the overdrive gear is open.

Assemble: Assemble the reverse gear in the case and push in the shaft. Install the countershaft front bearing, place the countershaft assembly in the case and replace the rear bearing.

NOTE—Be sure the washer is placed on the front of the shaft before inserting shaft through the front bearing.

Fasten the nut securely on the front end of the countershaft and replace the cover. Assemble the shims and bearing retainer cover at the rear end of the countershaft.

NOTE—Remove shims as required to eliminate end play.

Install the main drive gear assembly through the front of the case. Assemble the mainshaft gears in the reverse order of removal and place the assembly in position, then install the rear bearings and retainer. Fasten the nut securely to the end of the mainshaft, assemble the bearing adjusting shims and bolt the bearing retainer cover securely in place.

NOTE—Eliminate end play in the mainshaft by removing shims as required.

Install the speedometer drive gear and universal flange, lock the mainshaft and run the flange nut up tight. Install the shift rails and forks in the reverse order of removal, lubricating the lock balls and springs before replacing; be sure the lock screws engage the holes in the shift rails before wiring them in place.

Replace the transmission cover, the shift lever housing assembly and the bell housing. Adjust the set screws at the shift rail ends to prevent the rails from over-shifting.

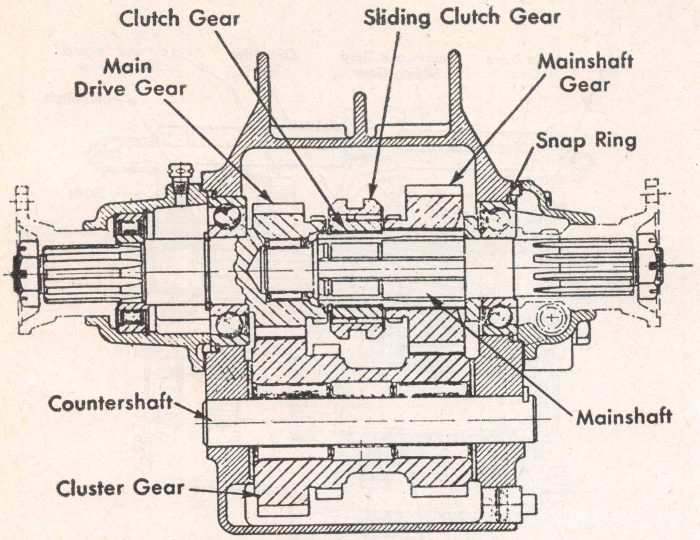
MODELS RL, URL

Five Speeds Forward and One Reverse with Direct on Fourth and Overdrive on Fifth.

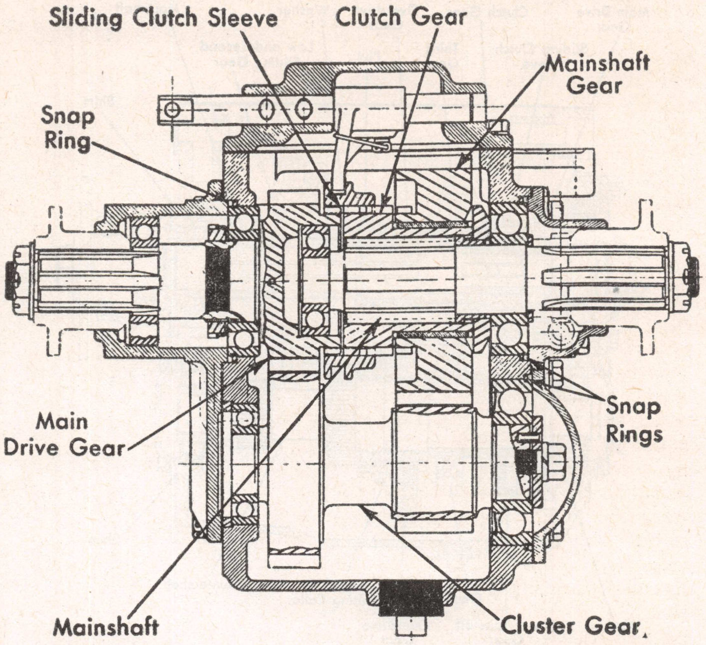
Disassemble: Take off the shift lever and housing assembly and the bell housing. Loosen the shift fork lock screws and pull out the shift rails, holding a hand over the lock ball holes to prevent the balls and springs from flying out.

CAUTION—As each rail is removed, it should be tagged to assure correct assembly; lift out the loose shift forks and tag them also.

Remove the speedometer driven gear. Lock the transmission in two gears to prevent the mainshaft from turning and unscrew the universal flange nut. Pull off the



BROWN-LIPE. Models 2321, 2323, Two-Speed Auxiliary.



BROWN-LIPE. Models 3221, 3222, Two-Speed Auxiliary.

universal flange, remove the rear bearing retainer, oil seal and the speedometer drive gear.

Remove the main drive gear bearing cover and the front and rear countershaft bearing covers. Pull the main drive gear and bearing assembly out through the front. If required, the gear and bearing may be separated after removing the bearing lock nut.

Grasp the mainshaft gears and pull the mainshaft through the gears and out through the rear of the case.

Unscrew the nut from the front end of the countershaft, push the shaft to the rear, remove the rear bearing and lift the countershaft assembly out of the case by its front end. Remove the reverse gear shift rail and take out the fork. Pull the reverse gear shaft out rearward and lift out the gear.

Assemble: Assemble the reverse gear and push in the shaft. Install the reverse shift rail and fork. If required, the countershaft helical gears may be removed by pressing them off one at a time, and when installed, be sure the keys are a tight fit. Place the washer over the front end of the countershaft, assemble the front bearing in position, place the countershaft assembly in the case and install the rear bearing. Run the nut up tight on the front end of the countershaft and replace the front bearing cover. Assemble the countershaft rear bearing cover and shims and check the end play, removing the required thickness of shims to eliminate any end play.

Install the main drive gear assembly through the front and replace the retainer cover. Install the mainshaft rear bearings and sleeve on the shaft, pass the shaft through the rear of the case, assembling the sliding gears on the shaft as the shaft is being inserted. Install the lock nut on the end of the mainshaft and replace the speedometer drive gear.

Assemble the shims and rear bearing retainer securely to the case and check for end play in the bearings; if end play exists, remove the required thickness of shims. Examine the rear oil seal and replace if necessary. Install the universal flange, lock the mainshaft and run the flange nut up tight.

Replace the shift rails and forks in the reverse order of removal, lubricating the balls and springs before replacing; see that the lock screws engage the holes in the shift rails before wiring them in place. Install the bell housing and shift lever housing assembly. If required, adjust the set screws at the shift rail ends to prevent the rails from overshifting.

BROWN-LIPE

MODELS 2321, 2323

Two Speeds Forward Auxiliary Transmission. Used in Conjunction with Four or Five Speed Units of the 2,000 Series.

Unscrew the front and rear companion flange nuts and pull off both flanges. Remove the speedometer driven gear and disconnect both bearing retainers. Unfasten the transmission cover and lift it off. The main drive gear and mainshaft assembly can then be lifted out as a unit. Remove the countershaft lock, drive the shaft out rearward and lift out the countergears and bearings. Separate the mainshaft from the drive gear and slip the gears from the shaft. If necessary, the bearing may be removed from the front retainer after releasing its snap ring.

Assemble in the reverse order, using new snap rings in the bearing grooves.

MODELS 3221, 3222, 5222

Two Speeds Forward Auxiliary Transmission. Used in Conjunction with Four or Five Speed Units of the 3,000 and 5,000 Series.

Remove the transmission cover. Unscrew the nuts from the front and rear companion flanges and pull off the flanges. Remove the speedometer driven gear and the rear bearing retainer. Pull the mainshaft to the rear far enough to permit the speedometer drive gear and rear bearing to be removed. Grasp the mainshaft gears, pull the shaft all the way out through the rear and lift the gears out through the top. Remove the main drive gear bearing retainer, unscrew the drive gear retaining nut, push the gear into the case and lift it out from the inside. The drive gear bearing may then be removed by tapping it out through the front. Take off the countershaft rear bearing cover, unscrew the lock bolt, force the gear assembly to the rear until the bearing is clear of the case and lift the gear out through the top by its front end.

Assemble in the reverse order, using new snap rings in the bearing grooves.

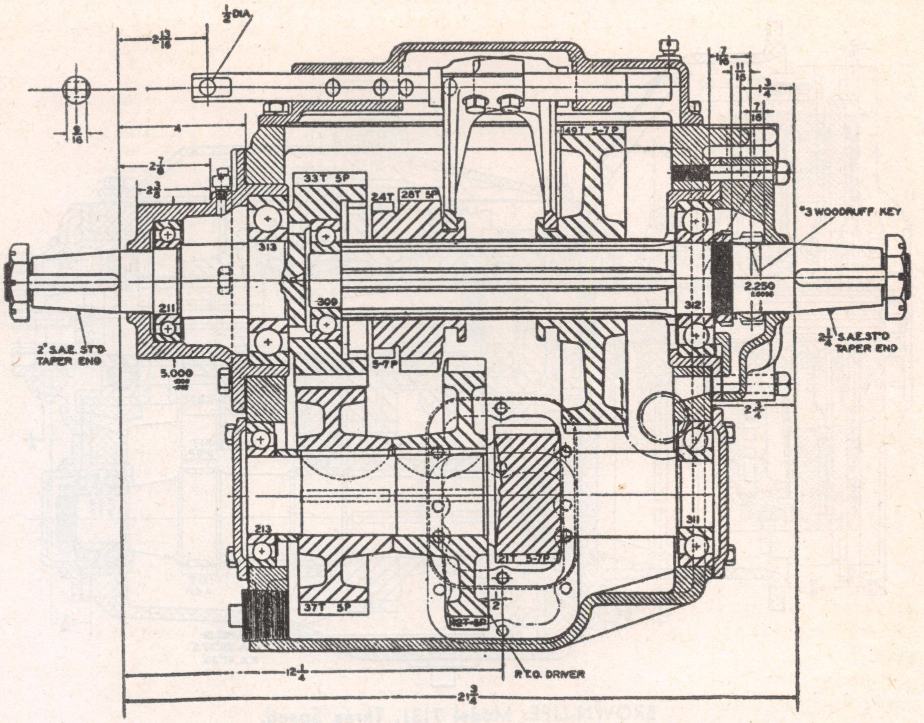
MODEL 703

Three Speeds Forward and No Reverse Auxiliary Transmission with Direct on Second and Overdrive on Third. Used in Conjunction with Standard Three and Four Speed Units.

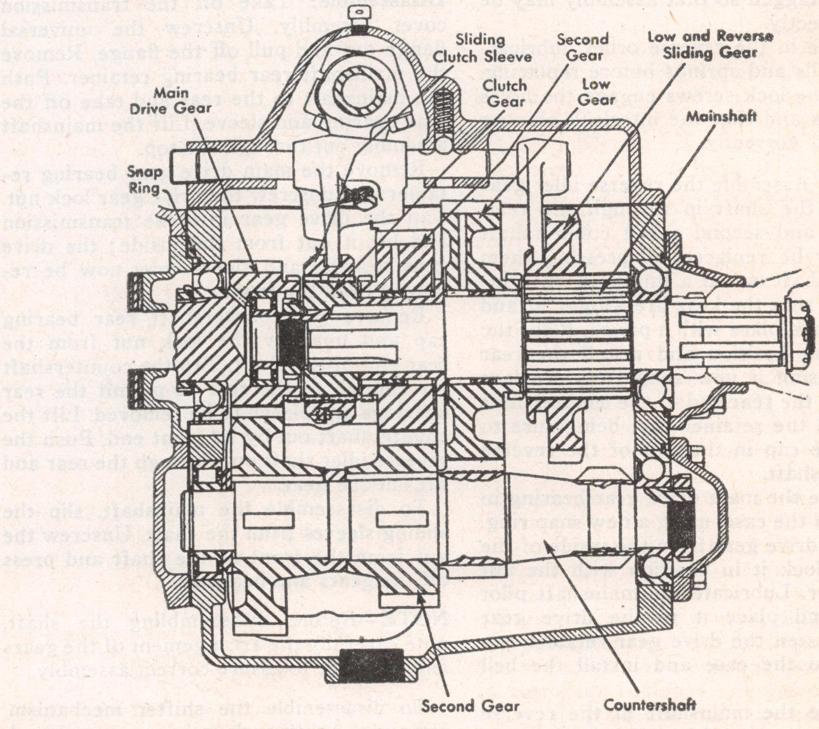
Disassemble: Take off the transmission cover assembly. Lock the mainshaft and unscrew the front and rear flange nuts, then pull off the flanges. Remove the covers from the side of the case. Disconnect the mainshaft rear bearing cap, grasp the mainshaft gears and withdraw the shaft rearward.

NOTE—Before removing the mainshaft, mark the mating position of the gears and shaft with chalk so that when assembled, the relative position of these parts will be known.

Push the main drive gear into the case and lift it out. Remove the front and rear countershaft bearing caps, shift the countershaft to the rear and lift out the assembly.



BROWN-LIPE. Model 703, Three-Speed Auxiliary.



BROWN-LIPE. Model 5331, Three Speed.

Assemble: If the countershaft gears have been removed, press them on the shaft, being sure the keys are a tight fit. Install the countershaft front bearing and bolt the bearing cap to the front of the case. Place the countershaft assembly in the case and slip its front end into the front bearing. Install the washer at the rear of the shaft and tap the bearing into position, then replace the rear bearing cap and gasket.

Install the main drive gear bearing cap and slip the drive gear in through the inside of the case. Lubricate the mainshaft pilot bearing and place it in the drive gear pocket.

Replace the mainshaft rear bearing retainer, using a new gasket between the retainer and the case, being sure the oil holes in the gasket line up with the corresponding holes in the case. Insert the mainshaft through the rear of the case, slipping on the gears at the same time, being sure to match the splines of the gears and shaft according to the chalk marks made when disassembling. Push the mainshaft into the pilot bearing and then bolt on the rear bearing cap, using a new gasket between the cap and the retainer. Assemble the transmission side covers, being sure the gaskets are in good condition, then replace the transmission top cover assembly.

NOTE—If the cover is to be disassembled, note that the longer shift rail is the low speed rail and is fitted in the lower hole in the shifter housing, while the short rail is the high speed rail and is fitted in the upper hole. Make sure all the balls, plungers and springs are installed properly before wiring the shift fork screws.

CAUTION—The companion flanges and end yokes must have at least an 80% contact which can be attained by grinding them on the taper, using fine valve grinding compound. Check the contact by applying a thin coating of prussian blue and continue grinding until the desired result is obtained. After the lapping operation is completed, use a metal scraper to break off the sharp edges at the large end of the tapered hole.

MODEL 5331

Three Speeds Forward and One Reverse with Direct on Third.

Disassemble: Take off the transmission cover assembly. Lock the transmission in two gears and unscrew the universal flange nut. Use a puller to remove the universal flange. Remove the speedometer driven gear and mainshaft rear bearing retainer. Push the mainshaft far enough to the rear to permit the removal of the speedometer drive gear and rear bearing. Tilt the front end of the shaft upward and lift the assembly out through the top.

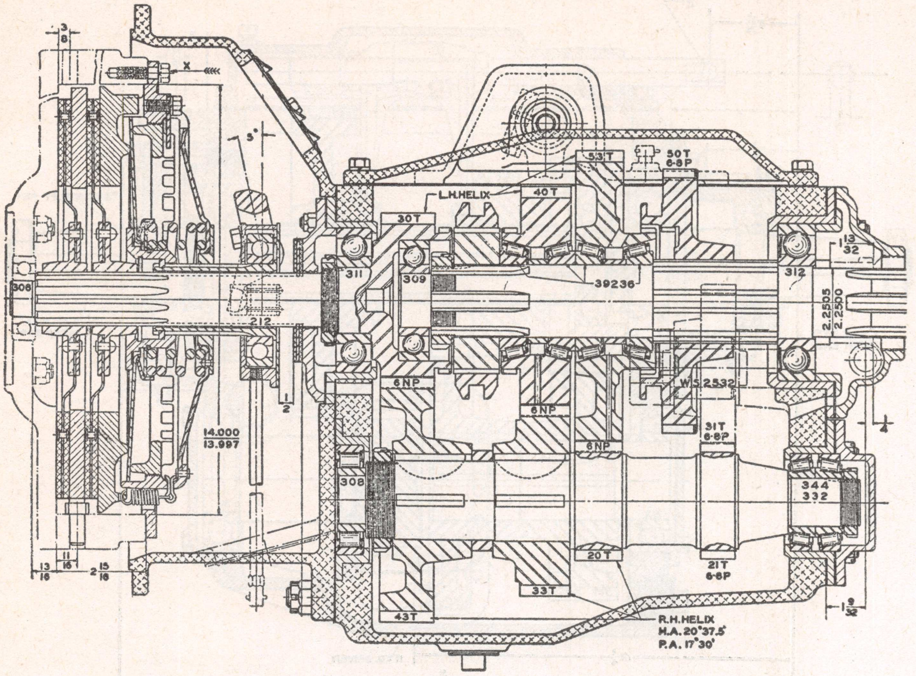
Remove the bell housing and the main drive gear bearing retainer and unscrew the drive gear lock nut. Use a soft hammer to tap the drive gear into the transmission and lift it out from the inside; the drive gear bearing may now be removed from the case.

Take off the countershaft rear bearing cap and unscrew the lock nut from the rear end of the countershaft. Tap the countershaft far enough to the rear to permit the removal of the rear bearing. Tilt the front end of the countershaft upward and lift it out. Push the reverse idler shaft out through the rear and lift out the gear. To disassemble the mainshaft, slip the sliding sleeve from the shaft. Unscrew the nut from the front end of the shaft; the shaft may now be removed by pressing off the gears.

NOTE—Before disassembling the shaft, note carefully the arrangement of the gears to assure correct assembly.

If necessary to disassemble the shift mechanism, remove the shift fork lock screws and push the rails out forward, forcing the thimbles out at the same time.

CAUTION—Hold a hand over the lock ball holes to prevent the balls and springs from flying out, and as each rail is removed, it



BROWN-LIPE. Model 7131, Three Speed.

should be tagged so that assembly may be made correctly.

Assemble in the reverse order, lubricating the balls and springs before replacing. See that the lock screws engage the holes in the rails and that the interlock plunger is installed correctly.

Assemble: Assemble the reverse idler gear and push the shaft in through the rear. The high and second speed countershaft gears may be replaced by pressing them from the shaft one at a time and when installed, be sure the keys are a tight fit and stake them in place with a punch. Place the assembly in position and install the rear bearing, using a new snap ring. Replace the nut on the rear end of the countershaft and install the retainer cap, being sure to engage the cap in the slot of the reverse idler gear shaft.

Assemble the main drive gear bearing in the bore of the case, using a new snap ring. Insert the drive gear from the inside of the case and lock it in position with the nut and washer. Lubricate the mainshaft pilot bearing and place it in the drive gear pocket. Fasten the drive gear retainer cap securely to the case and install the bell housing.

Assemble the mainshaft in the reverse order of removal and install it in the case. Replace the mainshaft rear bearing, using a new snap ring. Install the speedometer drive gear and mainshaft rear bearing retainer. Replace the universal flange, lock the transmission in two gears and draw the flange nut up tight. Install the speedometer driven gear and assemble the transmission cover.

MODEL 7131

Three Speeds Forward and One Reverse with Direct on Third.

Disassemble: Take off the transmission cover assembly. Unscrew the universal flange nut and pull off the flange. Remove the mainshaft rear bearing retainer. Push the mainshaft to the rear and take off the rear bearing and sleeve. Lift the mainshaft assembly out through the top.

Remove the main drive gear bearing retainer and unscrew the drive gear lock nut. Tap the drive gear into the transmission and lift it out from the inside; the drive gear bearing and sleeve may now be removed from the front.

Remove the countershaft rear bearing cap and unscrew the lock nut from the rear end of the shaft. Tap the countershaft far enough to the rear to permit the rear bearings and sleeve to be removed. Lift the countershaft out by its front end. Push the reverse idler shaft out through the rear and lift out the gear.

To disassemble the mainshaft, slip the sliding sleeves from the shaft. Unscrew the nut from the front of the shaft and press off the gears and bearings.

NOTE—Before disassembling the shaft, note carefully the arrangement of the gears and bearings to assure correct assembly.

To disassemble the shifter mechanism, remove the shift fork lock screws and push the rails out of the case, holding a hand over the lock ball holes to prevent the balls and springs from flying out. As each rail is removed, it should be tagged so that assembly may be made correctly.

Assemble: Assemble the reverse idler gear and push the shaft in through the rear. The high and second speed countershaft gears may be replaced by pressing them off the shaft one at a time and when installed, be sure the keys are a tight fit and staked in place with a punch. Install the countershaft assembly in the case and replace the rear bearings and sleeve. Run the rear nut on the end of the shaft. Install the front countershaft bearing and sleeve. Replace the countershaft rear bearing cover, removing shims as required to eliminate end play.

Assemble the main drive gear in the bore of the case, then install the drive gear bearing and sleeve, after which, run the drive gear bearing retaining nut up tight, using a new lock to hold it in place. Lubricate the mainshaft pilot bearing and place it in the drive gear pocket. Fasten the drive gear bearing retainer cap securely to the case and install the bell housing.

NOTE—Before installing the mainshaft, check the countershaft for end play. Assemble the mainshaft in the reverse order of removal and install in the case, then complete the assembly.

MODEL 224

Four Speeds Forward and One Reverse with Direct on Fourth.

Disassemble: Take off the transmission cover assembly. Lock the transmission in two gears and unscrew the universal flange nut and flange. Unfasten the mainshaft rear bearing retainer.

Remove the bell housing and drive gear bearing retainer. Withdraw the drive gear and bearing assembly through the front of the case. Push the mainshaft to the rear far enough to permit the removal of the speedometer drive gear and rear bearing. Tilt the front end of the assembly upward and lift it out through the top.

Drive the locking plate from the slots of the countershaft and reverse idler shaft. pull the shafts out through the rear and lift out the gears.

To disassemble the mainshaft, slip off the sliding gear, remove the sliding clutch sleeves and clutch gear and take off the third speed gear.

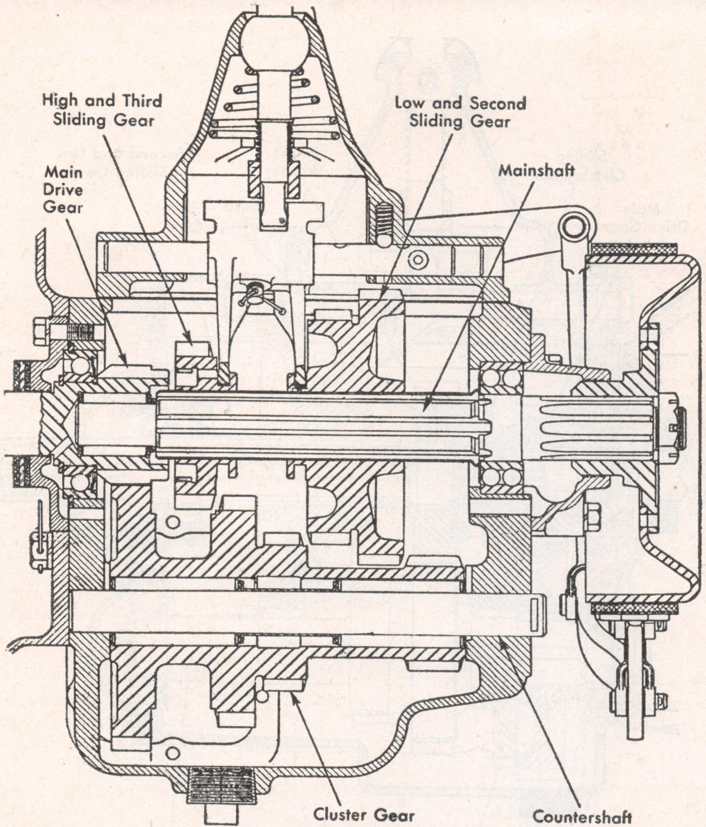
To disassemble the cover, remove the shift fork lock screws and push out the rails, holding a hand over the lock ball holes to prevent the balls and springs from flying out.

CAUTION—As each rail is removed, it should be tagged to assure correct assembly.

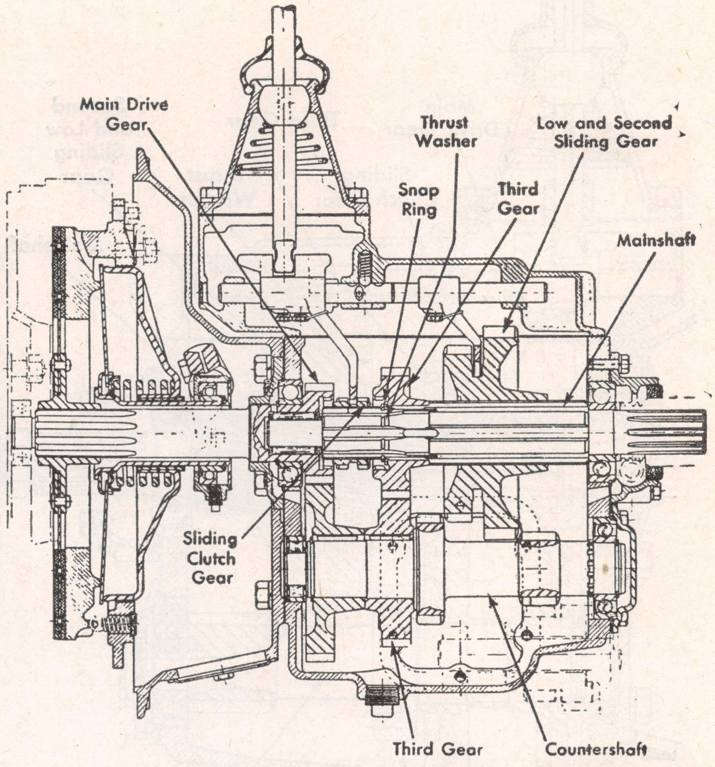
When assembling the cover, lubricate the balls and springs before replacing and be sure that the lock screws engage the holes in the rails. See that the interlock plungers are correctly assembled in the center rail.

Assemble: Assemble the reverse idler gear and push the shaft in through the rear. Install the bearings and spacer in the countergear and place the assembly in the case, pushing the countershaft in through the rear. With the slots of reverse idler shaft and countershaft facing each other, drive the lock plate in position and lock it securely with the cap screw.

Lubricate the mainshaft splines and assemble the gears in the reverse order of their removal and install in the case. Install the rear bearing retainer. Assemble the drive gear and bearing in position and



BROWN-LIPE. Model 234, Four Speed.



BROWN-LIPE. Model 2341, Four Speed.
WHITE Models, 27B, 28B, 401B are Similar.

replace the drive gear bearing retainer. Replace the speedometer drive gear and universal flange. Lock the transmission in two gears and fasten the flange nut securely. Replace the speedometer driven gear, assemble the transmission cover and connect the hand brake mechanism.

MODEL 234

Four Speeds Forward and One Reverse with Direct on Fourth.

Disassemble: Remove the transmission cover assembly. Lock the transmission in two gears and unscrew the universal flange nut and flange. Unfasten the mainshaft rear bearing retainer.

Remove the bell housing and the main drive gear bearing retainer. Pull the drive gear and bearing assembly out through the front. Push the mainshaft to the rear until the rear bearing is free of the case. Grasp the sliding gears and withdraw the mainshaft out through the rear and lift out the gears.

Remove the lock bolt and drive the lock plate from the slots of the reverse idler shaft and countershaft. Pull the shafts out through the rear and lift out the gear assemblies.

Assemble: Assemble the reverse idler gear and countershaft assembly and install the lock plate in the slots in the ends of the shafts. Insert the mainshaft through the rear, passing it through the sliding gears. Install the mainshaft rear bearing on the shaft, pushing it against the shoulder on the mainshaft, after which, fasten the retainer securely in position.

Replace the drive gear and bearing assembly, using new snap rings to hold the bearing in position. Install the drive gear bearing retainer and the bell housing.

Replace the speedometer drive gear and universal flange, lock the transmission in two gears and install the universal flange nut securely. Assemble the speedometer driven gear. Install the transmission cover assembly.

If necessary to disassemble the cover, remove the shift fork lock screws and push out the rails, holding a hand over the lock ball holes to prevent the balls and springs from flying out.

CAUTION—As each rail is removed, it should be tagged to assure correct assembly. When assembling the cover, lubricate the balls and springs before replacing, and be sure the lock screws engage the holes in the rails. See that the interlock plungers are installed correctly in the center rail.

MODEL 2341

Four Speeds Forward and One Reverse with Direct on Fourth.

NOTE—The following service also applies to White models 27B, 28B, 401B.

Disassemble: Take off the transmission cover and shifter assembly. Engage the second and low speed gears to prevent the mainshaft from turning and unscrew the nut from the rear end of the mainshaft. Use a puller if necessary, to remove the universal flange. Disconnect the mainshaft rear bearing retainer.

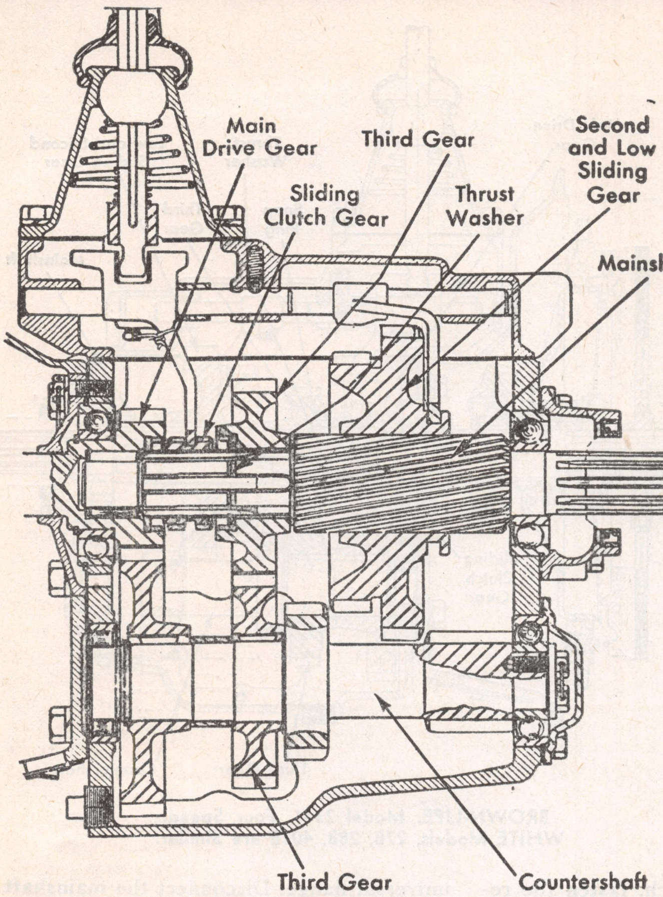
Remove the bell housing and main drive gear bearing retainer. Withdraw the main drive gear assembly through the front of the case. Slip the sliding clutch gear from the front of the mainshaft and push the mainshaft to the rear far enough to permit the rear bearing and speedometer drive gear to be removed. Tilt the front end of the mainshaft upward and lift the assembly out through the top.

Remove the countershaft rear bearing retainer cap and release the snap ring from the inner race of the bearing. Push the countershaft far enough to the rear to permit the rear bearing to be removed. Tilt the front end of the countershaft upward and lift it out of the case.

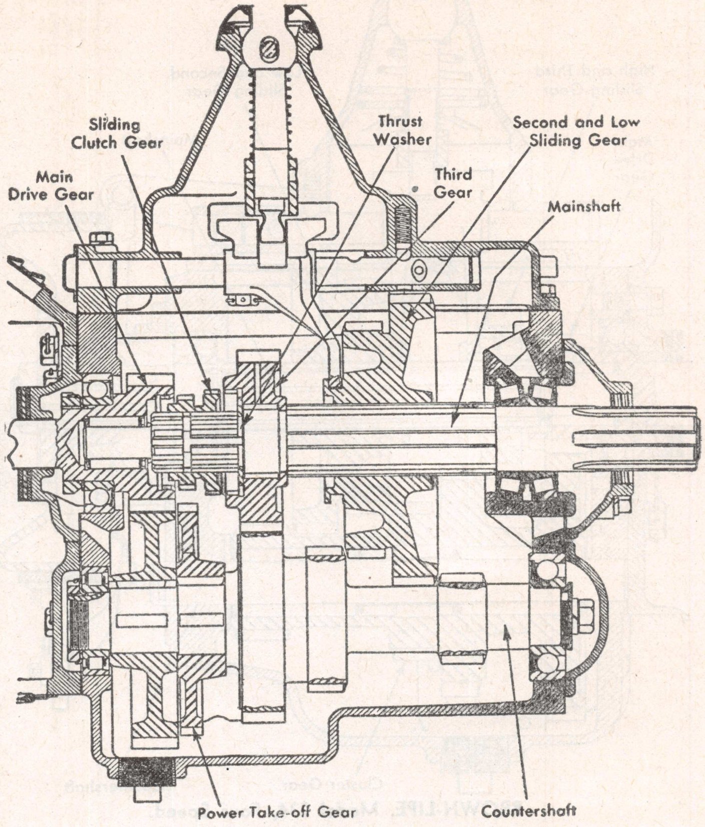
The fourth and third speed countershaft gears can be replaced by pressing them off one at a time after removing the snap ring, and when installed, be sure the keys are a tight fit and stake them in place with a punch. Remove the reverse idler shaft lock, tap the shaft out through the rear and lift out the gear.

To disassemble the mainshaft, slip the sliding gears from the shaft. Release the snap ring from in front of the third speed gear, rotate the thrust washer until the teeth register with the mainshaft splines and remove the washer and third speed gear.

NOTE—Assemble in the reverse order, using a new snap ring, and if the washer shows evidence of excessive wear, install a new one.



BROWN-LIPE. Model 2441, Four Speed.



BROWN-LIPE. Model 5341, Four Speed. Typical of 3241, 3341, 3400 and 7341.

If necessary to disassemble the shifter mechanism, drive out the expansion plugs at the front of the cover. With the shift rails in neutral, remove the set screws from the shift forks and push the rails out toward the front, holding a hand over the lock ball holes to prevent the balls and springs from flying out.

CAUTION—As each rail is removed, it should be tagged to assure correct assembly. Assemble the cover in the reverse order, lubricating the balls and springs before replacing. See that the interlock plungers are installed properly in the center rail, and that the lock screws are engaged in the holes in the shift rails before wiring them in place.

Assemble: Assemble the reverse idler gear and push the shaft in through the rear. Install the countershaft front bearing. Place the countergear assembly in the case and install the rear bearing, using new snap rings to retain the bearing and shaft.

Lubricate the mainshaft splines and slip the sliding gears on the shaft with the larger gear to the rear. Assemble the mainshaft in the case and replace the rear bearing, locking it in position with a new snap ring. Install the speedometer drive gear and rear bearing retainer, replacing the oil seal if excessive wear is evident.

Slip the sliding clutch gear on the shaft, lubricate the mainshaft pilot bearing and place it in the drive gear pocket. Install the drive gear assembly through the front, using a new snap ring in the bearing groove. Replace the drive gear bearing retainer and bell housing.

Lock the transmission in two gears, install the universal flange and tighten the flange nut securely. Complete the assembly by installing the speedometer driven gear, then place the gears in neutral and assemble the transmission cover.

MODEL 2441

Four Speeds Forward and One Reverse with Direct on Fourth. All Gears Including Reverse are Helical Cut.

Disassemble: Take off the transmission cover and shifter assembly. Lock the transmission in two gears and remove the universal flange nut, then take off the flange. Unfasten the mainshaft rear bearing retainer.

Remove the bell housing and main drive gear bearing retainer. Withdraw the drive gear assembly through the front of the case. Slip the sliding clutch gear from the front of the mainshaft and push the mainshaft to the rear far enough to permit the removal of the speedometer drive gear and rear bearing. Tilt the front end of the mainshaft upward and lift the assembly out through the top.

Remove the countershaft rear bearing retainer cap and unscrew the two bolts which retain the rear bearing. Push the countershaft to the rear far enough to permit the rear bearing to be removed. Tilt the front end of the countershaft upward and lift the assembly out of the case.

NOTE—The fourth and third speed countershaft gears and (if equipped) the power take-off gear can be replaced by pressing them off one at a time, and when installed, be sure the keys are a tight fit and staked in place. Push out the reverse idler shaft and lift out the gear.

To disassemble the mainshaft, slip off the sliding gear. Release the snap ring from in front of the third speed gear and remove the thrust washer and third speed gear from the shaft.

Assemble in the reverse order, using a new snap ring, and if the thrust washer shows evidence of excessive wear, install a new one.

If necessary to disassemble the cover, drive out the expansion plugs at the front of the cover. Place the shift rails in neutral and remove the shift fork lock screws. Push the rails out through the front, holding a hand over the lock ball holes to prevent the balls and springs from flying out.

CAUTION—As each rail is removed, it should be tagged to assure correct assembly. Assemble the cover in the reverse order, lubricating the balls and springs before replacing. See that the interlock plungers are installed correctly in the center rail, and that the lock screws engage the holes in the shift rails before wiring them in place.

Assemble: Assemble the reverse idler gear and push the shaft in through the rear. Install the countershaft front bearing. Place the countergear assembly in the case and replace the rear bearing, installing the two cap screws and washer securely, using wire to lock them in place; use a new snap ring in the bearing groove.

Lubricate the mainshaft splines and slip on the sliding gears, facing the larger gear to the rear. Assemble the mainshaft in the case and replace the rear bearing, locking it in position with a new snap ring. Install the speedometer drive gear and rear bearing retainer, replacing the oil seal if excessive wear is evident.

Slip the sliding clutch gear on the shaft, lubricate the mainshaft pilot bearing and place it in the drive gear pocket. Install the drive gear assembly through the front, using a new snap ring in the bearing groove. Replace the drive gear bearing retainer and bell housing.

Lock the transmission in two gears, install the universal flange and tighten the flange nut securely. Complete the assembly by replacing the speedometer driven gear, then place the gears in neutral and assemble the transmission cover.

MODELS 3241, 3341, 3440, 5341, 7341

Four Speeds Forward and One Reverse with Direct on Fourth in All Models Except on 3440, in which case, Direct is on Third and Overdrive on Fourth.

Disassemble: Take off the transmission cover and lock the gears in two speeds and remove the universal flange nut. Use a puller if necessary, to remove the flange. Unfasten the mainshaft rear bearing retainer cap, countershaft bearing cap and take off the bell housing. Unscrew the bolt from the rear end of the countershaft and the nut from the front end.

Remove the drive gear bearing retainer and withdraw the gear and bearing assembly through the front. Push the mainshaft far enough to the rear to permit the removal of the rear bearings. Tilt the forward end of the mainshaft upward and lift it out through the top.

Remove the reverse fork stud and lift out the fork. Take out the lock screw, pull out the reverse idler gear shaft and lift out the gear. Push the countershaft far enough to the rear to permit the rear bearing to be removed. Tilt the forward end of the assembly upward and lift it out.

To disassemble the mainshaft, slip the sliding gears and the sliding clutch gear from the mainshaft. Pull the T-shaped key from the slot in the shaft and disengage its point from the thrust washer. Rotate the thrust washer to align its internal teeth with the mainshaft splines and remove it from the shaft. Slide the third speed gear from the shaft, being careful not to lose any of the roller bearings.

NOTE—To assemble, clamp the mainshaft in a vise with its front end up and place the third speed gear on the shaft. Assemble the rollers in the bore of the gear, using grease to hold them in position. Replace the thrust washer, lining up its teeth with the mainshaft splines. Engage the end of the T-shaped key in the thrust washer—which prevents the washer from turning—and push the key into the slot of the shaft. The sliding gears and sliding clutch gear may now be installed.

Assemble: NOTE—When assembled in the case, the mainshaft end play should not exceed .003" and is controlled by shims under the rear bearing retainer cap. Shims of various thicknesses are available to obtain this end play.

If required, the countershaft helical gears may be replaced, and when installed, be sure the keys are a tight fit and staked in place with a punch. Place the countershaft assembly in position and install the front and rear bearings, locking them in position by replacing the bolt and washer at the rear and the nut at the front.

Assemble the reverse idler gear and shaft and install the lock screw. Install the reverse fork and shaft, being sure the set screw engages the hole in the shaft. Replace the mainshaft assembly and install the rear bearings.

Assemble the main drive gear in position, using a new snap ring to hold the front bearing in place. Complete the assembly by installing the bearing retainers, bell housing, universal flange and nut, hand brake lever and the transmission cover assembly.

If necessary to disassemble the cover, remove the shift fork lock screws and drive the rails out through the front.

CAUTION—Hold a hand over the lock ball holes to prevent the balls and springs from flying out as the rails are removed; as each rail is removed, it should be tagged to assure correct assembly.

Assemble in the reverse order, lubricating the balls and springs before replacing. Be sure that the lock screws engage the holes in the rails, and that the interlock plungers are correctly installed in the center rail.

MODELS 6241, 6440

Four Speeds Forward and One Reverse with Direct on Fourth in Model 6241. For Model 6440, Direct is on Third with Overdrive on Fourth.

Disassemble: Take off the transmission cover. Lock the mainshaft in order to remove the universal flange nut, after which, pull off the flange. Remove the mainshaft rear bearing cap, the countershaft bearing cap, and the bell housing. Push the mainshaft far enough to the rear to permit the removal of the rear bearings, then lift the mainshaft assembly out through the top by its front end.

Unscrew the bolt from the rear of the countershaft and push the assembly to the rear until the rear bearing is free of the case. Take off the main drive gear bearing retainer, unscrew the bearing retaining nut, push the drive gear into the case and lift it out; the drive gear bearing may now be removed through the front. Lift out the countershaft assembly.

To disassemble the mainshaft, slip the sliding gear and the sliding clutch gear from the shaft. Remove the thrust washer from in front of the third speed gear (fourth gear on 6440) and slide the gears from the shaft, being careful not to lose any of the roller bearings.

NOTE—To assemble, clamp the mainshaft in a vise with its front end up and place the second speed gear on the shaft. Assemble the rollers in the bore of the gear, using grease to hold them in position. Place the third speed gear sleeve (fourth on 6440) on the shaft with its shoulder against the second speed gear, after which, assemble the gear and roller bearings. Then lock the assembly in place with the thrust washer and snap ring. The sliding gear and sliding clutch gear may now be installed.

Assemble: NOTE—When assembled in the case, the mainshaft end play should not exceed .003" and is controlled by shims under the rear bearing cap.

If required, the countershaft third, fourth and power take-off gears may be replaced by pressing them off one at a time and when installed, be sure the keys are a tight fit and staked in place with a punch. Place the countershaft assembly in the case and install the front and rear bearings, using new snap rings. Install the bolt and washer at the rear end of the shaft. Assemble the reverse idler gear and shaft and install the lock screw. Replace the reverse fork and shaft, being sure the set screw engages the hole in the shaft.

Insert the main drive gear into the case after replacing the bearing, then lock the assembly by screwing the nut on the shaft. Replace the mainshaft assembly and install the rear bearings, removing shims as required to eliminate end play. Complete the assembly by replacing the bearing retainers, bell housing, universal flange and nut, and transmission cover assembly.

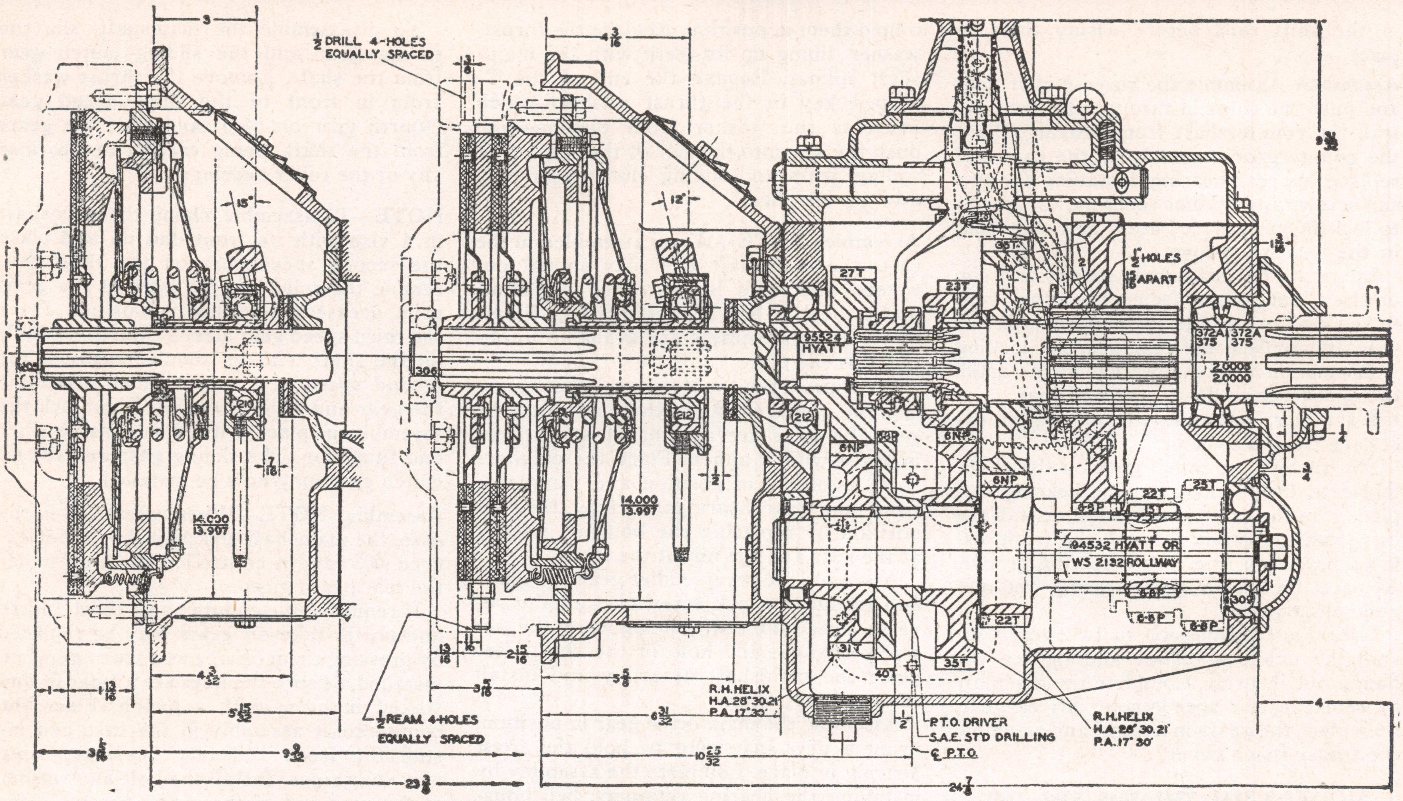
MODELS 7441, 7640, 7641

Four Speeds Forward and One Reverse with Direct on Fourth for Models 7441 and 7641. For Model 7640, Direct is on Third with Overdrive on Fourth.

Disassemble: Take off the transmission cover. Lock the mainshaft in order to remove the universal flange nut, after which, pull off the flange. Remove the mainshaft rear bearing cap, the countershaft bearing cap, and the bell housing. Push the mainshaft far enough to the rear to permit the removal of the rear bearings, then lift the mainshaft assembly out through the top by its front end.

Unscrew the bolt from the rear of the countershaft and push the assembly to the rear until the rear bearing is free of the case. Take off the main drive gear bearing retainer, unscrew the bearing retaining nut, push the drive gear into the case and lift it out; the drive gear bearing and snap ring may now be removed through the front. Lift out the countershaft assembly.

To disassemble the mainshaft, slip the sliding gear and sliding clutch sleeve from the shaft. Remove the clutch gear retain-


3
1/2 DRILL 4-HOLES EQUALLY SPACED
15°
12°
3 1/8
4 3/16
7/16
16.000 13.997
14.000 13.997
1 13/16
4 3/32
5 15/32
1/2 REAM 4-HOLES EQUALLY SPACED
3 1/16
9 3/32
23 3/8
3 5/16
5 5/8
6 31/32
10 23/32
24 7/8
R.H.HELIX H.A.28°30.21' P.A.17°30'
P.T.O. DRIVER
S.A.E. STD DRILLING
℄ P.T.O.
R.H.HELIX H.A.28°30.21' P.A.17°30'
27T
23T
30T
51T
95524 HYATT
212
6NP
1/2 HOLES 1 5/16 APART
372A 375
2.0005 2.0000
22T
25T
84532 HYATT OR WS 2132 ROLLWAY
6-8P
309
31T
40T
35T
22T
9 31/32
4
306
305
210

BROWN-LIPE. Model 6440, Four Speed. Typical of 6241.

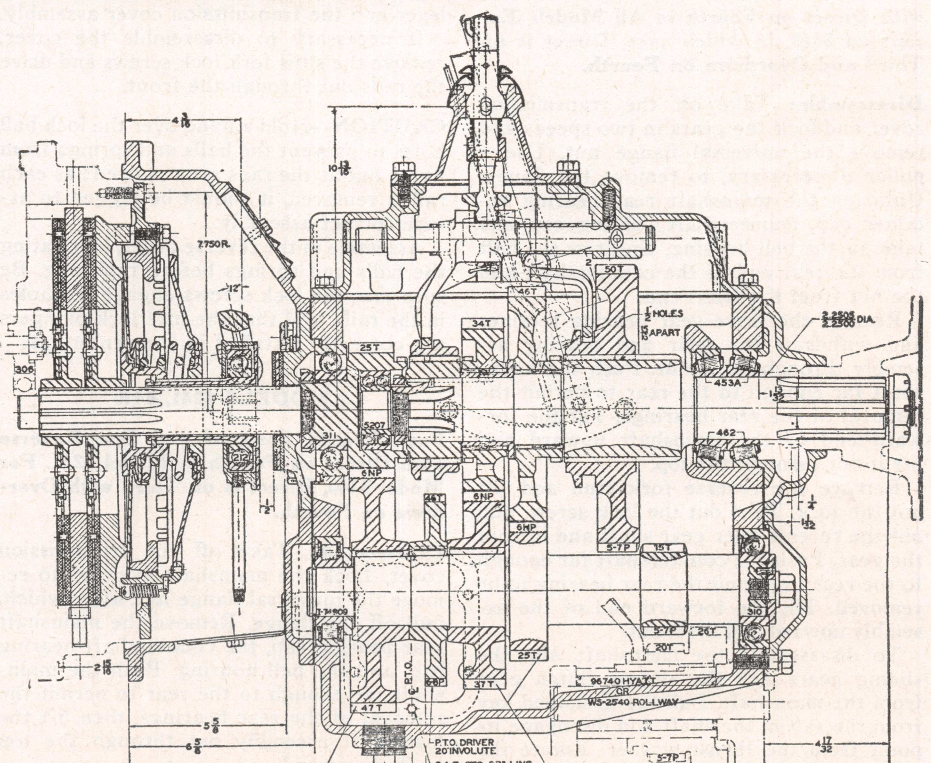
ing nut and slide the gears from the shaft, being careful not to lose any of the roller bearings.

To assemble, clamp the mainshaft in a vise with its front end up and place the second speed gear on the shaft. Assemble the rollers in the bore of the gear, using grease to hold them in position. Place the third speed gear sleeve (fourth gear on 7640) on the shaft with its shoulder against the second speed gear, after which, assemble the gear and rollers. Install the clutch gear on the shaft, locking the entire assembly in place with the clutch gear retaining nut. The sliding gear and sliding clutch sleeve may now be installed.

Assemble: When assembled in the case, the mainshaft end play should not exceed .003" and is controlled by shims under the rear bearing cap.

If required, the countershaft third, fourth and power take-off gears may be replaced by pressing them off one at a time and when installed, be sure the keys are a tight fit and staked in place with a punch. Place the countershaft assembly in the case and install the front and rear bearings, using new snap rings. Replace the bolt and washer at the rear of the shaft. Assemble the reverse idler gear and shaft and insert the lock screw. Replace the reverse fork and shaft, being sure the screw engages the hole in the shaft.

Insert the main drive gear into the case after replacing the bearing, then lock the assembly by screwing the nut on the shaft. Replace the mainshaft assembly and install the rear bearings, removing shims as required to eliminate end play. Complete the assembly by replacing the bearing retainers, bell housing, universal flange and nut, and the transmission cover assembly.

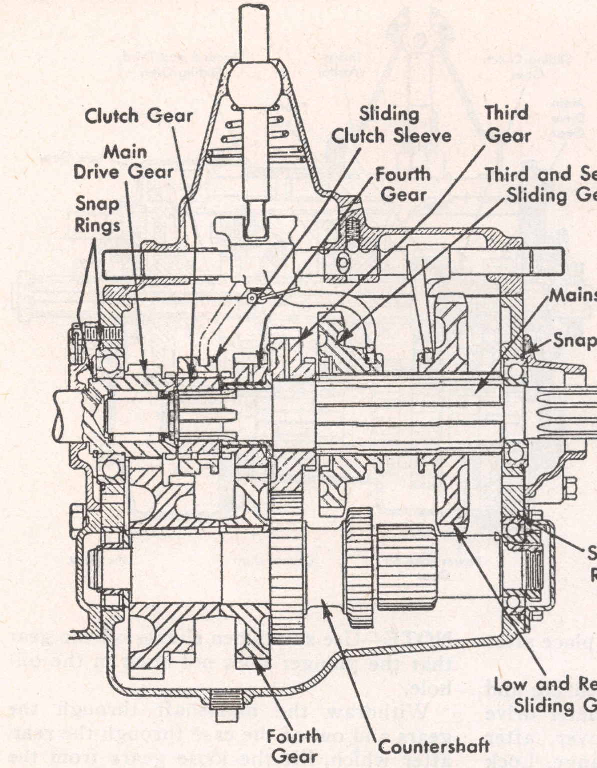

10 1/8
7.750R.
12°
305
50T
46T
34T
25T
1/2 HOLES 1 5/16 APART
2.2505 DIA. 2.2500
453A
462
5207
311
6NP
15T
5-7P
26T
20T
25T
37T
47T
℄ P.T.O.
96740 HYATT OR WS-2540 ROLLWAY
P.T.O. DRIVER 20°INVOLUTE S.A.E. STD. DRILLING
R.H.HELIX H.A.22°37.16' NPA 17°30' 6NP
R.H.HELIX H.A.24°27.56' NPA 17°30' 6NP
5 5/8
6 5/8
10 1/4
2 1/4
27 5/8
4 17/32
1 1/4
1 1/32

BROWN-LIPE. Model 7441, Four Speed. Typical of 7640 and 7641.

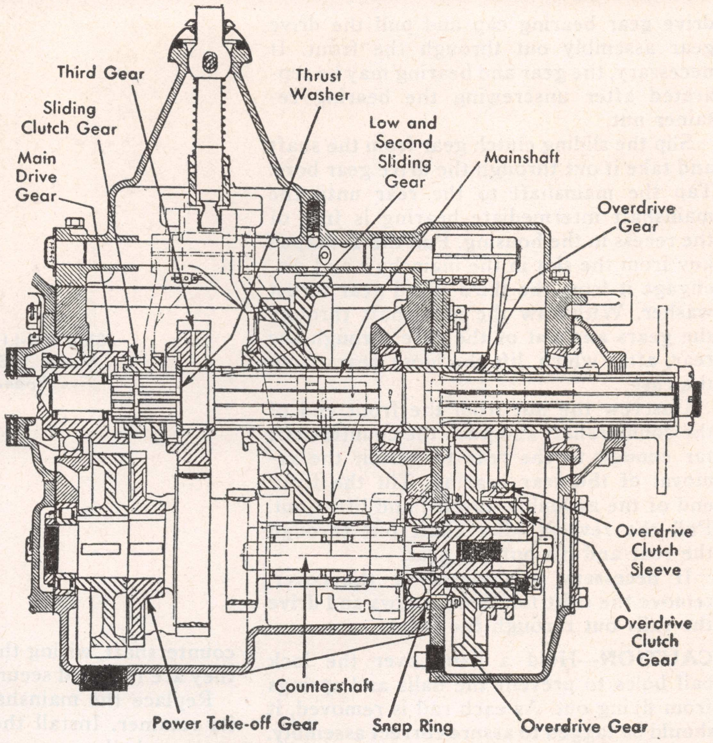
MODELS 2252, 2253, 2352, 2353, 3352, 3353

Five Speeds Forward with Direct Drive on Fifth on Models 2252, 2352 and 3352. On Models 2253, 2353 and 3353, Direct Drive is on Fourth With Overdrive on Fifth. Models 2252 and 2253 have One Reverse Speed While All Other Models have Two Reverse Speeds.

Disassemble: Shift the transmission into



BROWN-LIPE. Models 2252, 2253, 2352, 2353, Five Speed.



BROWN-LIPE. Model 5351, Five Speed.

first speed and lift off the transmission cover assembly. Remove the universal flange nut and pull off the flange. Take off the mainshaft and countershaft rear bearing retainer caps.

Unscrew the lock nut from the rear end of the countershaft and push both the mainshaft and countershaft assemblies to the rear at the same time until both bearings are clear of the case, then pull off the bearings.

Tilt the front end of the mainshaft upward, grasp the sliding gears and pull the mainshaft with the stationary gears out through the top, after which, lift out the sliding gears.

Remove the clutch release mechanism and take off the main drive gear bearing retainer. Withdraw the drive gear assembly out through the front.

On models equipped with two reverse speeds, take out the high speed reverse shift rail and yoke. On all units, withdraw the reverse gear shaft (or shafts) and remove the reverse gear (or gears) from the case. Push the countershaft to the rear and tilt the front end of the assembly upward and lift it out. The front bearing may be removed after removing its retainer or nut.

To disassemble the mainshaft, remove the mainshaft pilot bearing and sliding clutch sleeve from the mainshaft. Remove the snap ring or nut which retains the sliding clutch and slide the gears, sleeve, and thrust washers from the shaft.

To assemble, clamp the mainshaft in a vise with its front end up and install the third speed gear rear thrust washer. Then replace the third speed gear and bushing. Next, assemble the fourth speed gear and sleeve (fifth gear on overdrive units) and replace the sliding clutch gear, locking the assembly in position with the snap ring. Slip on the sliding clutch sleeve and mainshaft front pilot bearing, being sure to lubricate the bearing.

Assemble: Assemble the countershaft front bearing, locking it in place with its retainer. If required, the countershaft helical gears may be replaced by pressing them off one at a time, and when installed, be sure the keys are a tight fit and staked in place with a punch. Install the assembly in position but do not replace the bearing and retaining nut until after the mainshaft is in place.

Assemble the reverse gear shaft (or shafts) through the gear (or gears) through the rear. For units using two reverse speeds, install the high speed reverse shift rail and yoke.

Assemble the main drive gear through the front of the case, replace the bearing retainer and install the clutch release mechanism.

Insert the mainshaft partly into the case and slip on the sliding gears, placing the larger gear to the rear and with the shift fork channels facing each other. Push both the mainshaft and countershaft assemblies to the rear at the same time and replace the mainshaft rear bearing and rear countershaft bearing. Push both assemblies forward again and use new snap rings to hold the bearings in place. Replace the lock nut on the end of the countershaft and install the mainshaft and countershaft rear bearing retainer caps.

Install the speedometer drive gear and the universal flange, fastening the flange retaining nut securely. Install the speedometer driven gear, shift the transmission into first speed and replace the transmission cover assembly.

To disassemble the shift mechanism, place the rails in the neutral position and remove the shift yoke lock screws and drive the rails out of the cover.

CAUTION—Hold a hand over the lock ball holes to prevent the balls and springs from flying out as the rails are removed. As each rail is removed, it should be tagged to assure correct assembly. Assemble the cover in the reverse order after lubricating all poppet balls and springs.

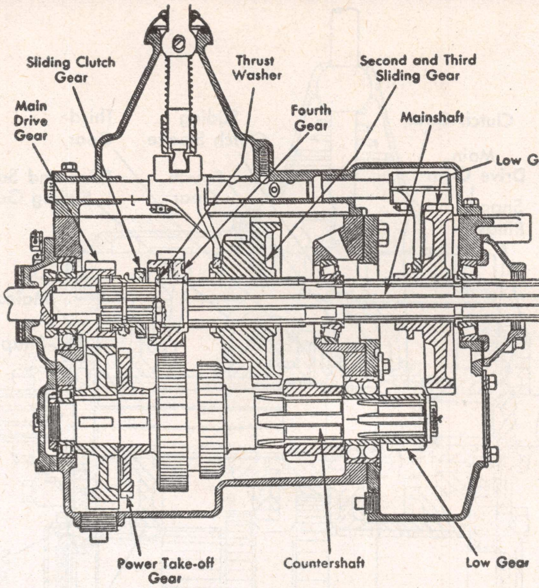
NOTE—Be sure the points of the lock screws engage the holes in the rails before wiring them securely in place. See that all the interlock plunger parts are installed correctly in the center rail.

MODEL 5351

Five Speeds Forward and One Reverse With Direct on Fourth and Overdrive on Fifth. Overdrive Gear Contained in a Separate Housing Attached to the Main Case.

Disassemble: Take off the transmission cover assembly. Lock the transmission in two gears and unscrew the universal flange nut and pull off the universal flange. Unfasten the retainer cap from the rear of the case and remove the speedometer drive gear and rear bearing retainer. Pull the overdrive shift shaft out through the rear and lift out the fork. Remove the overdrive housing countershaft cover and unscrew the lock bolts which retain the overdrive gears to the countershaft. Reach into the overdrive housing and remove the bolts which fasten this housing to the main case. Pull the overdrive housing and gears to the rear, and at the same time, force the rear bearing from the mainshaft.

Remove the bell housing and the main



BROWN-LIPE
Model 5352
Five Speed.

drive gear bearing cap and pull the drive gear assembly out through the front. If necessary, the gear and bearing may be separated after unscrewing the bearing retainer nut.

Slip the sliding clutch gear from the shaft and take it out through the drive gear bore. Tap the mainshaft to the rear until the mainshaft intermediate bearing is free of the recess in the housing. Pull the T-shaped key from the slot in the mainshaft and disengage it from the third speed gear thrust washer. Withdraw the mainshaft through the gears and out of the case through the rear, after which, lift the loose gears from the case.

Unscrew the nut from the front end of the countershaft and push the countershaft far enough to the rear to permit the removal of the rear bearing. Tilt the front end of the assembly upward and lift it out. Pull the reverse idler shaft out through the rear and lift out the gear.

If necessary to disassemble the cover, remove the shift fork lock screws and drive the rails out through the front.

CAUTION—Hold a hand over the lock ball holes to prevent the balls and springs from flying out. As each rail is removed, it should be tagged to assure correct assembly. When assembling, lubricate the balls and springs, and make sure the lock screws engage the holes in the rails. See that the interlock plungers are assembled correctly.

Assemble: Assemble the reverse idler gear and push the shaft in through the rear. Install the countershaft front bearing and assemble the countershaft assembly in the case, then replace the countershaft rear bearing, using a new snap ring in the bearing groove. Screw the retaining nut securely on the front end of the countershaft.

Hold the mainshaft gears in the case and insert the mainshaft through the rear, passing it through the gears. Install the mainshaft intermediate bearing on the shaft, pushing it against the shoulder on the mainshaft and into the recess of the case. Position the third speed gear and thrust washer, engage the point of the T-shaped key into the thrust washer to lock it in place, then push the key into the slot of the mainshaft. Slip the sliding clutch gear through the drive gear bore and push it into position.

Lubricate the mainshaft pilot bearing and place it in the drive gear pocket. Install the main drive gear assembly through the front and fasten the retainer to the case, then install the bell housing.

Install the spacer sleeve behind the mainshaft intermediate bearing, then replace the overdrive mainshaft gear, pushing it against the sleeve, after which, the rear spacer sleeve is placed on the shaft up against the overdrive gear.

Assemble the overdrive countershaft gears and hold them in their relative position in the housing, then pass the housing over the rear end of the mainshaft, working the gears over the countershaft as the housing is pushed forward. Install the cap screws which connect the overdrive housing to the main case. Install the washers and bolts which retain the overdrive gears to the countershaft, wiring the bolts in place after they are fastened securely.

Replace the mainshaft rear bearing and its retainer. Install the speedometer drive gear and the rear retainer cover, after which, push in the universal flange. Lock the transmission in two gears and run the universal flange nut up tight. Replace the speedometer driven gear and the countershaft rear cover. Assemble the overdrive shift rail and fork in the overdrive housing. Set the gears in neutral and replace the transmission cover.

MODEL 5352

Five Speeds Forward and One Reverse With Direct Drive On Fifth. Low Gear Contained in a Separate Housing Attached to the Main Case.

Disassemble: Remove cover and shifter assembly. Lock the transmission in two gears and unscrew the universal flange nut, then pull off the universal flange. Unfasten the retainer cap from the rear of the case, remove the speedometer drive gear and bearing retainer.

Reach into the low gear housing and remove the bolts which fasten this housing to the main case. Pull the low gear housing and the mainshaft low gear to the rear, and at the same time, force the rear bearing from the mainshaft.

Remove the bell housing and the main drive gear bearing cap and pull the drive gear assembly out through the front; the gear and bearing may be separated after unscrewing the bearing retainer nut.

Slip the sliding clutch gear from the shaft and take it out through the drive gear bore. Tap the mainshaft to the rear until the mainshaft intermediate bearing is free of the recess in the housing. Use a suitable pointed tool to depress the fourth speed gear thrust washer plunger, then rotate the thrust washer to align its teeth with the mainshaft splines and slide the washer and gear toward the front of the shaft.

NOTE—Use care when sliding off the gear that the plunger does not stick in the oilhole.

Withdraw the mainshaft through the gears and out of the case through the rear, after which, lift the loose gears from the case.

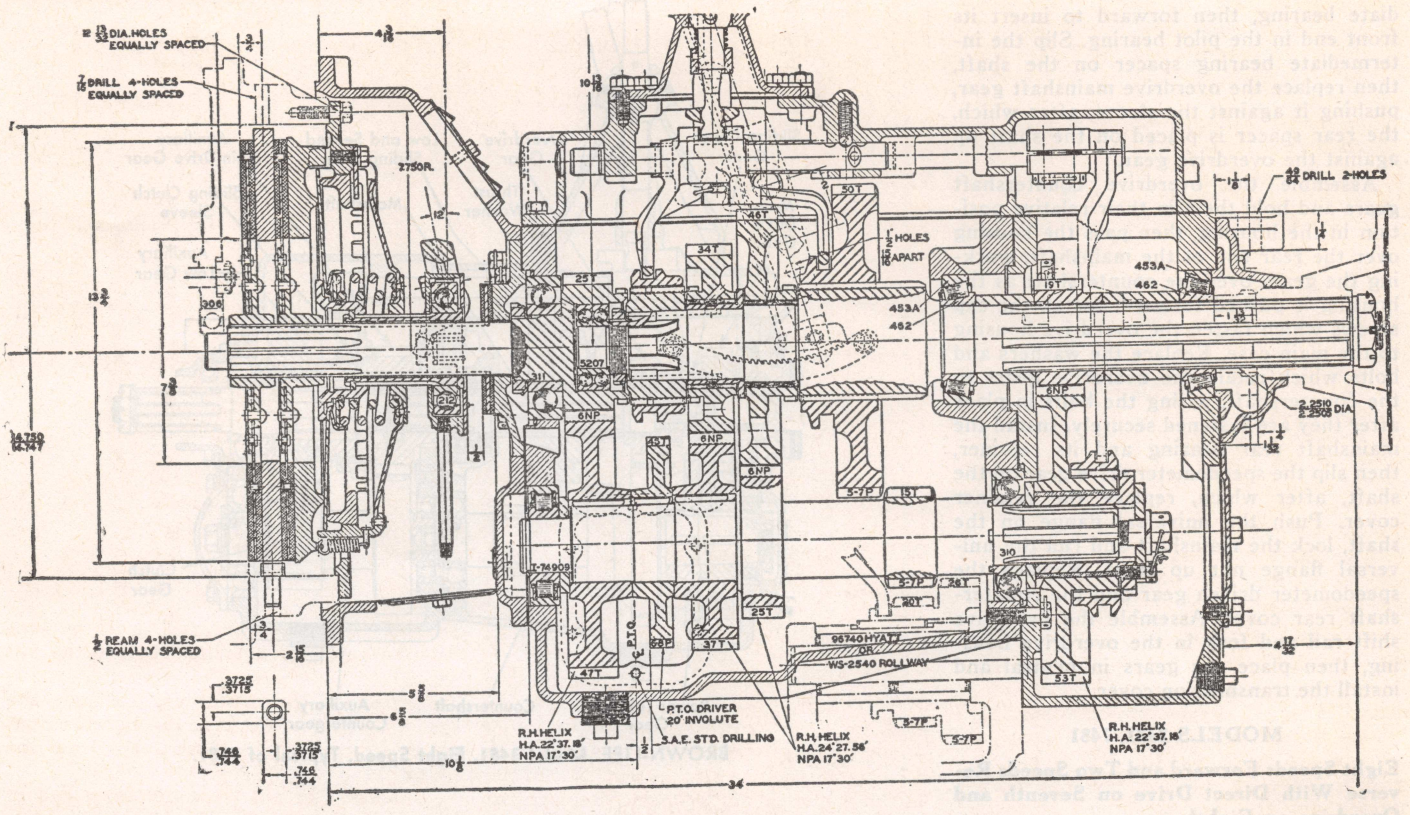
Unscrew the nut from the front end of the countershaft. Take out the two bolts from the rear end of the countershaft, remove the retainer and pull the low speed gear from the shaft. Force the countershaft far enough to the rear to permit the removal of the rear bearing, then tilt the front end of the assembly upward and lift it out through the top. Pull the reverse idler shaft out through the rear and lift out the gear.

If necessary to disassemble the cover, remove the shift fork lock screws and drive the rails out through the front.

CAUTION—Hold a hand over the lock ball holes to prevent the balls and springs from flying out. As each rail is removed, it should be tagged to assure correct assembly. When assembling, lubricate the balls and springs and make sure the lock screws engage the holes in the rails. See that the interlock plungers are assembled correctly.

Assemble: Assemble the reverse idler gear and push the shaft in through the rear. The fifth speed countershaft and the power take-off gear may be removed by pressing them off the shaft one at a time, and when installed, be sure the keys are a tight fit and staked in place with a punch. Replace the countershaft front bearing, install the countershaft assembly and replace the rear bearing, using a new snap ring in the bearing groove. Slip the low speed gear on the rear end of the countershaft, replace the retainer, fastening the gear and retainer securely with the two lock bolts. Run the lock nut up tight on the front end of the countershaft.

Insert the mainshaft through the rear of the case, passing it through the sliding gears. Assemble the fourth speed gear and


DIA. HOLES EQUALLY SPACED
DRILL 4-HOLES EQUALLY SPACED
2750R.
50T
46T
34T
25T
HOLES APART
453A
462
5207
311
6NP
5-7P
15T
T-74909
28T
20T
37T
47T
P.T.O.
96740 HYATT OR WS-2540 ROLLWAY
53T
19T
310
DRILL 2-HOLES
2.2510 2.2505 DIA.
14.750 14.747
REAM 4-HOLES EQUALLY SPACED
.3725 .3715
.746 .744
R.H. HELIX H.A. 22°37.18' NPA 17°30'
P.T.O. DRIVER 20° INVOLUTE
S.A.E. STD. DRILLING
R.H. HELIX H.A. 24°27.58' NPA 17°30'
R.H. HELIX H.A. 22°37.18' NPA 17°30'
34

BROWN-LIPE. Model 7451, Five Speed. Typical of 7651.

thrust washer on the shaft, being sure to install the plunger.

NOTE—Hold the plunger down and slide the gear and thrust washer in position, depress the plunger again and rotate the washer to permit the plunger to lock it in place. Install the mainshaft intermediate bearing and slip on the sliding clutch gear.

Lubricate the mainshaft pilot bearing and insert it in the drive gear pocket. Install the drive gear assembly through the front and replace the front retainer cap and the bell housing.

Hold the mainshaft low speed gear in the low gear housing and pass the gear and housing over the rear end of the mainshaft. Install the cap screws which fasten the low gear housing to the main case. Replace the mainshaft rear bearing, its retainer and the speedometer drive gear. Attach the rear retainer cap, push the universal flange in position, lock the mainshaft in two gears and fasten the flange nut securely. Replace the speedometer driven gear and install the transmission cover assembly.

MODELS 7451, 7651

Five Speeds Forward and One Reverse With Direct Drive On Fourth and Overdrive On Fifth. Overdrive Gear Contained in a Separate Housing Attached to the Main Case.

Disassemble: Take off the transmission cover assembly. Lock the transmission in two gears and unscrew the universal flange **nut. Take out the speedometer driven gear and pull off the universal flange. Unfasten the retainer cap from the rear of the case and remove the speedometer drive gear and rear bearing retainer. Pull the overdrive shift shaft out through the rear and lift out the fork.**

Remove the overdrive housing countershaft cover and unscrew the lock bolts which retain the overdrive gears to the countershaft. Reach into the overdrive housing and remove the bolts which fasten this housing to the main case. Pull the overdrive housing and gears to the rear and at the same time, force the rear bearing from the mainshaft.

Push the mainshaft to the rear until the intermediate bearing is free of the recess of the housing, then tilt the front end of the mainshaft upward and lift the assembly out through the top.

Remove the bell housing and main drive gear bearing cap. Unscrew the nut from the drive gear shaft and push the drive gear into the case and lift it out; the bearing may now be removed by tapping it out forward.

Remove the snap ring from the front end of the countershaft, push the countershaft to the rear until the rear bearing is free of the case, then lift out the countershaft assembly. Pull the reverse idler shaft out through the rear and lift out the gear.

To disassemble the mainshaft, remove the sliding gear and sliding clutch sleeve from the shaft. Unscrew the nut which holds the clutch gear on the mainshaft, then strip the **shaft, being careful not to lose the bearing rollers.**

To assemble, fasten the mainshaft in a vise with its front end up and install the third speed gear. Assemble the rollers in the bore of the gear, using grease to hold them in position. Place the fourth speed gear sleeve on the shaft with its shoulder against the third gear. Assemble the fourth gear and rollers in the same manner as the third gear. Slip the clutch gear on the shaft and lock the entire assembly by replacing the nut on the forward end of the shaft.

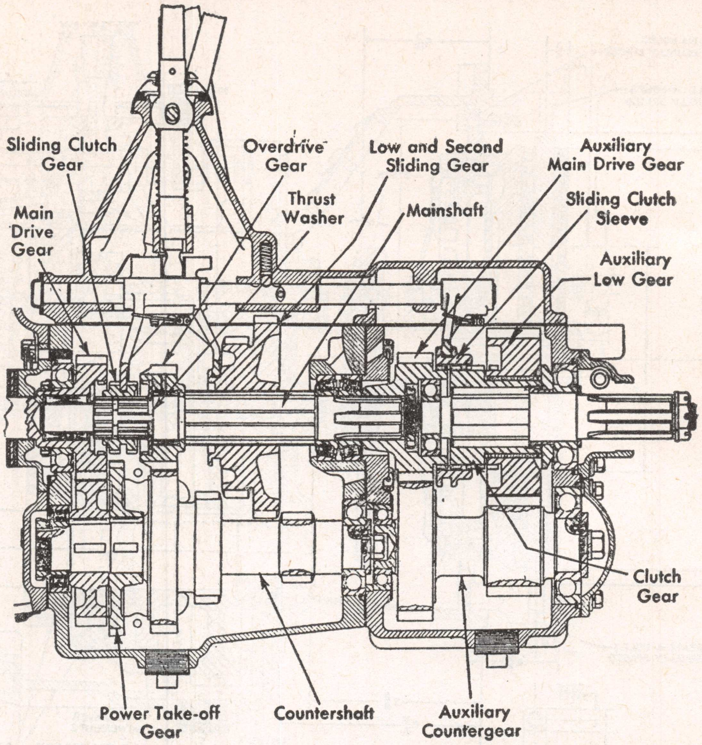
If the cover is to be disassembled, remove the shift fork lock screws and drive out the rails, holding a hand over the lock ball holes to prevent the balls and springs from flying out. As each rail is removed, it should be tagged to assure correct assembly.

Assemble: Install the reverse idler gear and push the shaft in through the rear. Assemble the countershaft in the case and replace the front and rear bearings, using new snap rings in the grooves.

Insert the main drive gear through the inside of the case and install the bearing, using a new snap ring, after which, secure the assembly by running the retaining nut on the drive gear shaft. Replace the drive gear bearing cap and bell housing. Lubricate the mainshaft front pilot bearing and place it in the drive gear pocket.

Install the mainshaft intermediate bearing, pushing it up against the shoulder of the case. Place the mainshaft assembly in the case, pushing it through the intermediate bearing, then forward to insert its front end in the pilot bearing. Slip the intermediate bearing spacer on the shaft, then replace the overdrive mainshaft gear, pushing it against the sleeve, after which, the rear spacer is placed on the shaft up against the overdrive gear.

Assemble the overdrive countershaft gears and hold them in their relative position in the housing, then pass the housing over the rear end of the mainshaft, working the gears over the countershaft as the housing is pushed forward. Install the cap screws which fasten the overdrive housing to the main case. Replace the washers and bolts which retain the overdrive gears to the countershaft, wiring the bolts in place after they are fastened securely. Install the mainshaft rear bearing and its retainer, then slip the speedometer drive gear on the shaft, after which, replace the retainer cover. Push the universal flange on the shaft, lock the mainshaft and run the universal flange nut up tight. Replace the speedometer driven gear and the countershaft rear cover. Assemble the overdrive shift rail and fork in the overdrive housing, then place the gears in neutral and install the transmission cover.



BROWN-LIPE. Model 3481, Eight Speed. Typical of 7481.

MODELS 3481, 7481

Eight Speeds Forward and Two Speeds Reverse With Direct Drive on Seventh and Overdrive on Eighth.

Disassemble: Take off the transmission cover assembly. Lock the mainshaft and unscrew the universal flange nut, then pull off the flange. Remove the mainshaft and countershaft bearing covers from the auxiliary housing. Slip the speedometer drive gear and washer from the auxiliary mainshaft. Remove the cap screw and washer from the auxiliary countershaft. Grasp the auxiliary mainshaft gears and pull the shaft out rearward, forcing the auxiliary mainshaft bearing out at the same time, then lift the loose gears from the case.

Take the auxiliary mainshaft pilot bearing from the drive gear pocket, lock the mainshaft and remove the nut from the end of the shaft, after which, the auxiliary main drive gear may be removed. Reach into the auxiliary housing and unscrew the bolts which fasten this housing to the main case, then remove the auxiliary housing.

NOTE—At this point, the auxiliary countershaft may be removed by forcing the shaft far enough to the rear until the rear bearing is clear of the case, then the gear assembly may be lifted out by its front end.

Push the mainshaft far enough to the rear to permit the removal of the rear bearings.

NOTE—On the 3481 unit, slip the sliding clutch gear forward on the mainshaft to gain access to the T-shaped key in the mainshaft slot. Pick the key out of the slot and disengage its end from the overdrive gear thrust washer. Rotate the washer to align its teeth with the mainshaft splines and slide it forward. Pull the mainshaft to the rear, picking off the gears as the shaft is withdrawn.

For the 7481 unit, follow the above procedure except that the clutch gear is retained on the shaft by a nut and when this nut is removed, pull the mainshaft to the rear and pick off the gears as the shaft is withdrawn.

On both units, remove the bell housing and the main drive gear cover and push the drive gear assembly into the case and lift it out through the top. The drive gear and bearing may be separated after removing the retaining nut.

Unscrew the nut from the front end of the countershaft, then force the shaft far enough to the rear to permit the removal of the rear bearing, after which, lift the countershaft assembly out of the case. Pull the reverse idler shafts out of the case and lift out the gears.

If the transmission cover is to be disassembled, remove the shift fork lock screws and push out the rails, holding a hand over the lock ball holes to prevent the balls and springs from flying out.

CAUTION—As each rail is removed, it should be tagged to assure correct assembly. And when assembling the cover, lubricate the lock balls and springs, and be sure the lock screws engage the holes in the rails before wiring them in place. Care must be exercised to see that all the interlock plunger parts are assembled correctly.

Assemble: Replace the reverse gears and shafts. Install the front countershaft bearing, place the countershaft assembly in the case, slip in the rear bearing and a new snap ring, then replace the nut on the front end of the shaft and the lock bolt and washer at the rear.

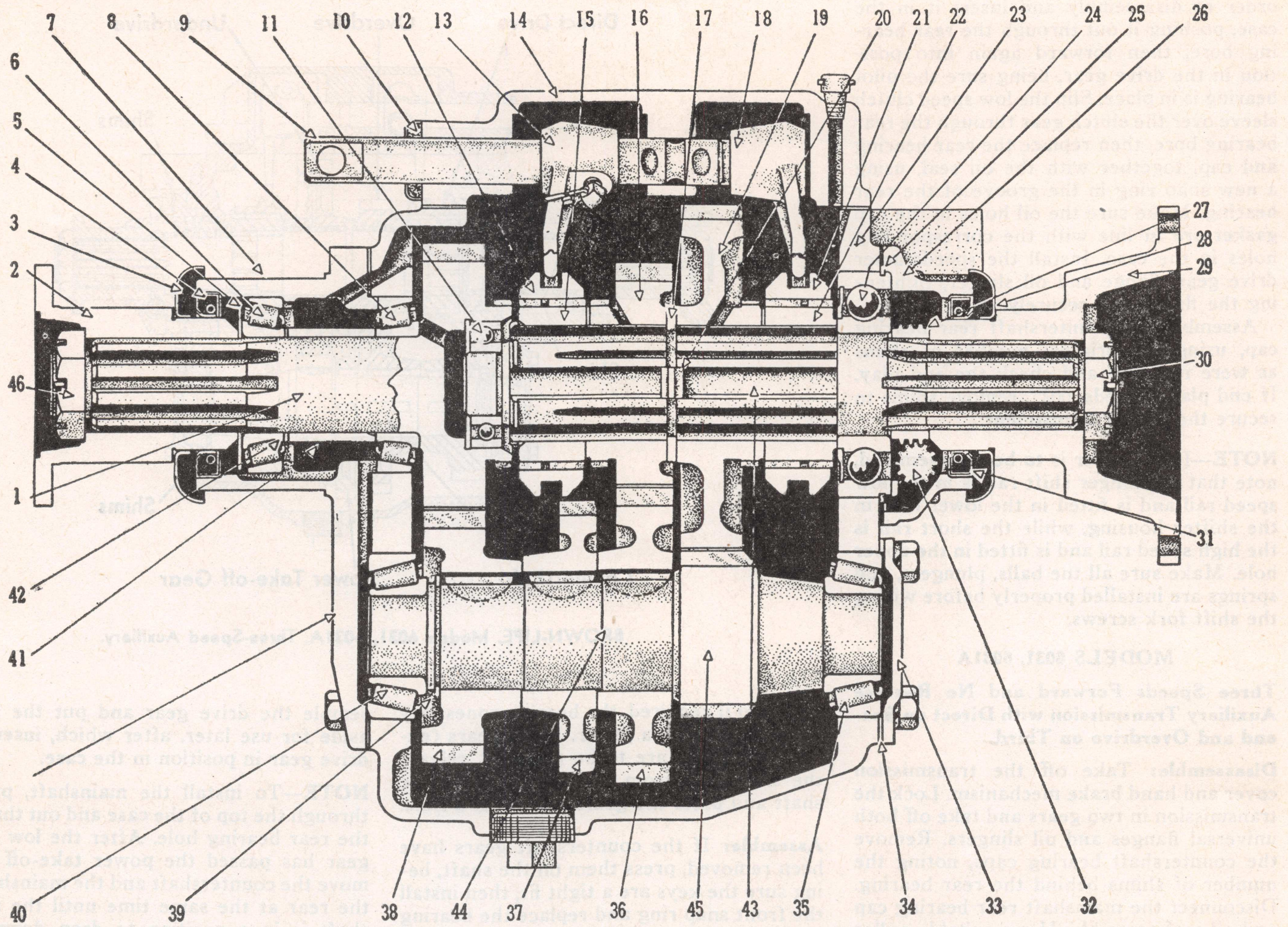
Assemble the main drive gear and insert it through the inside of the case, using a new snap ring in the bearing groove. Replace the drive gear retainer cover and bell housing. Lubricate the mainshaft front pilot bearing and slip it in the drive gear pocket.

Pass the mainshaft through the rear of the case, slipping on successively, the sliding gears, the overdrive gear and thrust washer.

NOTE—On the 3481 unit, before installing the sliding clutch gear, engage the end of the T-shaped key in the overdrive gear thrust washer, then push the key into its groove in the mainshaft. Slip the clutch gear on the shaft, push the shaft all the way into position and install the mainshaft rear bearings in the recess of the housing.

On the 7481 unit, the procedure is the same as above except that the gears are retained by the nut at the front end of the shaft.

On both units, assemble the auxiliary countershaft gears and bearings in the housing and connect both housings. Place the auxiliary drive gear on the end of the mainshaft and fasten the retaining nut securely. Lubricate the auxiliary pilot bearing and install it in the drive gear pocket. Pass the auxiliary mainshaft through the rear of the case, assembling the gears on the shaft as the shaft is being inserted. Install the auxiliary shaft rear bearing, using a new snap ring in the bearing groove. Replace the washer, speedometer drive gear and rear bearing cover. Complete the assembly by installing the universal flange, speedometer driven gear and transmission cover.



BROWN-LIPE. Model 5531, Three Speed Auxiliary.

1—Main drive gear. 2—Propeller shaft flange. 3—Oil slinger. 4—Oil seal. 5—Oil slinger washer. 6—Main drive gear front bearing. 7—Drive gear bearing cap. 8—Main drive gear rear bearing. 9—Overdrive shift rod. 10—Shift rod packing. 11—Mainshaft front bearing. 12—Overdrive sliding clutch. 13—Overdrive shift fork. 14—Transmission cover. 15—Sliding clutch sleeve. 16—Mainshaft overdrive gear. 17—Low and overdrive gear spacer. 18—Low speed shift fork. 19—Mainshaft low gear. 20—Spacer locks. 21—Low speed sliding clutch. 22—Sliding clutch sleeve. 23—Transmission case. 24—Mainshaft rear bearing. 25—Bearing locating ring. 26—Mainshaft rear bearing cap. 27—Speedometer drive gear. 28—Oil slinger. 29—Propeller shaft flange. 30—Flange nut. 31—Oil seal. 32—Speedometer driven gear. 33—Countershaft rear bearing cap. 34—Bearing adjusting shims. 35—Countershaft rear bearing. 36—Countershaft overdrive gear. 37—Power take-off gear. 38—Countershaft main drive gear. 39—Snap ring. 40—Front bearing. 41—Spacing sleeve. 42—Bearing adjusting shims. 43—Mainshaft. 44—Countershaft. 45—Countershaft low gear. 46—Flange nut.

MODEL 5531

Three Speeds Forward and No Reverse Auxiliary Transmission with Direct on Second and Overdrive on Third.

Disassemble: Take off the transmission cover and hand brake mechanism. Lock the mainshaft and remove both universal flanges and oil slingers. Remove the main drive gear and countershaft front bearing cap, front bearing and oil seal, noting the thickness of shims behind the cap. Use a suitable puller to remove the oil seal and bearing cup from the cap. Take off the countershaft bearing cap and note the thickness of shims used at this point.

Remove the mainshaft bearing cap and oil seal, then move the mainshaft back until the rear bearing is clear of the case. Pull the bearing from the mainshaft and remove the low speed sliding clutch through the rear bearing bore. Separate the main drive gear and mainshaft, leaving the pilot bearing in the drive gear pocket. Lift the mainshaft assembly out through the top by its front end.

To disassemble the mainshaft, remove the low speed clutch sleeve and gear. After removing the spacer locks, turn the spacer to align its splines with the mainshaft splines and slide it from the shaft. The overdrive gear, high speed clutch sleeve and clutch gear may then be removed.

Push the main drive gear into the case and lift it out through the top. The bearing and spacer may be removed from the drive gear by using a suitable puller.

Use a soft hammer to drive the countershaft rearward until the rear bearing cup is out of the case, then tilt the front end of the shaft upward and lift it out. Use a puller to remove the bearings and, if the gears are to be replaced, remove the front snap ring and press the gears from the shaft one at a time (except low gear which is integral with shaft).

Assemble: Press the gears on the countershaft, using new keys. Install a new snap ring in the groove at the front of the shaft and press on the front and rear bearing cones. Assemble the countershaft in the case and replace the bearing cups.

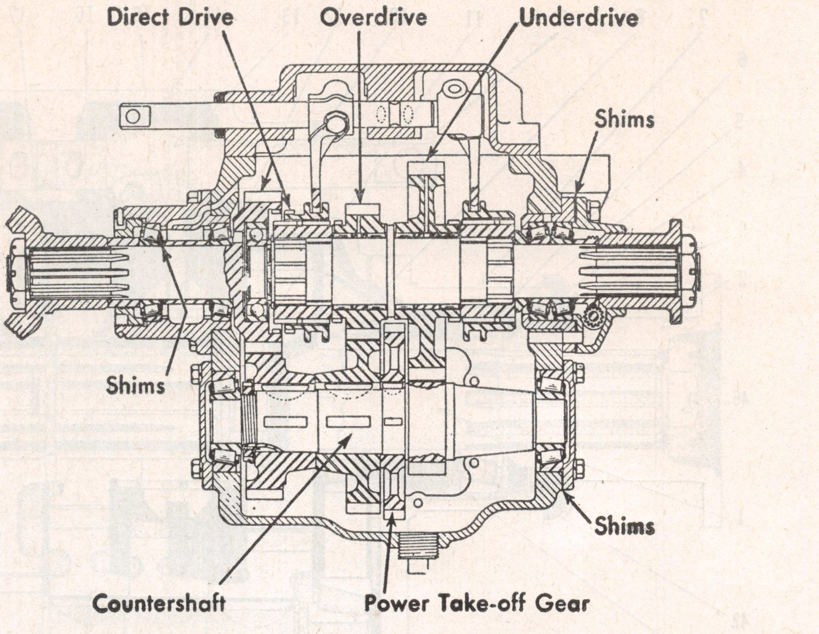
Install the main drive gear rear bearing cone and spacer on the gear and insert the gear through the inside of the case, then replace the countershaft and drive gear bearing cap, using a new gasket if required. Install the original number of shims on the main drive gear and replace the drive gear front bearing and oil slinger washer. Push the front universal flange on the shaft and run the flange nut up tight, then check the main drive gear end play which should not exceed .002"; if excessive, end play can be reduced by removing shims. When the proper adjustment is obtained, remove the flange and install the oil seal, oil slinger, then reinstall the flange and nut.

Assemble the mainshaft in the reverse

order of disassembly and insert it in the case, pushing it out through the rear bearing bore, then forward again into position in the drive gear, being sure the pilot bearing is in place. Slip the low speed clutch sleeve over the clutch gear through the rear bearing bore, then replace the rear bearing and cap, together with the oil seal, using a new snap ring in the groove of the rear bearing. Make sure the oil holes in the cap gasket are in line with the corresponding holes in the case. Install the speedometer drive gear, flange and oil slinger, tightening the flange nut securely.

Assemble the countershaft rear bearing cap, using the original number of shims as were removed and check the end play. If end play exceeds .002", remove shims to secure the proper adjustment.

NOTE—If the cover is to be disassembled, note that the longer shift rail is in the low speed rail and is fitted in the lower hole in the shifter housing, while the short rail is the high speed rail and is fitted in the upper hole. Make sure all the balls, plungers, and springs are installed properly before wiring the shift fork screws.



BROWN-LIPE. Models 6031, 6031A. Three-Speed Auxiliary.

MODELS 6031, 6031A

Three Speeds Forward and No Reverse Auxiliary Transmission with Direct on Second and Overdrive on Third.

Disassemble: Take off the transmission cover and hand brake mechanism. Lock the transmission in two gears and take off both universal flanges and oil slingers. Remove the countershaft bearing caps, noting the number of shims behind the rear bearing. Disconnect the mainshaft rear bearing cap and oil seal assembly. Use a suitable puller to remove the cage and bearing assembly, noting the number of shims behind the cap.

Remove the main drive gear bearing cage, together with the front bearing and oil seal, noting the thickness of shims behind the front bearing. Use a suitable puller to remove the oil seal and bearing cup from the cage.

NOTE—Tap the countershaft to the rear, moving the mainshaft back at the same time, until the countershaft rear bearing is free of the case. Separate the mainshaft from the main drive gear, leaving the pilot bearing in the drive gear, then shift the countershaft forward again, after which, the mainshaft may be lifted out of the case.

Push the main drive gear into the case and lift it out through the top. Use a suitable puller to remove the main drive gear spacer and rear bearing.

To disassemble the mainshaft, slip the sliding clutch sleeves off the clutch gears. Remove the retainer and snap ring from the front end of the shaft and, if necessary, the clutch gear may be removed with a puller.

CAUTION—If a puller is used to remove the clutch gear, hold a cloth under the assembly to prevent the loss of the rollers as the gear and sleeve are removed. Likewise, when removing the low speed gear, this same precaution must be observed.

Lift the countershaft assembly from the case, and if required, the bearing cones may be removed with a puller. If the gears (except low gear) are to be removed, release the snap ring from the front end of the shaft and press the gears off one at a time.

Assemble: If the countershaft gears have been removed, press them on the shaft, being sure the keys are a tight fit, then install the front snap ring and replace the bearing cones. Place the assembly in the case but do not install the bearing races.

To assemble the mainshaft gears, clamp the shaft in a vise with its rear end up. Apply a liberal quantity of grease around the low speed gear bearing surface and assemble the rollers around the shaft, being sure to account for 47 rollers. Press the rollers tightly around the shaft and assemble the low speed gear over the rollers, with the splined hub of the gear facing up. Slip the bearing spacer into the bore of the gear, pushing it down against the rollers, then assemble the other 47 rollers in the same manner. Install the low speed clutch gear with the splined end up, and the collar with the conical end up, pressing the gear and collar tight against the low speed gear. Then fasten the rear end of the shaft in a vise and assemble the overdrive gear and bearings in the same manner, using the high speed clutch gear and snap ring to hold the gear in place. Assemble the sliding clutch sleeves over the clutch gears with the shift fork channels facing each other.

Assemble the main drive gear, bearing cage and spacer, using the original thickness of shims as were removed. When assembled properly, the cage should turn freely but not spin on the shaft when these parts are subjected to pressure as they are being assembled in an arbor press. The proper adjustment may be obtained by adding or removing shims as required. When the desired adjustment is obtained, disassemble the drive gear and put the shims aside for use later, after which, insert the drive gear in position in the case.

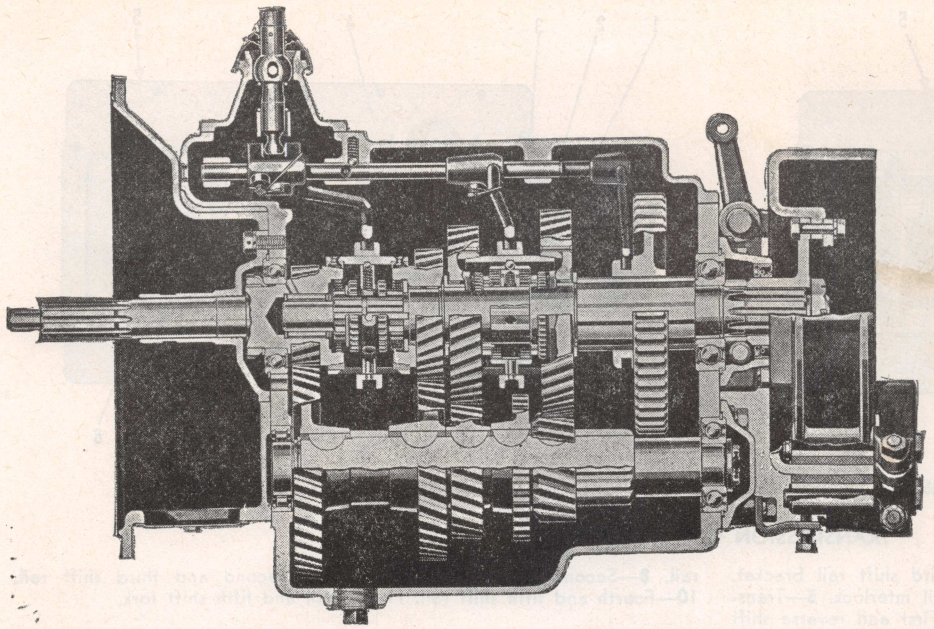
NOTE—To install the mainshaft, pass it through the top of the case and out through the rear bearing hole. After the low speed gear has passed the power take-off gear, move the countershaft and the mainshaft to the rear at the same time until the mainshaft is in a position to drop down and enter the pilot bearing in the drive gear. Now move both the mainshaft and countershaft forward again at the same time to their normal positions.

Reassemble the drive gear bearing cage and related parts and bolt the assembly to the front of the case, being sure the oil return hole in the gasket is in line with the oil hole in the case. Install the front universal flange and oil slinger, tightening the flange nut securely.

Assemble the rear bearing cage and gasket, lining up the oil hole with the corresponding hole in the case. Install the rear bearings, speedometer drive gear, rear outer bearing race and the bearing cap and oil seal, using the original number of shims as were removed.

CAUTION—Be sure the oil hole in the shims line up with the oil return hole in the bearing cage and cap. Then tighten the screws and check the end play in the bearings. When properly adjusted, the shaft should turn freely by hand. Add or remove the required thickness of shims to obtain the desired adjustment. Install the rear universal flange and oil slinger, tightening the flange nut securely.

Install the countershaft front bearing cap and gasket. Assemble the original number of shims under the countershaft rear bearing cap and check end play in the bearings, changing shims as required to obtain the proper adjustment which should be from



BROWN-LIPE. Models 4452, 4453, Five Speed. Models 5552, 5553 are similar.

.000" to .002". Complete the assembly by replacing the transmission cover and hand brake mechanism.

NOTE—If the cover is to be disassembled, note that the longer shift rail is the low speed rail and is fitted in the lower hole in the shifter housing, while the short rail is the high speed rail, fitted in the upper hole. Make sure all the balls, plungers and springs are installed properly before wiring the shift fork screws.

MODELS 4452, 4453, 5552, 5553

Five Speeds Forward and One Reverse with Direct on Fifth for Models 4452 and 5552. For Models 4453 and 5553, Direct on Fourth and Overdrive on Fifth. Models 5552 and 5553 are Equipped with an Oil Pump Driven from the Front End of the Countershaft to Force Lubricant to All the Constant Mesh Gears.

Disassemble: Take off the transmission cover and shift lever, then remove the shifter housing assembly. Lock the mainshaft in two gears and remove the universal flange nut, then pull off the flange. Remove the bearing caps from the main drive gear and mainshaft, and take off the drive gear bearing retaining nut and plate. Push the mainshaft to the rear far enough to permit the removal of the rear bearing and speedometer drive gear.

NOTE—Tilt the front end of the mainshaft up slightly to permit the main drive gear to clear the countershaft drive gear, then pull the main drive gear out through the front of the case. Lift the mainshaft out of the case and at the same time, slip the low and reverse gear from the shaft.

To disassemble the mainshaft, clamp the rear end of the shaft in a vise. Remove the pilot bearing and snap ring and take off the high speed synchronizer unit. Remove the T-shaped key from the shaft on the 4452 and 4453, or the snap ring on 5552 and 5553. Rotate the fourth gear, thrust washer (fifth gear on overdrive units) to align its splines with the mainshaft splines and slide it forward off the shaft. Lift the fourth gear, roller bearings and spacer from the shaft (also sleeve on 5552 and 5553 models). Remove the third gear sleeve snap ring on 4452 and 4453 models.

NOTE—Take off the third gear with roller bearings and spacer. The sleeve used on the 4452 and 4453 models will come off with the gear and bearings, while on the 5552 and 5553 series, the sleeve is removed after taking off the gear and bearings. Lift off the second and third speed synchronizer, and when doing so on the 4452 and 4453 models, wrap a piece of wire around the poppet spring retainers after partially removing the unit to prevent the loss of the springs, retainers and balls.

Use a puller to remove the synchronizer clutch gear, then lift off the second speed gear, together with the needle bearings and spacer as an assembly.

To remove the countershaft, take off the rear bearing cap and remove the bolts which fasten the rear bearing to the countershaft. Move the countershaft far enough to the rear to permit the rear bearing to be removed from the shaft, then lift the assembly out of the case.

NOTE—If the gears are to be removed from the countershaft, release the front snap ring and press them off one at a time, noting the direction the long part of the gear hubs should face so that assembly will be made correctly. On series 4452 and 4453, one spacer is used between the fourth gear and main drive gear, while on series 5552 and 5553, two spacers are used; the narrow one between the main drive gear and the power take-off gear and the wide spacer between the second and third gears.

The reverse idler gear shaft is tapped at the rear for the use of a puller when necessary to remove these parts. Models 4452 and 4453 use two bronze bushings which may be pressed out of the gear, while series 5552 and 5553 use roller bearing and a spacer which may be removed from the gear after removing the shaft from the case.

Assemble: Install the gears on the countershaft in the reverse order of removal, being sure all the keys are a tight fit in their respective gears. Insert the countershaft front bearing in the case and lower the countershaft assembly into the case, pushing it forward into the front bearing. Install the snap ring in the rear bearing groove and tap the bearing in place, installing the washer and screws to hold it in position.

Install the reverse idler gear and bearing assembly, with the tooth chamfer facing forward, then tap the idler shaft in place, being sure the offset on the shaft is facing the countershaft bearing cap. Install the countershaft bearing cap and gasket.

To assemble the mainshaft, fasten the rear end of the shaft in a vise and slip on the second gear thrust washer. Assemble the roller bearings and spacer in the second gear, using cup grease to hold them in place, then place this assembly on the shaft with the clutch teeth facing the front of the shaft. Insert the second and third speed clutch gear keys in the shaft and press the clutch gear in place.

On series 4452 and 4453, position the four poppet springs on the clutch gear and insert the four balls. Use a small piece of wire to compress the four plungers in order to slip on the synchronizer sleeve, pulling the wire out gradually as the sleeve is being installed.

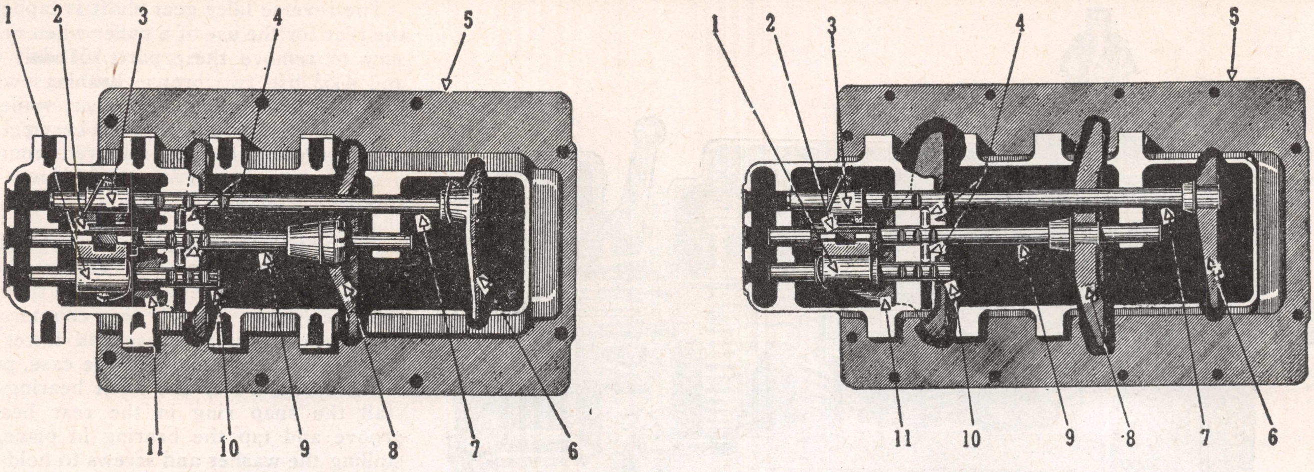
On all models, slip the synchronizer over the clutch gear and slide the clutch gear sleeve into place. On 4452 and 4453 series, assemble the sleeve with the thrust face toward the front. On 5552 and 5553 models, be sure the hole in the sleeve lines up with the oil hole in the mainshaft.

Assemble the roller bearings and spacer in the third speed gear in the same manner as the second gear, and place this assembly on the shaft, facing the clutch gear teeth to the rear. The sleeve on models 4452 and 4453 has lugs which must register with the keyways of the clutch gear, and after the sleeve is installed on these units, lock it with a snap ring.

On series 5552 and 5553, slide the fourth gear sleeve (fifth gear on 5553) and dowel in place, being sure the oil hole in the sleeve lines up with the oil hole in the mainshaft.

On all units, assemble the roller bearings and spacer in the fourth gear in the same manner as already described and slide the assembly in place with the clutch gear facing the front.

Slip on the thrust washer and, on 4452 and 4453 units, lock the washer with the T-shaped key, or with the snap ring on 5552 and 5553 models. Then assemble the front synchronizer in position, being sure the



BROWN-LIPE. Models 4452, 4453.

BROWN-LIPE. Models 5552, 5553.

TRANSMISSION COVER ASSEMBLY

1—Fourth and fifth shift fork. 2—Second and third shift rail bracket. 3—First and reverse shift rail bracket. 4—Shift rail interlock. 5—Transmission cover. 6—First and reverse shift fork. 7—First and reverse shift rail. 8—Second and third shift fork. 9—Second and third shift rail. 10—Fourth and fifth shift rail. 11—Fourth and fifth shift fork.

long portion of the hub, on 4452 and 4453 models, is to the front. Install the pilot bearing spacer ring on the front of the shaft, at which time, the mainshaft assembly is ready for installation.

To install the mainshaft, hold the low and reverse gear in the case at an angle and pass the rear end of the mainshaft through the low gear and out through the rear of the case, then forward to the position where the mainshaft and countershaft gears line up. Lubricate the pilot bearing and slip it on the front of the mainshaft. Raise the front of the mainshaft slightly and, at the same time, install the main drive gear. Replace the drive gear bearing and snap ring, locking the bearing with the nut and locking plate. Tap the mainshaft rear bearing in place with its snap ring to the rear and slip the bearing cap over the drive gear and bolt it in place.

NOTE—The oil holes in the drive gear bearing cap and gasket must line up and the leather oil seal (on 5552 and 5553) should be renewed. And when the seal is slipped over the shaft, use a thin piece of shim stock to cover the splines to prevent cutting the leather or seal.

Install the speedometer drive gear and a new rear bearing oil seal, after which, replace the bearing cap and universal flange, tightening the flange nut securely.

NOTE—The oil pump on models 5552 and 5553 is bolted to the inner side of the clutch housing. The pump is fitted with a non-adjustable pressure relief valve consisting of a ball and spring held in place by a pipe plug in the side of the oil pump housing.

When assembling the pump, press the oil pump drive gear on the shaft so that the distance from the front end of the shaft to the front side of the gear measures 17/32". This dimension should be held closely to prevent excessive wear on the side of the gear.

Assemble the driving gear and shaft in the housing, then press the driven gear shaft in the housing, after which, install the driven gear on the shaft. Assemble the relief ball and spring in the housing and replace the plug. Position the housing gasket, being sure the holes in the case are not covered by the gasket. Fill the oil pump full of lubricant and bolt the assembly in place, being sure the oil holes in the housing line up with corresponding holes in the case.

CAUTION—Remove the pipe plug from the side of the pump housing and fill with lubricant. Rotate the clutch shaft in the direction of rotation while filling until all the oil passages are filled and all air displaced. This system of priming the pump will serve to prevent damage to the transmission which otherwise would occur if the lubricant is not picked up when first started.

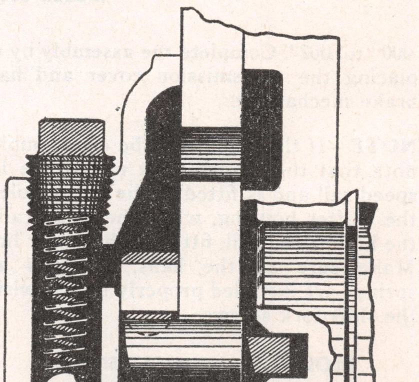
If the transmission cover is to be disassembled, see the illustrations for the arrangement of parts to assure correct assembly

CHEVROLET

THREE-SPEED SYNCHROMESH

1933-36 ½ Ton

Disassemble: Take off the transmission cover assembly and lock the transmission in two gears to prevent the mainshaft from turning. Disconnect the universal joint front yoke with its ring and trunnion bearings. Unfasten the universal joint ball retainer and turn it to clear the countershaft. Drive the countershaft out rearward. Remove the universal ball retainer with the second speed gear and clutch sleeve as an assembly. Lift out the first speed gear, mainshaft pilot bearing and the front synchronizing drum through the top. Unscrew the main drive gear bearing retainer from the case and remove the retainer and main drive gear assembly. Drive out the reverse idler gear expansion plugs, remove the lock screw and drive the idler shaft out rearward. Lift out the idler gear and the countergear cluster assembly.



BROWN-LIPE. Showing Oil Pump Mounting at Front End of Countershaft on Models 5552 and 5553.

To disassemble the mainshaft, remove the clutch sleeve from the shaft and press the mainshaft out of the rear bearing retainer. Expand the snap ring which retains the rear bearing in the retainer and take out the bearing. Slip the second speed gear and

thrust washers from the mainshaft. With a suitable spreader tool, remove the synchronizer spring from the mainshaft, then take off the second speed synchronizing drum, thrust washer retainer and thrust washer.

NOTE—Check the countergear, idler gear and second speed gear bushings for wear by using a new shaft and a narrow feeler gauge. The clearance between the bushing and its shaft should be from .002" to .004". If the clearance exceeds this amount, it is recommended that the bushing and gear assembly be replaced to assure proper alignment of the bushings with their gears as well as proper mesh of the gears. However, if the bushings are replaced, they must be line reamed to size. When replacing countershaft bushings, be sure to install the longer bushing in the rear of the gear.

Assemble: Hold the reverse idler gear in position and install the idler shaft in through the rear of the case, lining up the hole in the shaft with the hole in the case; then install the lock screw securely. Dip the countershaft thrust washers in heavy oil and assemble them to the case, lining up the raised part of the washers with the cutout in the case. Install the countergear into the case, allowing it to rest on the bottom.

Install the oil slinger and bearing on the main drive gear, supporting the bearing on its inner race during the process to avoid damaging the bearing. Replace the bearing lock ring, and install the main drive gear assembly and retainer to the transmission.

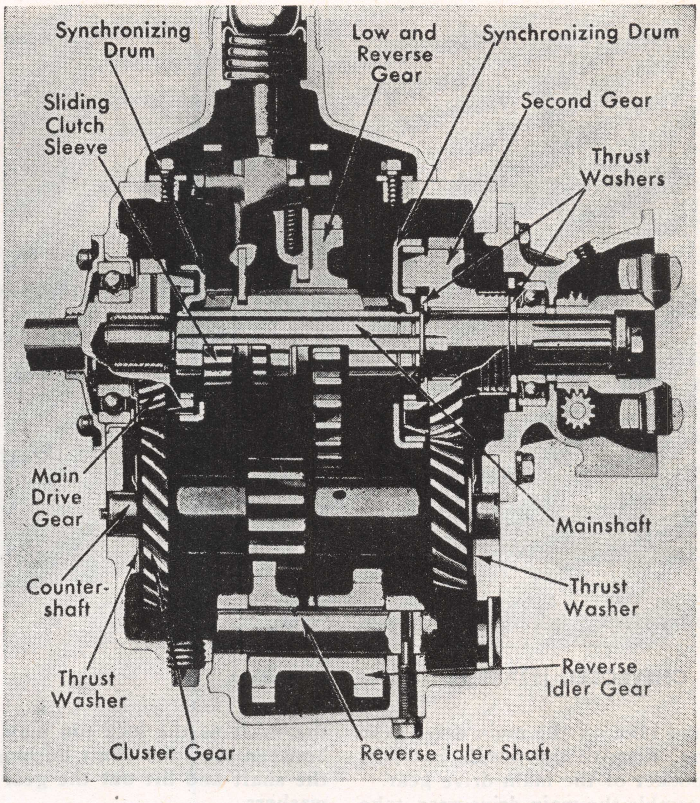
NOTE—When installing this assembly, tap the outer race of the bearing and not the gear, as the gear is apt to go through the bearing, causing the oil slinger to become loose and cause a rattle. The main drive gear bearing is marked "Top" and should be so installed.

Dip the mainshaft pilot bearing in transmission lubricant and insert it in the pocket of the main drive gear.

Assemble the front synchronizer drum to the front cone. Place the second speed gear thrust washer on the mainshaft and lock it in position with its retainer. Install the rear synchronizer drum on the mainshaft.

NOTE—Measure the dimension of the rear synchronizing spring, using a micrometer across the three slots, and note the size. This dimension determines the proper clearance between the drum and the cone.

Install the rear synchronizing spring on the mainshaft by expanding it just enough so it slips over the shaft. Assemble the second speed gear to the mainshaft and drum. Measure the clearance between the spring and the shoulder on the mainshaft by pressing the second speed gear against its thrust washer and the drum against the cone. This clearance should not be less than .025" nor more than .035". If not within these limits, change the springs—which are available in several thicknesses.



CHEVROLET. 1933-36 Three-Speed Synchromesh.

Install the mainshaft rear bearing in the retainer with its oil seal side toward the transmission. Replace the oil slinger and bearing lock ring, being sure that the ring seats in the groove in the transmission case. Install the rear thrust washer to the inside of the oil slinger with the grooves facing the second speed gear. Insert the mainshaft into the rear bearing and retainer.

CAUTION—Be sure the legs on the synchronizing drum line up with the slots in the rear synchronizing spring.

Replace the clutch sleeve on the mainshaft, lining up the slots in the sleeve with the legs of the drum.

NOTE—Measure the dimension of the front synchronizing spring in the same manner as described for the rear spring and note the size. Install this spring on the mainshaft, being sure that the prongs of the spring face the sleeve.

Hold the first speed gear in position in the case and insert the mainshaft and rear bearing retainer assembly into the transmission and through the first speed gear.

NOTE—Be sure the fork channel of the gear is toward the front, and that the notches in the sleeve line up with the front drum.

Fasten the rear retainer securely to the transmission case. Drive in the idler gear shaft expansion plugs.

NOTE—Check the clearance between the front synchronizer spring and the shoulder of the mainshaft which should not be less than .025" nor more than .035". If not within these limits, compute the difference between this clearance and the micrometer measurements previously taken and change the springs accordingly. It is only necessary to remove the main drive gear to change the front spring.

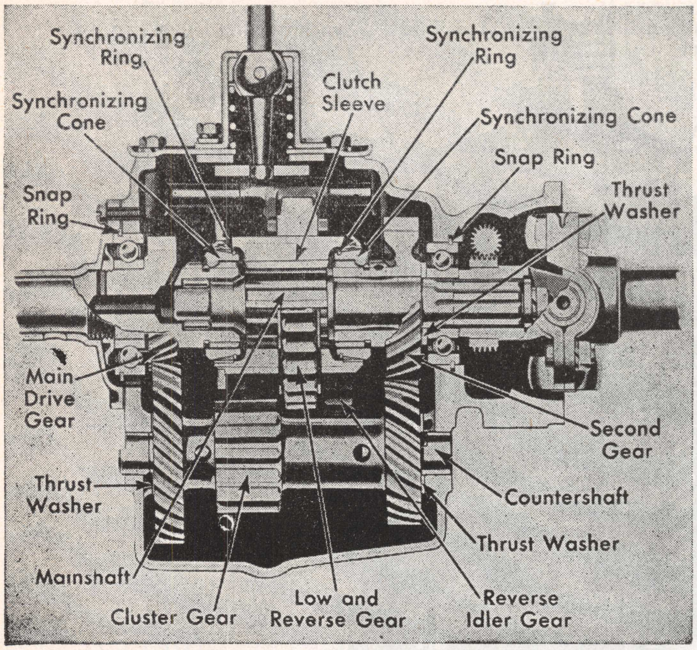
Align the countergear and thrust washers with the holes in the case and drive the countershaft in through the rear. Replace the universal yoke and install the transmission cover.

THREE-SPEED SYNCHROMESH

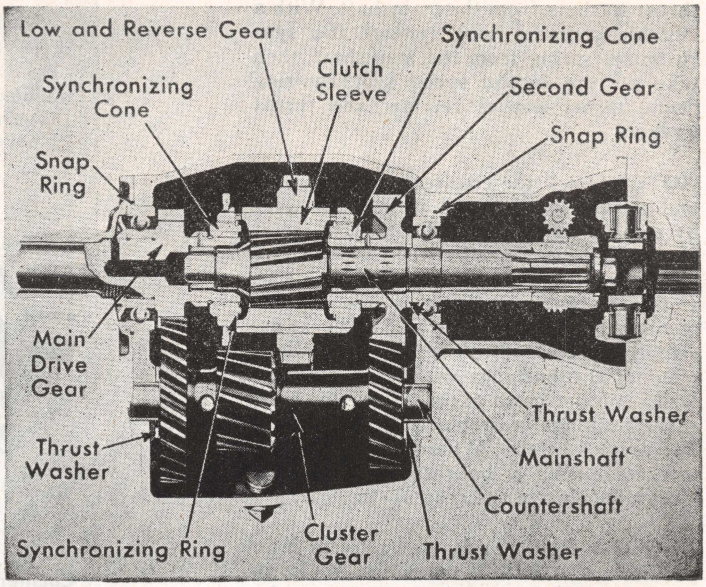
1937-46 All ½, ¾ and 1 Ton

Disassemble: Shifter Mechanism: If the shift mechanism is to be disassembled, remove two opposite screws from the lever housing and replace with two longer screws so that they all may be removed evenly to relieve the tension on the lever spring before taking off the retainer. The two front screws are special in that they lock the shifter shafts in the transmission case. After removing the interlock, drive the shafts from the case rearward. These shafts are .003" larger in diameter where they fit into the front of the case. Remove the shifter yokes, lock balls and springs.

Main Drive Gear: Lock the transmission in two gears, being careful not to damage the wedge angles on the synchronizing clutch mechanism. Disconnect the universal joint and slide the joint and spacer from the mainshaft. Remove the main drive gear bearing retainer, but before removing the gear, mark the relationship between the clutch gear and the second speed gear with their rings so they may be assembled in the same relative position. Using a suitable puller, screw the threaded sleeve of the puller onto the shaft in a counter-clockwise



CHEVROLET. 1937-39 Three-Speed Synchromesh.



CHEVROLET. 1940-46 Three-Speed Syncromesh.

direction and take off the main drive gear and bearing. Remove the needle bearings from the pocket of the main drive gear.

To disassemble the main drive gear, take off the retaining nut and oil slinger—which is a one-piece assembly with a left-hand thread and is locked in place by being staked into a hole provided for that purpose. Use a press to remove the bearing from the shaft.

For 1938-39 trucks, a new main drive gear bearing retainer is available for service for use on vehicles subjected to extreme service.

Mainshaft: Turn the front synchronizer ring so that one lug lines up directly between a land and a spline on the mainshaft. Force the mainshaft out of the rear bearing and remove the shaft out through the front of the case. Shift the second gear into the synchronizer clutch sleeve and take out the sleeve, second speed gear and the first and reverse sliding gear as an assembly.

NOTE—To disassemble the clutch sleeve, remove the sliding gears and turn the synchronizing ring in the clutch sleeve until the ends of the ring retainers can be seen through the slot in the sleeve. Then expand the retainer into the counterbore in the sleeve and slip out the ring.

Countershaft: Before removing the countergears, expand the mainshaft rear bearing lock ring to raise it from the bearing groove. Tap lightly on the outer race of the bearing and remove it from the inside of the case. Drive the countershaft out through the front and lift out the cluster gear and thrust washers.

Reverse Idler: Drive out the reverse idler gear expansion plug from the inside of the case. Drive the reverse idler shaft lock pin into the shaft, being careful not to turn the shaft as the lock pin may drop down between the idler shaft bushings. Remove the shaft and lift out the gear and thrust washers.

Inspection: See that the synchronizing cones are not loose in the clutch sleeve. If the cones are damaged, it will be necessary to replace the clutch sleeve assembly and both synchronizing rings. The rings must be smooth and should not rock in the cones, as excessive rocking affects proper synchronizing of the gears when shifting. Normally, it should not be necessary to replace the synchronizer energizing springs. However, should this be required, the spring is assembled in its groove with its offset and between the second and third clutch teeth of any bank of teeth—which will prevent the spring from turning in its groove. Whenever removed, these springs should always be replaced with new ones, and when doing so, care should be exercised to prevent distortion when expanding the spring over the clutch teeth.

NOTE—The countergear and idler gear bushings (if equipped) are not serviced separately as they are a pressed fit and accurately bored to assure proper alignment with their gears as well as proper mesh of the gears. If the clearance between these bushings and their shafts is in excess of .004", the gear and bushing assembly should be replaced.

ASSEMBLE

Reverse Idler: Hold the idler gear in position in the case and install the idler shaft, being sure that the lock pin hole in the shaft lines up with the holes in the case. Using a new lock pin, drive it in about 1/16" below the case and peen the hole slightly to provide a tight fit and to prevent an oil leak. Install the idler shaft expansion plug.

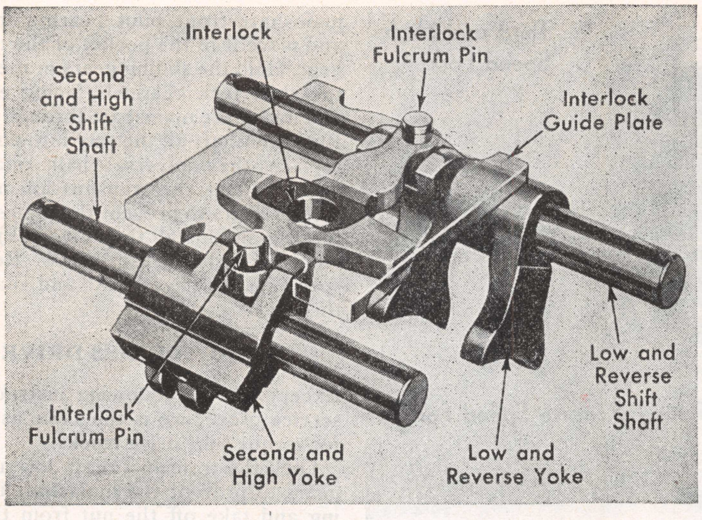
Countershaft: Place the countergear assembly into the case. Dip the countershaft thrust washers in transmission lubricant and place them in their proper position at each end of the gear. Use a suitable tool to pick up and align the gear and thrust washers with the holes in the case and drive the countershaft in from the front.

CAUTION—The flat on the front end of the shaft should be in a horizontal position and facing upward, otherwise it will not engage the clutch housing. The step on this end of the shaft should be flush with the front face of the case or about 1/64" below the face—to maintain proper transmission alignment.

NOTE—A countergear cluster equipped with needle bearings instead of bushings is available for replacement on 1941-42. To install this assembly, apply a liberal amount of cup grease at each end of the countergear where the needle bearings are to be inserted. With a shaft, or arbor—which is not any longer than the length of the countergear and thrust washers combined—installed in place of the regular countershaft to hold the bearings in place, install the assembly into the case and drive the dummy shaft out with the regular countershaft.

Clutch Sleeve: Install the ring retainers in the counterbores in the ends of the clutch sleeve. Expand the ring retainer and at the same time, hold it flush with the back face of the cone. Install the rings, being sure the retainers are properly seated in the grooves. Slip the first and reverse sliding gear on the sleeve. Install the second speed gear at the rear end of the sleeve, meshing the clutch teeth on the gear with those in the sleeve.

CAUTION—Be sure that the synchronizing ring lugs engage the clutch teeth on the second speed gear in their original position by aligning the marks which were made on these parts before they were disassembled.



CHEVROLET. Shifter Mechanism for Three-Speed, 1937-46.

Coat the grooved side of the second speed gear thrust washer with gear oil and place it on the back of the gear. Line up one lug on the front synchronizing ring with an internal spline tooth in the clutch sleeve. If this precaution is not taken, the clutch sleeve splines and the mainshaft splines will be burred when installing the mainshaft.

Mainshaft: When installing the mainshaft, lubricate the portion upon which the second speed gear fits. The proper seating of the mainshaft shoulder against the inner race of the rear bearing can be checked by the end play of the second speed gear which should be .010".

Shifter Mechanism: Install the shift yoke lock balls and springs in the transmission case. Assemble the shift yokes, placing the first and reverse yoke in its sliding gear channel and the second and high yoke over the rings on the sliding clutch sleeve. Install the shift shafts from the front—the longer one being for first and reverse—then line up the lock holes in the shafts with the cover holes in the top of the case. Place the shifter interlocks in the slots in the yokes with the pins pointing upward and with the hole nearer to the second and high speed shift shaft. Assemble the cover to the case, being sure to use the two special cap screws at the front.

FOUR-SPEED SLIDING GEAR

1932-42 All 1½ Ton

TORQUE TUBE DRIVE

Disassemble: Remove the transmission cover assembly and place the transmission in low and second gears to prevent the mainshaft from turning. Remove the speedometer driven gear. Take off the cap screw from the rear of the mainshaft and slip off the universal joint. Disconnect the universal ball retainer from the transmission. Remove the main drive gear bearing retainer and tap the main drive gear out through the front.

Slip the mainshaft pilot bearing from the front end of the mainshaft and tap the mainshaft to the rear until the rear bearing is clear of the case. Grasp the sliding gears and withdraw the mainshaft out through the rear and lift out the sliding gears through the top.

Drive the reverse idler shaft out toward the rear and lift out the gear assembly. Drive the countershaft toward the rear until the rear bearing and its retainer is free of the case. Slip the bearing and retainer from the shaft and lift out the countergear assembly. Tap the countershaft front bearing out by using a soft drift against its outer race.

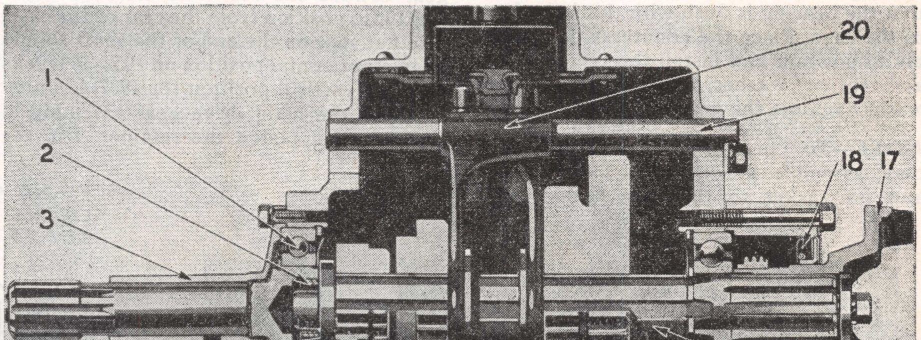
ASSEMBLY NOTES

Reverse Idler: If necessary to replace the idler gear bushings, they must be pressed in place and reamed to a diameter of from .876" to .877", which will provide the necessary clearance for proper lubrication. On 1941-42 trucks, this dimension should be from .877" to .878".

Countergears: With the exception of the low speed gear—which is integral with the countershaft—the gears may be replaced and when installed on the shaft, be sure all four keys between the shaft and the gears are staked in place.

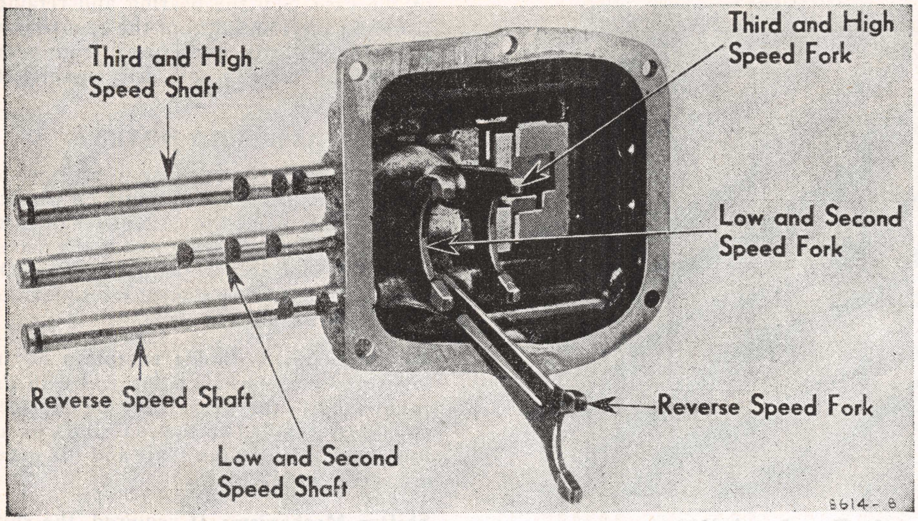
Shifter Mechanism: If required, the shift plate and fork assembly is replaced as a unit after cutting off the four rivets holding it in place.

If the shift shafts have been removed, the shaft with the three equally spaced notches should go in the central position; the one with the three unequally spaced notches belongs at the left (cover inverted), and the reverse shaft—with two notches—belongs at the right.



CHEVROLET. 1932-46 Four-Speed Sliding Gears.

1—Main drive gear bearing. 2—Mainshaft pilot bearing. 3—Drive gear bearing retainer. 4—Main drive gear. 5—High speed sliding gear. 6—Countershaft front bearing. 7—Countershaft drive gear. 8—Reverse countergear. 9—Third speed countergear. 10—Second speed countergear. 11—Low speed countergear. 12—Countershaft rear bearing. 13—Low, second and reverse sliding gear. 14—Rear bearing retainer. 15—Mainshaft rear bearing. 16—Mainshaft. 17—Universal yoke. 18—Oil seal. 19—Shift rail. 20—Shift forks.


Third and High
Speed Shaft
Third and High
Speed Fork
Low and Second
Speed Fork
Reverse Speed Shaft
Reverse Speed Fork
Low and Second
Speed Shaft
8614-B

CHEVROLET. Shift Mechanism for Four-Speed Transmission.

To assemble the shift forks, place the plunger spring in the fork and install the plunger ball. Using an old shifter shaft with a notch ground in its end, force the ball down on the spring, using the ground tool as a guide to push the regular shaft into place.

Assemble: Position the countershaft front bearing and retainer in place, being sure that the bearing is flush with the front face of the case. Place the countershaft assembly in position and install the rear bearing and thrust washer, placing the thrust washer against the gear.

NOTE—To check the countershaft end play, assemble the universal ball retainer and its gasket to the case temporarily. Force the countershaft back as far as possible and check the clearance between the front bearing and the gear. If the clearance exceeds .015", install a shim of the required thickness between the front bearing and its retainer. With the proper end play established, remove the universal ball retainer and gasket and go on with the assembly.

Install the idler gear, placing the small gear toward the rear and drive the idler shaft into position from the rear of the case. The flat spot on the end of the shaft should be in a horizontal position on 1932-36 trucks and in a vertical position for 1937-46 units.

Install the main drive gear assembly in the case and fasten the retainer. Dip the mainshaft front pilot bearing in gear oil and place it in the pocket of the main drive gear. Hold the sliding gears in the case with the shift fork channels facing each other and insert the mainshaft through the gears. Push the shaft all the way into position and replace the universal ball retainer and gasket. Place the transmission in low and second gears to prevent the mainshaft from turning and install the universal joint, fastening it with the cap screw. Replace the speedometer driven gear and shaft. Install the cover.

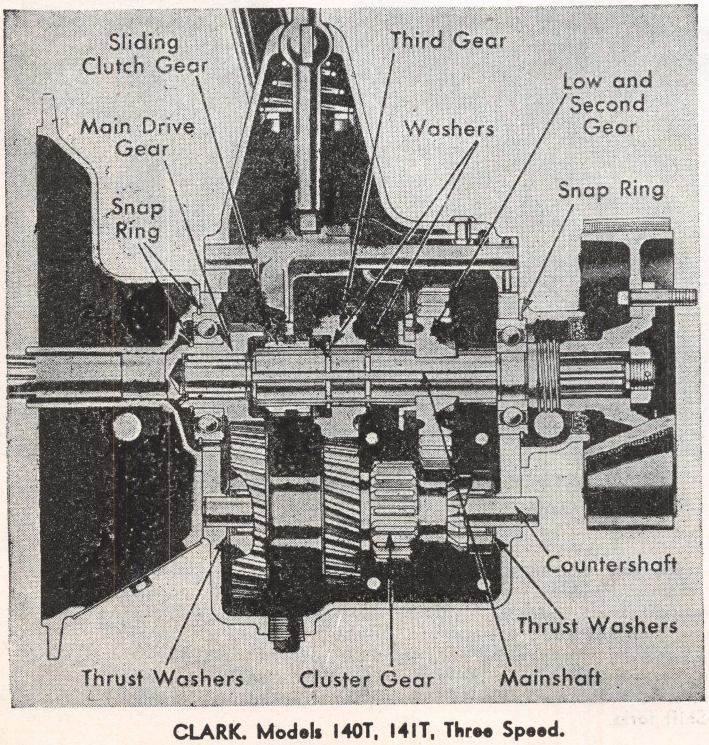
HOTCHKISS DRIVE

Except for the following instructions, the service procedure is the same as described for torque tube drive trucks.

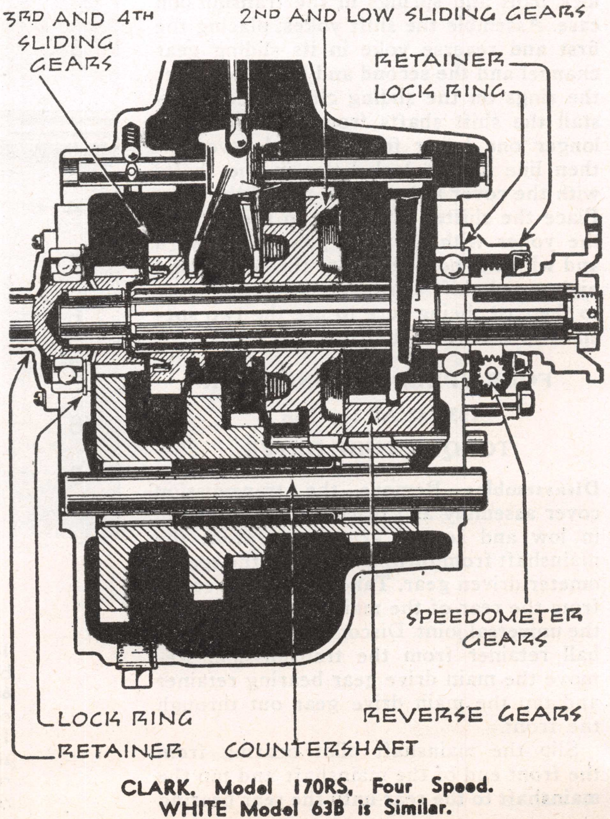
Lock the transmission in low and second gears to prevent the mainshaft from turning and take off the nut from the stud in the end of the universal joint flange. Unbolt the oil seal retainer from the mainshaft rear bearing retainer and use a puller to remove the oil seal, its retainer and speedometer drive gear as a unit.

NOTE—At this point, if repairs are to be made to the transmission, proceed as already described.

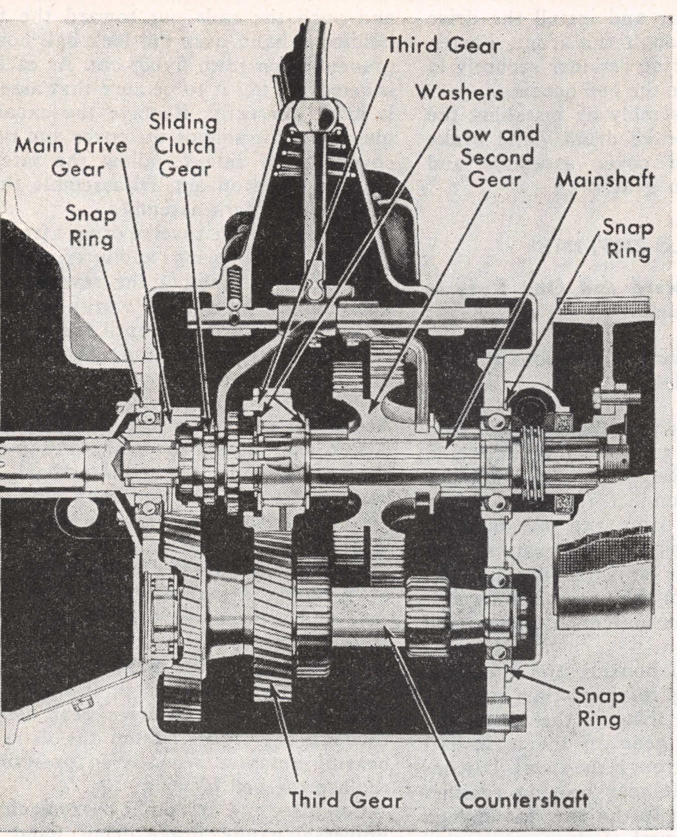
If the oil seal is to be replaced, press off the speedometer drive gear, take out the oil seal and replace with the new one after first soaking the seal in light engine oil for about one hour. Install the speedometer drive gear with its chamfered edge facing the front of the transmission.


Sliding
Clutch Gear
Third Gear
Low and
Second
Gear
Main Drive
Gear
Washers
Snap Ring
Snap
Ring
Countershaft
Thrust Washers
Thrust Washers
Cluster Gear
Mainshaft

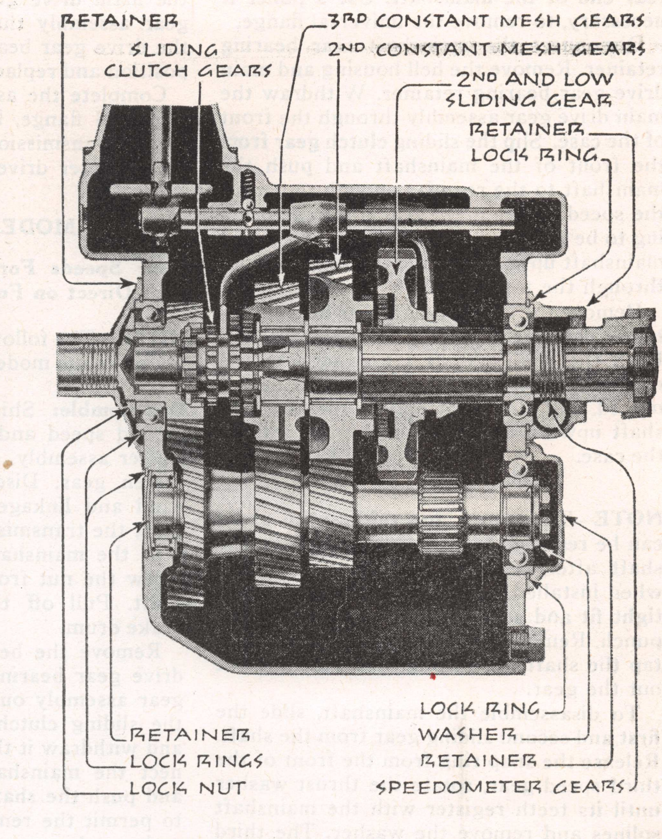
CLARK. Models 140T, 141T, Three Speed.


3RD AND 4TH
SLIDING
GEARS
2ND AND LOW SLIDING GEARS
RETAINER
LOCK RING
SPEEDOMETER
GEARS
LOCK RING
REVERSE GEARS
RETAINER
COUNTERSHAFT

CLARK. Model 170RS, Four Speed.
WHITE Model 63B is Similar.



CLARK. Model 185F, Four Speed.
WHITE Model 44B is Similar.



CLARK. Models 230F, 231F, Four Speed.
WHITE Model 43B is Similar.

CLARK

MODELS 140T, 141T, 142T

Three Speeds Forward and One Reverse with Remote Control Shift on Model 142T.

Disassemble: Take off the transmission cover assembly. Remove the speedometer driven gear, lock the mainshaft in any two positions and remove the universal flange nut and flange. Remove the main drive gear and mainshaft rear bearing caps and pull the main drive gear out through the front. Slide the clutch gear from the front end of the shaft and take it out through the drive gear opening. Push the mainshaft far enough to the rear to permit the removal of the speedometer drive gear and rear bearing, then lift the mainshaft out through the top of the case. Drive the reverse idler shaft and countershaft out rearward and lift out the gears.

To disassemble the mainshaft, slip the low gear from the rear end of the shaft. Release the snap ring from the rear side of the second speed gear and slide the second gear off the rear of the shaft, after which, remove the front snap ring.

Assemble: Install the idler shaft and countershaft by driving them in through the rear. Assemble the mainshaft and place it in the case, then install the speedometer drive gear and rear bearing. Lubricate the mainshaft pilot bearing and install the main drive gear through the front, then replace the bearing retainers. Complete the assembly by replacing the speedometer driven gear, universal flange and transmission cover assembly.

MODEL 170FS

Four Speeds Forward and One Reverse with Direct on Fourth.

NOTE—The following instructions also apply to White model 63B.

Disassemble: Take off the transmission cover and shifter assembly. Engage the low and second speed gears to prevent the mainshaft from turning and remove universal flange nut and flange. Remove the bell housing, the mainshaft rear bearing retainer and main drive gear bearing retainer. Pull the drive gear assembly out through the front.

Push the mainshaft far enough to the rear to permit the removal of the speedometer drive gear and rear bearing. Remove the pilot bearing from the end of the mainshaft and lift the mainshaft and gears out through the top. Disconnect the plate which locks the countershaft and idler shaft and tap both shafts out toward the rear. Lift out the gears.

To disassemble the cover, drive out the expansion plugs from the rear of the cover. Place the rails in neutral and take out the shift fork lock screws. Drive out the rails through the front and hold a hand over the lock ball holes to prevent the balls from flying out. Be sure to tag the rails as they are removed to assure correct assembly.

Remove the expansion plug from the side of the cover, tip the cover up on edge to allow the interlock plungers to drop out. Disassemble the reverse shifter fork plunger.

Assemble in the reverse order after lubricating all balls, springs and interlock plungers.

Assemble: Install the spacer and roller bearings in the countergear and place the assembly in the case. Insert the countershaft with the slot at the rear facing the idler gear shaft. Replace the reverse idler gear and shaft, locking both the idler and countershafts with the lock plate.

Place the mainshaft and gear assembly in the case and install the rear bearing and speedometer drive gear, being sure that the rear bearing snap ring is firmly seated in the groove. Replace the main drive gear and bearing through the front, after lubricating the mainshaft front pilot bearing. Install the front and rear bearing retainers. Complete the assembly by replacing the universal flange, speedometer drive gear, transmission cover and bell housing.

MODEL 185F

Four Speeds Forward and One Reverse with Direct on Fourth.

NOTE—The following instructions also apply to White model 44B.

Disassemble: Take off the transmission cover and shifter assembly. Remove the speedometer driven gear. Disconnect the hand brake mechanism and remove the hand brake band. Engage the second and low speed gears to prevent the mainshaft from turning and unscrew the nut from the rear end of the mainshaft. Use a puller if necessary, to remove the universal flange.

Disconnect the mainshaft rear bearing retainer. Remove the bell housing and main drive gear bearing retainer. Withdraw the main drive gear assembly through the front of the case. Slip the sliding clutch gear from the front of the mainshaft and push the mainshaft to the rear far enough to permit the speedometer drive gear and rear bearing to be removed. Tilt the front end of the mainshaft upward and lift the assembly out through the top.

Remove the countershaft rear bearing retainer cap, the retaining bolts and washer. Push the countershaft far enough to the rear to permit the rear bearing to be removed. Tilt the front end of the countershaft upward and lift the assembly out of the case.

NOTE—The fourth and third speed gears can be replaced by pressing them from the shaft after releasing the snap ring, and when installed, be sure that the keys are a tight fit and staked in place with a prick-punch. Remove the reverse idler shaft lock, tap the shaft out through the rear and lift out the gear.

To disassemble the mainshaft, slide the first and second sliding gear from the shaft. Release the snap ring from the front of the third speed gear, rotate the thrust washer until its teeth register with the mainshaft splines and remove the washer. The third speed gear, together with the bearings and rear thrust washer may then be removed.

If necessary to disassemble the cover, drive out the expansion plugs at the front of the cover. With shift rails in neutral position, remove the set screws from the shift forks and push the rails out toward the front, holding a hand over the lock ball holes to prevent them from flying out. Be sure to tag the rails as they are removed to assure correct assembly.

Drive the expansion plug from the side of the cover and turn the cover up on edge to allow the interlock plungers to drop out. Disassemble the reverse shifter fork assembly.

Assemble the cover in the reverse order, being sure to lubricate all balls, springs and interlock plungers.

Assemble: Insert the reverse idler with the larger gear toward the rear and tap the shaft in through the rear. Assemble the countershaft front bearing, its retainer and snap ring. Place the countergear assembly in the case and install the rear bearing, the two retaining cap screws and washer and the retainer cap.

Assemble the mainshaft in the reverse order of removal, using cup grease to hold the roller bearings in the third speed gear; be sure that the third speed gear inner race locating pin engages a spline on the mainshaft. Lubricate the mainshaft splines and slip the sliding gear on the shaft with the larger gear to the rear. Assemble the mainshaft and gears in the case and replace the rear bearing, speedometer drive gear and rear bearing retainer. Lubricate the mainshaft pilot bearing, place it in position in the main drive gear and install the drive gear assembly through the front. Fasten the drive gear bearing retainer securely in position and replace the bell housing.

Complete the assembly by installing the universal flange, brake drum, hand brake band, transmission cover assembly and speedometer driven gear.

MODELS 230F, 231F

Four Speeds Forward and One Reverse with Direct on Fourth.

NOTE—The following instructions also apply to White model 43B.

Disassemble: Shift the transmission into second speed and take off the cover and shifter assembly. Remove the speedometer driven gear. Disconnect the hand brake band and linkage from the transmission. Lock the transmission in two gears to prevent the mainshaft from turning and unscrew the nut from the rear of the mainshaft. Pull off the universal flange and brake drum.

Remove the bell housing and the main drive gear bearing retainer, then pull the gear assembly out through the front. Slip the sliding clutch gear off the mainshaft and withdraw it through the front. Disconnect the mainshaft rear bearing retainer and push the shaft to the rear far enough to permit the removal of the rear bearing and speedometer drive gear. Tilt the front end of the mainshaft upward and lift the assembly out through the top.

Take off the countershaft rear bearing cap and remove the two screws and washer from the rear bearing. Push the countershaft far enough to the rear to permit the rear bearing to be removed. Tilt the front end of the countershaft upward and lift the assembly out of the transmission case. Remove the lock, tap the reverse idler shaft out rearward and lift out the gear.

To disassemble the mainshaft, slip the sliding gear from the shaft. Remove the snap ring from the front of the third speed gear. Rotate the front thrust washer until its teeth align with the mainshaft splines and take off the gears, together with the roller bearings, inner race, and washers.

To assemble, clamp the shaft in a vise with the front end up and slip on the second speed gear rear thrust washer. Assemble the second speed gear over the shaft and insert the rollers between the gear and the shaft, using grease to hold them in place. Install the third speed gear rear thrust washer and the inner race, with the locating pin engaging mainshaft spline. Assemble the third speed gear over the race and insert the rollers, using grease to hold them in place. Slip on the front thrust washer and hold it down in order to install the snap ring. Lubricate the mainshaft splines and slip the sliding gear on the shaft with its internal teeth facing the front. Assemble the sliding clutch gear on the front of the shaft with the larger gear to the rear.

If necessary to disassemble the cover, drive the expansion plugs out of the cover. With all rails in the neutral position, remove the set screws from the shift forks and push the rails out toward the front, holding a hand over the lock ball holes to prevent them from flying out. As each rail is removed, tag it to be sure that assembly is made correctly. Remove the expansion plug from the side of the cover and tilt the cover on its side to allow the interlock plungers to drop out. Disassemble the reverse shifter fork assembly.

Assemble in the reverse order after lubricating all balls, springs and interlock plungers. When assembling the reverse shifter lug plunger, be sure it works freely and turn the adjusting nut until the plunger is flush with the face of the slot for the end of the shift lever.

Assemble: Insert the reverse idler with the larger gear toward the rear and tap in the shaft. Assemble the countershaft front bearing, its retainer and snap ring. Place the countershaft assembly in the case and install the rear bearing, the two retaining screws, washer and the retainer cap.

Position the mainshaft assembly in the case and replace the rear bearing, speedometer drive gear and rear bearing retainer. Lubricate the mainshaft pilot bearing, place it in position in the main drive gear and install the drive gear assembly through the front. Fasten the drive gear bearing retainer securely in position and replace the bell housing.

Complete the assembly by replacing the universal flange, brake drum, hand brake mechanism, transmission cover and speedometer driven gear.

MODELS 200V, 200VO, 202V, 202VO, 204V, 204VO, 205V, 205VO

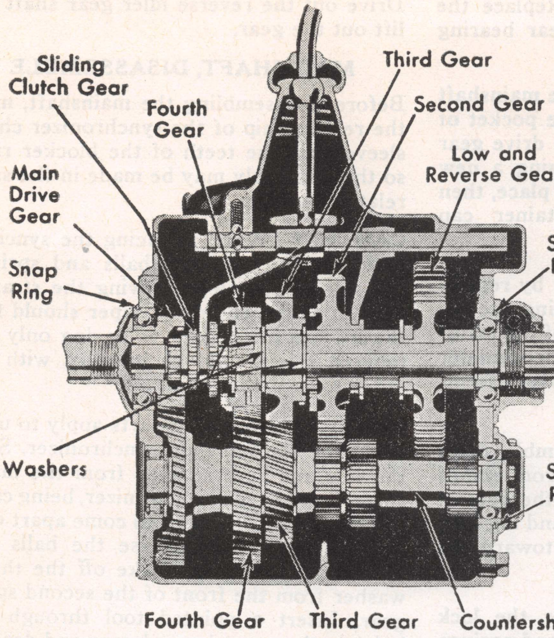
Five Speeds Forward and One Reverse with Direct on Fifth Models havings a V Suffix and Direct on Fourth with Overdrive on Fifth on Models having the VO Suffix.

NOTE—The following instructions also apply to White models 41B, 42B, 54B, 55B, 552B.

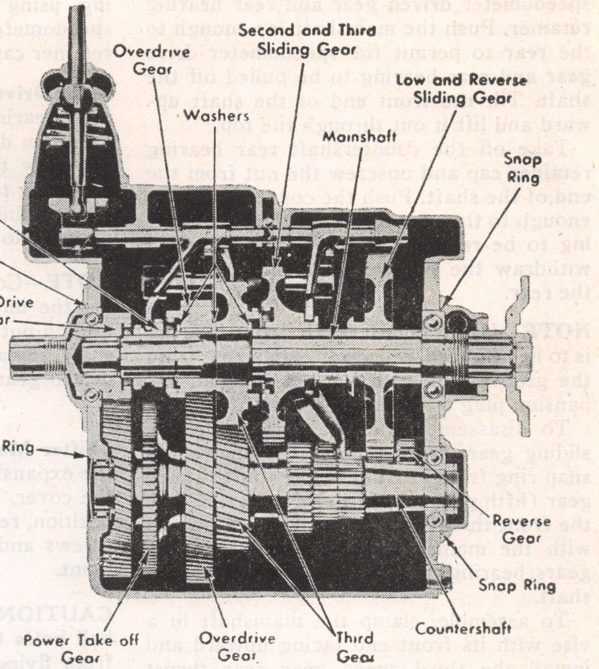
Disassemble: Take off the transmission cover and shift lever assembly. Remove the speedometer driven gear. Disconnect the hand brake lever mechanism and remove the hand brake band. Lock the transmission in two gears to prevent the mainshaft from turning and unscrew the nut which fastens the universal flange to the mainshaft. Use a puller if necessary, to remove the universal flange and brake drum.

Unfasten the main drive gear bearing retainer and withdraw the gear assembly out through the front. Slip the sliding clutch gear from the mainshaft. Disconnect the mainshaft rear bearing retainer and push the mainshaft far enough to the rear to permit the removal of the rear bearing and speedometer drive gear. Tilt the front end of the mainshaft upward and lift the assembly out through the top.

Remove the countershaft rear bearing retainer cap and unscrew the two bearing retainer bolts. Push the countershaft far enough to the rear to permit the removal of the rear bearing. Tilt the forward



CLARK. Typical of All Models 200V, 202V, 204V, 205V, Five Speed. WHITE Models 41B, 42B, 54B, 55B and 552B are Similar.



CLARK. Typical of All Models 270, 272v, 326V, Five Speed. WHITE Models 50B, 51B, 58B, 59B and 551B are Similar.

end of the countershaft assembly upward and lift it out of the case. Release the front bearing snap ring and tap the countershaft front bearing and retainer out through the front of the case. Remove the lock and tap the reverse idler shaft out through the rear and lift out the gear and bearings.

To disassemble the mainshaft, slip the sliding gears off the shaft. Align the splines of the front thrust washer with the mainshaft splines and slide the gears, bearings and thrust washers from the front end of the shaft.

To assemble, clamp the mainshaft in a vise with its front end facing upward and install the third speed gear rear thrust washer. Place the third speed gear on the shaft and insert the roller bearings, using grease to hold them in position. Install the intermediate thrust washer and the fourth speed gear inner race (fifth speed inner race on overdrive units), engaging the pin with a mainshaft spline.

NOTE—On underdrive units, install the fourth speed gear and roller bearings in the same manner as the third speed gear. On overdrive units, before installing the fifth speed gear and bushing, make sure all the oil holes are clear and the bushing lubricated.

Place the front thrust washer in position and install a new snap ring. Lubricate the mainshaft splines and slip the sliding gears on the shaft, with the larger gear at the rear and with the shift fork channels facing each other. Install the sliding clutch gear on the front end of the mainshaft.

ASSEMBLE

Reverse Idler: Assemble the bearing spacer and bearings in the gear and place the assembly in the case with the smaller gear toward the rear. Tap the idler shaft in through the rear and engage the slot in the locking plate and bolt it securely.

Countershaft: With the exception of the low and reverse gear, the gears may be replaced, and when installed, be sure the four keys are a tight fit and stake them in place with a prick-punch. Assemble the countershaft front bearing and its retainer and lock it with a new snap ring. Place the countershaft assembly in position and install the rear bearing, fastening it securely with the two retaining cap screws. Replace the bearing retainer cap and gasket.

Mainshaft: Assemble the mainshaft and gears in position and install the rear bearing. Replace the speedometer drive gear and rear bearing retainer.

Main Drive Gear: Lubricate the mainshaft front pilot bearing and place it in the pocket of the main drive gear. Install the main drive gear through the front and replace the retainer, fastening it securely to the case.

NOTE—Complete the assembly by replacing the universal flange and brake drum, fastening the nut securely to the end of the mainshaft. Install the hand brake band and connect the linkage, after replacing the cover.

Shifter Mechanism: To disassemble, drive the expansion plugs out of the front end of the cover. With all the rails in the neutral position, remove the shift fork and lug lock screws and drive the rails out toward the front.

CAUTION—Hold a hand over the lock ball holes to prevent the balls and springs from flying out as the rails are removed. As soon as each rail is taken out, it should be tagged so that assembly may be made correctly.

Drive the expansion plug from the side of the cover and tip the cover up on edge to allow the interlock plunger balls, springs and pin to drop out. Disassemble the reverse shifter lug plunger.

NOTE—Assemble the cover in the reverse order, lubricating all balls and springs before replacing. Be sure to insert the interlock balls, springs and interlock pin correctly in the center rail. See that the points of all lock screws engage the holes in the rails before wiring the screws in place. To prevent the loss of lubricant, always install new expansion plugs. Check the reverse shifter lug plunger for freedom of operation, and when assembled, turn the adjusting nut so that the plunger is flush with the face of the slot to line up with the end of the shift lever.

MODELS 270V, 270VO, 272V, 272VO, 326V, 326VO

Five Speeds Forward and One Reverse with Direct on Fifth for 270V, 272V and 326V and Direct on Fourth with Overdrive on Fifth for Models 270VO, 272VO and 326VO. Also used with Two Reverse Speeds.

NOTE—The following instructions also apply to White models 50B, 51B, 58B, 59B 551B.

Disassemble: Take off the transmission cover and shifter assembly. Lock the transmission in two gears to prevent the mainshaft from turning and unscrew the universal flange nut. Use a puller if necessary to remove the flange. Remove the bell housing and main drive gear bearing retainer. Withdraw the drive gear assembly out through the front.

Slip the sliding clutch gear and mainshaft front pilot bearing from the shaft and out through the front of the case. Remove the speedometer driven gear and rear bearing retainer. Push the mainshaft far enough to the rear to permit the speedometer drive gear and rear bearing to be pulled off the shaft. Tilt the front end of the shaft upward and lift it out through the top.

Take off the countershaft rear bearing retainer cap and unscrew the nut from the end of the shaft. Push the countershaft far enough to the rear to permit the rear bearing to be removed. Remove the lock and withdraw the reverse idler shaft through the rear.

NOTE—If the countershaft front bearing is to be removed, release the snap ring from the groove and push the bearing and expansion plug out through the front.

To disassemble the mainshaft, slip the sliding gears from the shaft. Remove the snap ring from in front of the fourth speed gear (fifth gear on overdrive units). Rotate the front thrust washer until its teeth align with the mainshaft splines and slide the gears, bearings and thrust washers from the shaft.

To assemble, clamp the mainshaft in a vise with its front end facing upward and install the third speed gear rear thrust washer. Place the third speed gear on the shaft and insert the roller bearings, using grease to hold them in position. Install the intermediate thrust washer and the fourth speed gear inner race (fifth gear inner race on overdrive units), engaging the pin with the mainshaft spline.

NOTE—On underdrive units, install the fourth speed gear and roller bearings in the same manner as the third speed gear, using grease to hold the rollers in place. On overdrive units, before installing the fifth speed gear and bushing, make sure the oil holes are clear and the bushing lubricated.

Place the front thrust washer in position and lock the assembly in place with a new snap ring. Lubricate the mainshaft splines and slip the sliding gears on the shaft, with the larger gear to the rear and with the shift fork channels facing each other. Install the sliding clutch gear on the front of the shaft.

ASSEMBLE

Reverse Idler: Assemble the bearing spacer and bearings in the gear and place the assembly in the case with the smaller gear toward the rear. Push the reverse idler shaft in through the rear and engage the slot in the locking plate and bolt it securely.

Countershaft: The countershaft gears, including the power take-off gear, but not the low speed gear can be replaced by pressing them from the shaft, and when installed, be sure that the five keys are a tight fit and stake them in place with a prick-punch. Assemble the front countershaft bearing in the case, install the expansion plug and use a new snap ring to lock it in place. Place the countershaft assembly in position and install the rear bearing, fastening it securely with the lock nut. Replace the rear bearing retainer cap and gasket.

Mainshaft: Assemble the mainshaft and gears in position and install the rear bearing, using a new snap ring. Replace the speedometer drive gear and rear bearing retainer cap.

Main Drive Gear: Lubricate the mainshaft pilot bearing and place it in the pocket of the main drive gear. Install the drive gear assembly through the front, using a new snap ring to lock the bearing in place, then fasten the front bearing retainer cap securely to the case.

NOTE—Complete the assembly by replacing the universal flange, fastening the retaining nut securely to the end of the mainshaft. Install the bell housing, speedometer driven gear and transmission cover assembly.

Shifter Mechanism: To disassemble, drive the expansion plugs out of the front end of the cover. With all the rails in the neutral position, remove the shift fork and lug lock screws and drive the rails out toward the front.

CAUTION—Hold a hand over the lock ball holes to prevent the balls and springs from flying out as the rails are removed. As soon as each rail is taken out, it should be tagged so that assembly may be made correctly.

Drive the expansion plug from the side of the cover and tip the cover up on edge to allow the interlock plunger balls, springs and pin to drop out. Disassemble the reverse shifter lug plunger.

Assemble the cover in the reverse order, lubricating all balls and springs before replacing. Be sure to replace the interlock balls, springs and pin correctly in the center rail. See that the points of all lock screws engage the holes in the rails before wiring the screws in place. To prevent the loss of lubricant, always install new expansion plugs. Check the reverse shifter lug plunger for freedom of operation, and when assembled, turn the adjusting nut so that the plunger is flush with the face of the slot to line up with the end of the shift lever.

FORD

THREE-SPEED SYNCHROMESH

1932-46

Disassemble: Detach the universal joint from the end of the transmission shaft. Disconnect the mainshaft rear bearing retainer and rear engine mounting assembly. Remove the transmission cover. Unhook the spring from the clutch throwout bearing and slide the bearing from the main drive gear shaft. Unscrew the bolts which fasten the main drive gear bearing retainer and slip the retainer from the shaft.

After removing the cotter pin, drive out the pin which retains the countershaft and reverse idler gear shaft in position. Remove the countershaft by driving it out toward the rear. Take out the main drive gear assembly from the front. Push the mainshaft to the rear until the rear bearing is clear of the case. Remove the rear bearing and lift the mainshaft assembly out through the top. Lift out the countershaft assembly. Drive out the reverse idler gear shaft and lift out the gear.

MAINSHAFT, DISASSEMBLE

Before disassembling the mainshaft, mark the relationship of the synchronizer clutch sleeve with the teeth of the blocker rings so that assembly may be made in the same relative position.

CAUTION—When replacing the synchronizer on units using 6 balls and springs, the side of the sleeve having the straight portion at the end of its taper should face toward the front. Sleeves having only one tapered side should be installed with the taper toward the front.

NOTE—The following parts apply to units using the six-ball type synchronizer. Slide the low and reverse gear from the mainshaft. Remove the synchronizer, being careful not to allow the unit to come apart during the process, otherwise the balls and springs may be lost. Take off the thrust washer from the front of the second speed gear. Insert a pointed tool through the holes in the second speed gear and depress the spring plunger. With the plunger depressed, push the locking key forward until it is clear of the rear thrust washer. Slide the gear and washers from the shaft.

NOTE—The following applies to synchronizers using the 3-balls and also to those which employ a spring retainer. Slide the low and reverse gear from the mainshaft. After taking off the spacer, remove the snap ring which retains the synchronizer in place. Slide the synchronizer unit from the shaft. The second gear and its thrust washers may now be removed.

SYNCHRONIZER

Six-Ball Retainer Type: Before disassembling, mark the relationship of the clutch gear with the sleeve so that assembly may be made in the same relative position.

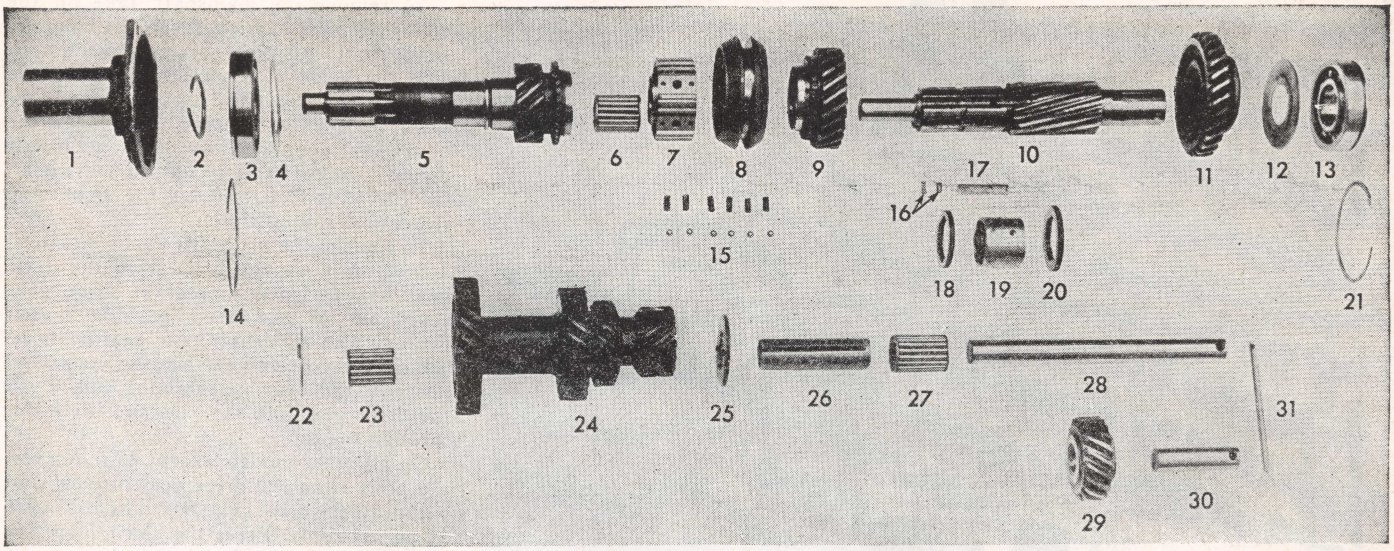
To disassemble, wrap a cloth around the assembly to avoid losing the balls and springs, then push the gear out of the sleeve.

NOTE—To assemble the unit, apply a liberal quantity of grease to the holes in the clutch gear and also to the balls and springs. Place the balls and springs in a position in the clutch gear and, using a clamp—similar to a piston ring compressor—compress the assembly enough to enable the sleeve to be installed.

CAUTION—When replacing the synchronizer assembly on the mainshaft, be sure that the hub portion of the gear and the side of the sleeve having the straight portion at the end of its taper are toward the front.

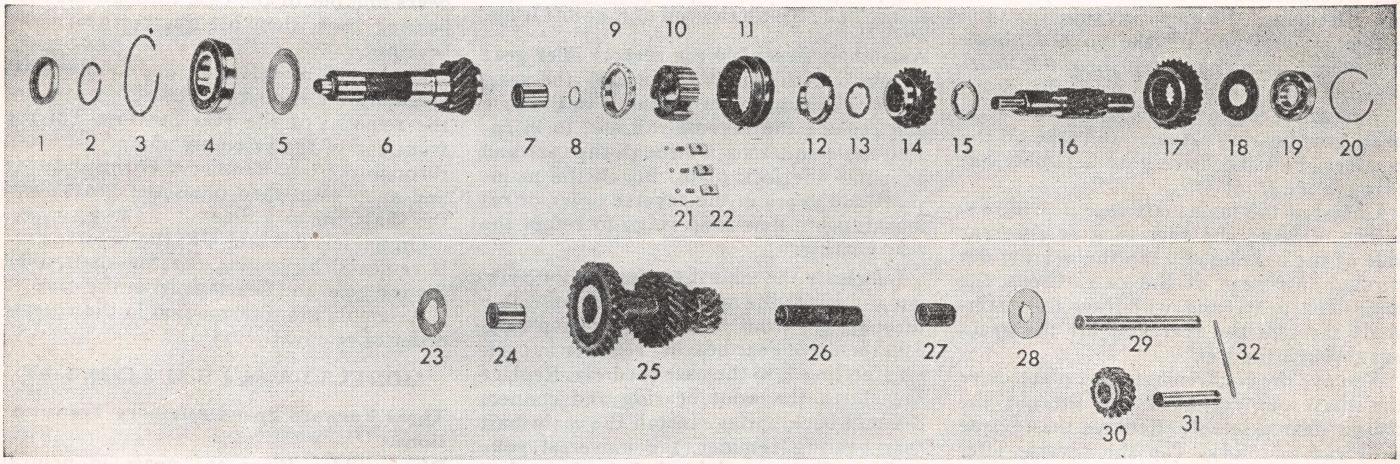
Three-Ball Retainer Type: Before disassembling, be sure that the relationship of the synchronizer rings and the clutch sleeve is marked so that installation may be made in the original position.

To disassemble, wrap a cloth around the unit to avoid losing the balls, springs and shifting plates, then push the gear out of the sleeve.



FORD. 1932-38 and Partial 1939, Three Speed.

1—Drive gear bearing retainer. 2—Lock ring. 3—Drive gear bearing. 4—Snap ring. 5—Main drive gear. 6—Mainshaft pilot bearing. 7—Synchronizer clutch gear. 8—Clutch sleeve. 9—Second speed gear. 10—Mainshaft. 11—Mainshaft low gear. 12—Oil baffle. 13—Mainshaft rear bearing. 14—Snap ring. 15—Synchronizer balls and springs. 16—Mainshaft second gear thrust washer plunger and spring. 17—Second gear thrust washer plunger key. 18—Second gear front thrust washer. 19—Second gear sleeve. 20—Second gear rear thrust washer. 21—Rear bearing snap ring. 22—Countershaft front thrust washer. 23—Countershaft front bearing. 24—Cluster gear. 25—Rear thrust washer. 26—Bearing spacer. 27—Rear bearing. 28—Countershaft. 29—Reverse idler gear. 30—Reverse idler shaft. 31—Countershaft and idler shaft retainer pin.



FORD. 1939-46, Three Speed.

1—Main drive gear oil seal. 2—Lock ring. 3—Snap ring. 4—Drive gear bearing. 5—Oil baffle. 6—Main drive gear. 7—Mainshaft pilot bearing. 8—Pilot bearing snap ring. 9—Front synchronizer clutch ring. 10—Synchronizer clutch gear. 11—Synchronizer clutch sleeve. 12—Rear Synchronizer ring. 13—Second gear front thrust washer. 14—Second gear. 15—Second gear thrust washer. 16—Mainshaft. 17—Low gear. 18—Oil baffle. 19—Rear bearing. 20—Bearing snap ring. 21—Synchronizer ball and springs. 22—Synchronizer shifting plates. 23—Countershaft front thrust washer. 24—Front bearing. 25—Cluster gear. 26—Bearing spacer. 27—Rear bearing. 28—Rear thrust washer. 29—Countershaft. 30—Reverse idler gear. 31—Reverse idler shaft. 32—Countershaft and reverse idler shaft retainer pin.

NOTE—To assemble the unit, apply a liberal quantity of grease to the holes in the clutch gear and also, to the balls and springs. Place the shifting plates in position and use a clamp to compress the assembly sufficiently to enable the sleeve to be installed.

Spring Retainer Type: Push the gear out of the sleeve and take out the spring and shifting plates. To assemble, position the shifting plates in the cut-outs of the gear and install the spring over the gear and into the grooves of the shifting plates. The assembly may then be installed into the sleeve but be sure that the spring is positioned properly in the groove of the sleeve.

TRANSMISSION, ASSEMBLE

The assembly procedure is the reverse of the disassembly, but attention should be paid to the following remarks.

When assembling the countershaft, the long countershaft bearing should be placed at the rear of the assembly.

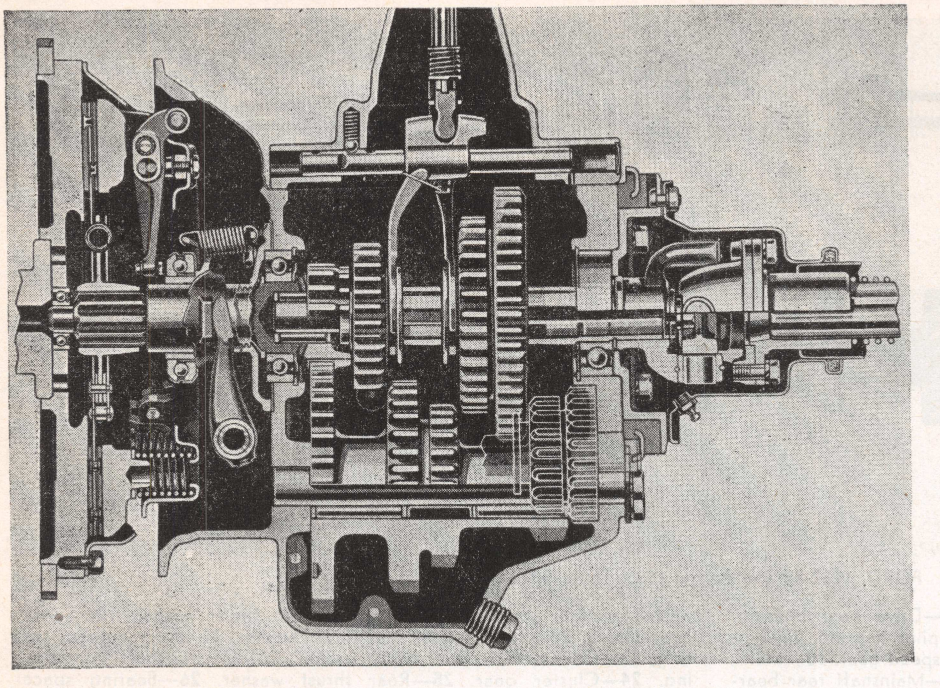
When assembling the mainshaft on units equipped with the 6-ball retainer type synchronizer, make sure that the second speed gear thrust washers are locked to prevent their rotating on the mainshaft. Be sure that the spring plunger engages the locking key. If the second speed gear bushing was removed, make sure that the omitted spline on the mainshaft is directly over the locking key and plunger when replacing the bushing.

To install the mainshaft, slip the assembly into the case from above. Tilt the forward end of the shaft upward, allowing the rear of the shaft to protrude through the rear of the case. Press the rear bearing on the end of the mainshaft and install the snap ring. Then push the assembly into position in the case and replace the rear bearing retainer.

FOUR-SPEED SLIDING GEAR

1932-46

Disassemble: Set the gearshift lever in neutral, remove the cover screws and lift off



FORD. 1936-46 Four-speed Transmission with Clutch and Universal Joint.

the transmission cover and shifter assembly. Disconnect the universal yoke from the mainshaft and pull off the yoke. Unhook the spring from the clutch throwout bearing and slip the bearing from the shaft. Unscrew the bolts which fasten the main drive gear bearing retainer and take off the retainer. Pull the drive gear assembly out through the front.

Unfasten the mainshaft rear bearing retainer. Expand the snap ring at the rear side of the bearing and tap the bearing out through the rear of the case. Grasp the mainshaft gears and withdraw the mainshaft through the rear and lift the gears out through the top.

Remove the countershaft lock plate, drive the shaft out rearward and lift out the cluster gear assembly. Remove the reverse shift rail and fork. Tap the reverse idler shaft out rearward and lift out the gear.

To disassemble the cover, place the rails in the neutral position and remove the shift fork lock screws. Drive the rails out through the rear, forcing the expansion plugs out at the same time.

CAUTION—Hold a hand over the lock ball holes to prevent the balls and springs from flying out as the rails are removed; as soon as each rail is taken out, it should be tagged to assure correct assembly.

Drive the expansion plug from the side of the cover and tip the cover up on edge to allow the interlock plungers to drop out. Disassemble the reverse shifter plunger.

Assemble the cover in the reverse order, lubricating all balls and springs before replacing. Be sure to replace the interlock plungers correctly in the center rail. See that the points of all lock screws are engaged in the rail holes before wiring the screws in place. Check the reverse shifter plunger for freedom of operation, and when assembled, turn the adjusting nut so that the plunger is flush with the face of the slot to line up with the end of the shift lever.

Assemble: Assemble the reverse idler gear by pushing the shaft in through the rear. Place the countergear assembly in the case and replace the reverse rail and fork. Install the countershaft through the rear and assemble the lock plate. Install the mainshaft and gears in the reverse order of removal, using new snap rings to retain the rear bearing.

Lubricate the mainshaft front pilot bearing and insert the main drive gear assembly through the front, using a new snap ring. Slip the drive gear bearing retainer in position, bolting it to the case securely. Replace the clutch throwout bearing and connect the pull-back spring. Install the mainshaft rear bearing retainer, the universal yoke and install the retaining bolt in the end of the mainshaft. Place the gears in neutral and assemble the transmission cover assembly.

FULLER

MODELS AR, UR, AR-163, UR-163, 2-A-53, 2-B-53, 2-A-62, 2-B-62, 2-A-86, 2-B-86

With the Exception of Models AR and UR, these Units are Two Forward Speed Auxiliary Transmissions. Models AR and UR are Reversing Transmissions and can be Converted into Auxiliary Units by Exchanging Gears.

Disassemble: Shift the transmission into neutral and take off the cover. On all models except 86's, remove the shifting yoke lock screw and pull out the yoke bar. On the 86's, unscrew the bolt from the inside of the short shift lever, move this lever aside and take out the key, then remove the shift shaft.

To remove the mainshaft, take off the mainshaft rear bearing cover, the countershaft front and rear bearing covers, then lock the gears and unscrew the countershaft bearing retaining nut. Jerk the mainshaft sharply to the rear to dislodge the pilot bearing, withdraw the mainshaft through the rear and lift out the loose gear. On the 86 models, remove the snap ring, sleeve and sliding clutch.

To remove the main drive gear on model 2-B-62, unscrew the bolts from the drive gear bearing cover, force the drive gear shaft out of the gear, pushing it out through the mainshaft rear bearing bore. Take off the drive gear bearing cover and unscrew the bearing retaining nut. Push the drive gear into the case and lift it out through the top.

On all other models except 86's, unscrew the bolts from the drive gear bearing and withdraw the drive gear, bearings and cover as an assembly. Press the shaft from the gear, unscrew the bearing lock nut and separate the gear and bearing.

On the 86's, force the drive gear out of the cover and bearings, pushing it into the case, then take out the cover, bearings and spacer.

To remove the countershaft on all models except the 86's, force the shaft through the gears and out of the case through the rear bearing bore, then lift out the gears and bearings.

On the 86 models, pull the countershaft assembly far enough to the rear to permit the removal of the rear bearing. Tilt the front end of the assembly up and lift it out through the top. Remove the front bearing and snap ring, then press the gears from the shaft one at a time.

On models AR and UR, the reverse gear is removed by pulling out the shaft, then lift the gear and bearings from the case.

Assemble the transmission in the reverse order of removal.

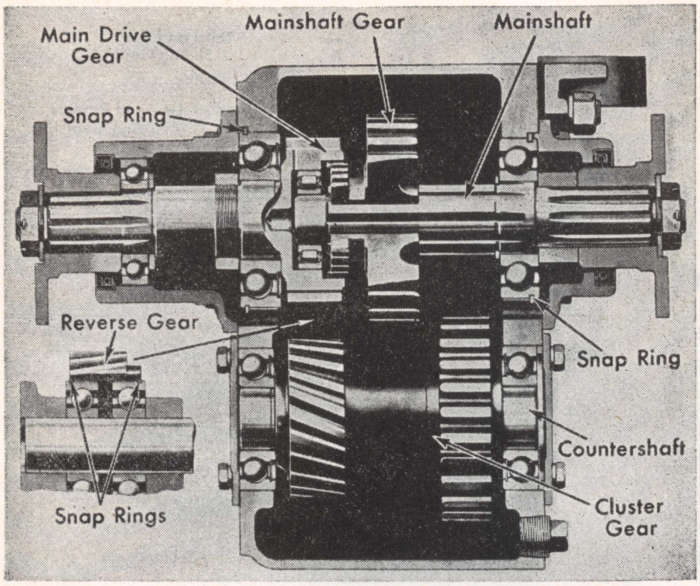
MODELS 3-A-86, 3-B-86, 3-C-86, 3-AY

Three Forward Speed Auxiliary Transmissions.

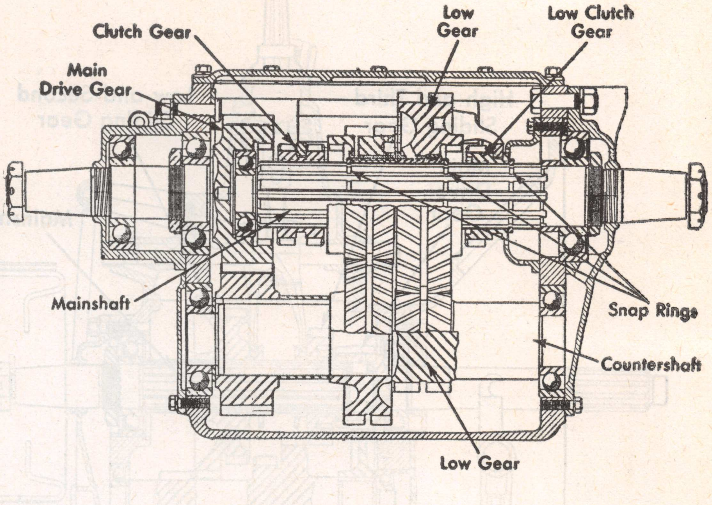
Disassemble: Place the gears in neutral and take off the transmission cover. Remove the shift rail tension spring cover and the screws from the shift yokes. Pull out the shift rails—upper one first—and lift the yokes from the case. Care must be exercised when removing the rails to see that none of the small rail parts are lost.

Lock the transmission in two gears to prevent the mainshaft from turning and remove the nuts from the front and rear ends of the mainshaft, then pull off both companion flanges. Take off the mainshaft rear bearing retainer cap and also the front and rear countershaft bearing retainer caps. With the transmission locked in two gears, remove the nut from the front end of the countershaft (except 3-AY). Take out the mainshaft rear bearings and jerk the mainshaft toward the rear to release the pilot bearing. With the pilot bearing loose, unmesh the herringbone gears, pull the mainshaft to the rear, tilt the front end up and lift out of the case.

Tap the main drive gear through the re-



FULLER. Models AR Reversing Unit, AR-163 Two-Speed Auxiliary.



FULLER. Model 3-AY, Three-Speed Auxiliary. Others Similar.

tainer and bearings and lift the drive gear out through the inside of the case. Take off the drive gear retainer, bearings and bearing spacer. Push the countershaft far enough to the rear to remove the rear bearing. Tilt the front end of the assembly upward and lift it out through the top. If required, the front bearing may be removed from the case after removing the snap ring (if equipped).

NOTE—The mainshaft may be disassembled by removing the sliding clutch gear, after which, the gears may be removed by releasing the snap rings. If necessary, press the countershaft gears from the shaft one at a time, and when installed, be sure the keys are a tight fit and stake them in place with a prick-punch.

Assemble: Assemble the countershaft front bearing in the case. Place the countershaft assembly in the case, push it to the rear and install the rear bearing. Assemble the main drive gear bearing retainer, being sure the spacer is installed between the two bearings and that the oil seal is in good condition. Insert the main drive gear through the inside of the case, pushing it through until the shoulder of the gear is against the rear bearing. Lubricate the mainshaft pilot bearing and insert it in the recess of the main drive gear.

Assemble the mainshaft through the top and work the assembly to the rear until the front end of the shaft can be inserted into the pilot bearing, then replace the rear bearing. Assemble the mainshaft rear bearing and countershaft rear bearing retainer caps and replace both companion flanges. Lock the transmission in two gears and install the nuts on each end of the mainshaft and on the front end of the countershaft (on 86's). Replace the countershaft front bearing retainer. Complete the assembly by installing the shift mechanism in the reverse order of removal and replace the transmission cover.

MODELS H, HU, HOG, HUOG, MG, MGOG, MGU, MH, MHU, MHOG, MHUOG, MKU, MLU, MR, MRU, WO

Four Speeds Forward and One Reverse Sliding Gear Transmissions.

Disassemble: Set the transmission in second gear, remove the cover attaching screws and lift off the cover and shifter assembly. If the shift rails are supported in the cover at both ends, remove the oil retaining thimbles from one end, set the rails in neutral, loosen the yoke set screws and drive out the shift rails.

NOTE—As the rails are being removed, hold a hand over the lock ball holes to prevent the balls and springs from flying out. Lay all the parts on the bench in their proper sequence to assure correct assembly and to avoid the possibility of omitting some of the small locking parts.

Lock the transmission in two gears to prevent the mainshaft from turning, and unscrew the universal flange nut, then pull off the flange and mainshaft rear bearing retainer. Grasp the sliding gears and withdraw the mainshaft through the rear, then lift the sliding gears out through the top.

Remove the main drive gear bearing retainer and withdraw the drive gear out through the front on some models. On other models where the drive gear is larger than the drive gear bearing bore, push the gear into the case and lift it out through the top.

To remove the countershaft on all models except WO, unfasten the countershaft rear bearing cover, push the countershaft far enough to the rear to permit the removal of the rear bearing and lift the gear assembly out through the top by its front end. On the WO model, pull the countershaft out through the rear of the case and lift out the cluster gear.

On all models, pull the reverse idler shaft out through the rear of the case and lift out the gear.

Assemble: Install the reverse idler gear by pushing the shaft in through the rear. Assemble the countershaft assembly in the case, replace the countershaft bearings and install the bearing covers.

NOTE—When assembling the countershaft bearing covers, be sure the countershaft moves freely and the shaft has about .010" end play when the covers are assembled.

Install the main drive gear in the reverse order of removal and fasten the drive gear bearing retainer. Lubricate the mainshaft front pilot bearing and place it in the drive gear pocket. Install a new snap ring in the mainshaft rear bearing bore groove (if equipped). Hold the gears in the case and pass the mainshaft through the gears and out through the rear bearing bore, then forward to its normal position in the pilot bearing. Assemble the rear bearing, speedometer drive gear and rear bearing retainer. Replace the universal flange, lock the mainshaft and run the flange nut up tight.

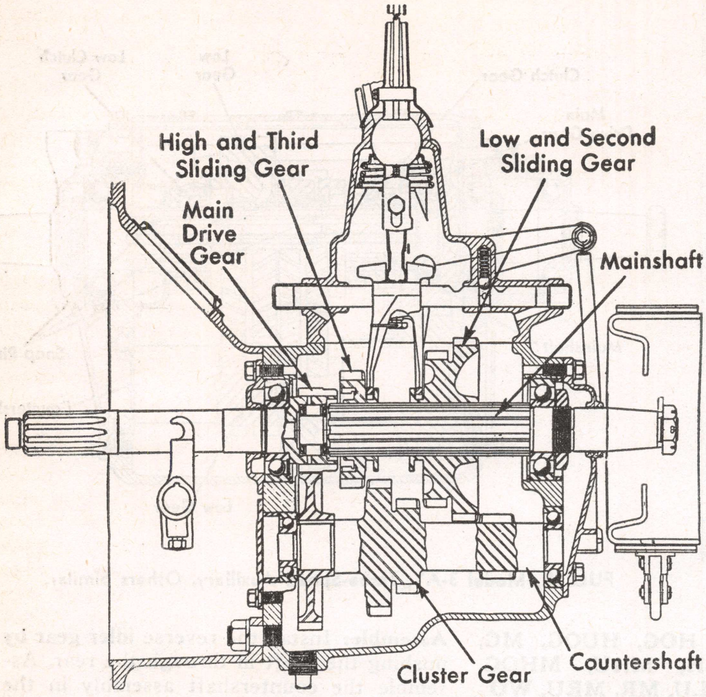
If the cover has been disassembled, assemble in the reverse order, lubricating the balls and springs before replacing. Be sure the shift fork lock screws engage the holes in the shift rails before wiring them in place. Place the transmission gears and cover in second gear position and replace the cover assembly.

MODELS 4-A-86, 4-B-86, 4-AM-86, 4-BM-86, 4-A-860, 4-B-860, 4-AM-860, 4-BM-860.

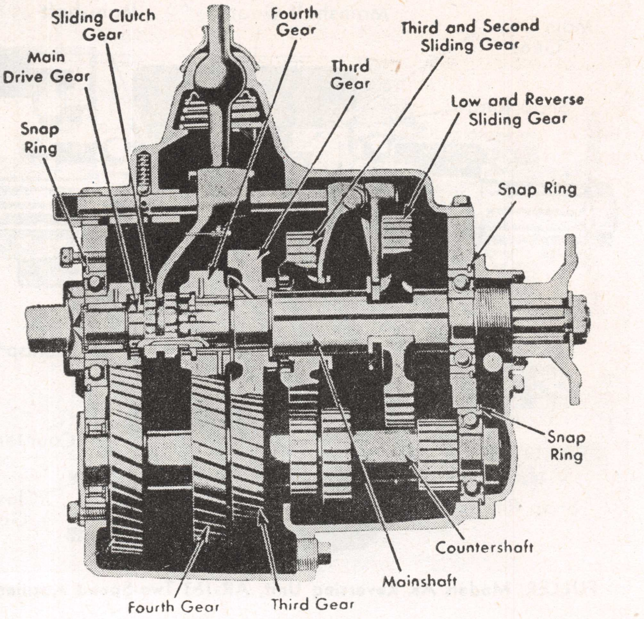
Four Speeds Forward and One Reverse with Direct on Fourth for 86 Models and Direct on Third for 860 Models with Overdrive on Fourth. Except for Low and Reverse, the Gears are Helical Cut. AM and BM Units are Amidship Models.

Disassemble: Shift the transmission into first speed and remove the hand brake lever assembly. Remove the cover screws and lift off the control assembly, guiding the reverse shifting yoke into and up through the yoke slot in the first speed sliding gear.

If the cover is to be disassembled, shift the control into neutral and remove the



FULLER. Model MHU, Four Speed.



FULLER. Typical Five-Speed Transmission.

shift yoke screws. Take off the tension spring cover, tension springs and balls. Starting with an outside shift rail, drive the rails out through the front.

NOTE—If an outside rail will not move readily, a slight hand adjustment of the rails to the neutral position will permit the rail to be removed. And as the parts are removed, lay them on the bench in the proper assembly sequence to assure correct assembly and to avoid the possibility of omitting some of the small locking parts.

To remove the mainshaft, take off the mainshaft and countersahft rear bearing covers, lock the gears and unscrew the countershaft rear bearing retaining nut. Pull the mainshaft to the rear and take off the rear bearing. Tilt the front end of the mainshaft upward and lift out through the top, allowing the sliding gear to remain in the case until the mainshaft is removed.

To disassemble the mainshaft, remove the pilot bearing and sliding clutch, then take out the mainshaft gear retaining washer key. Rotate the retaining washer until its inside lugs line up with the grooves in the mainshaft. The mainshaft may then be stripped by using the rear bushed gear to start the sleeve in order to remove the gears, sleeve and washers.

To remove the main drive gear on 4-A-86 and 4-B-86 models, remove the clutch release mechanism and the drive gear bearing cover, then pull the gear out through the front.

On the 4-A-860 and 4-B-860 models, after removing the clutch release mechanism and the drive gear bearing cover, force the drive gear forward until the bearing snap ring is exposed, then remove the snap ring and withdraw the drive gear from the inside of the case.

On Amidship models with direct on fourth gear, remove the nuts and washers from the drive gear bearing housing studs and withdraw the drive gear, bearings and housing as an assembly. The gear may then be pressed from the housing. On Amidship models with overdrive, since the main drive gear is larger than the bearing bore, it must be removed from the inside of the case after pushing it through the housing and bearings.

To remove the reverse gearing on all models, remove the shaft lock, withdraw the shaft and lift both sections of the reverse gearing from the case, using a strap inserted under and between the two sections.

To remove the countershaft, pull the assembly far enough to the rear to permit the removal of the rear bearing, tilt the assembly upward and lift it out by its front end. If the gears are to be removed, take off the front bearing, remove the gear retaining snap ring, then press the gears from the shaft one at a time.

Assemble: Install the countershaft front bearing, locking it in place with its retainer. Place the assembly in the case and install the rear bearing and retaining nut. Assemble the reverse gear shaft through the gear, suspending the gear in the case and pushing the shaft in through the rear.

Install the main drive gear in the case in the reverse order of removal, locking it in place by installing the retaining nut. Pass the mainshaft assembly through the sliding gear and through the rear bearing bore, then forward again to its normal position in the mainshaft pilot bearing. Replace the mainshaft and countershaft bearing covers, and complete the assembly by installing the universal flange, hand brake mechanism and the transmission cover assembly.

MODELS 5-A-29, 5-A-290, 5-B-29, 5-B-290, 5-C-29, 5-C-290, 5-A-33, 5-A-330, 5-B-33, 5-B-330, 5-F-33, 5-F-330, 5-G-33, 5-G-330, 5-M-33, 5-M-330, 5-A-38, 5-A-380, 5-A-43, 5-A-430, 5-F-43, 5-F-430, 5-M-43, 5-M-430, 5-A-53, 5-A-530, 5-A-62, 5-A-620, 5-F-62, 5-F-620, 5-M-62, 5-M-620.

Five Speeds Forward and One (or Two) Reverse with Direct on Fifth for Models without the 0 Suffix. Models Having the 0 Suffix, Direct is on Fourth with Overdrive on Fifth. Models having the Letter M following the 5 are Amidship Models.

NOTE—The following instructions also apply to the White models 20B, 36B, 37B.

Disassemble: Shift the transmission into first speed, disconnect the hand brake lever, remove the cover screws and lift off the transmission cover and shifter assembly. Remove the universal flange nut and pull off the flange. Take off the mainshaft and countershaft rear bearing covers, lock the gears and unscrew the countershaft rear bearing nut. Push both the mainshaft and countershaft to the rear at the same time until the mainshaft rear bearing is clear of the case and pull off the bearing. Tilt the front end of the mainshaft upward, grasp the sliding gears and pull the mainshaft with the stationary gears out through the top, then lift out the sliding gears.

To remove the main drive gear, take off the clutch release mechanism (except Amidship models). On all models, pull off the drive gear bearing cover, and also on Amidship models, the bearing retaining screws and washers.

NOTE—On most models, the drive gear is removed by withdrawing it through the front of the case. However, on some units the drive gear is larger than the bearing bore in the case, in which case, push the drive gear into the case and lift it out from the inside, after first removing the bearing lock nut.

If equipped with two reverse speeds, take out the high speed reverse shift rail and yoke. Then on all units, withdraw the reverse gear shaft (or shafts) and remove the reverse gear (or gears). Push the countershaft far enough to the rear to permit the removal of the rear bearing, then tilt the front end of the assembly upward and lift it out.

To disassemble the mainshaft, remove the pilot bearing and clutch gear. Take out the locking key or snap ring which retains the splined retaining washer. Rotate the washer until its internal teeth align with the mainshaft splines and slide the washer, gears, sleeve and thrust washers from the shaft.

To assemble, clamp the mainshaft in a vise with its front end up and install the third speed gear rear thrust washer. Then replace the third gear and bushing, and the intermediate thrust washer against the third gear. Assemble the fourth speed gear and sleeve (fifth gear on overdrive models) and the splined washer, locking the assembly in position with the locking key or snap ring. Slip on the sliding clutch gear and front pilot bearing, being sure to lubricate the bearing.

Assemble: Install the countershaft front bearing, locking it in place with the retainer. If required, the countershaft helical gears may be replaced by pressing them off one at a time, and when installed, be sure the keys are a tight fit. Place the countershaft assembly in the case but do not install the rear bearing until after the mainshaft is in place. Assemble the reverse gear shaft (or shafts) through the gear (or gears) through the rear of the case. For units having two reverse speeds, install the high speed reverse shift rail and yoke.

Assemble the main drive gear in the reverse order of removal. Insert the mainshaft partly into the case and slip on the sliding gears, placing the larger gear to the rear and with the shift fork channels facing each other. Push both the mainshaft and countershaft assemblies to the rear at the same time and replace the mainshaft and countershaft rear bearings. Push both assemblies forward again to their normal positions and use new snap rings to hold the bearings in place. Replace the lock nut on the end of the countershaft and install the countershaft and mainshaft rear bearing caps. Install the speedometer drive gear and universal flange, running the flange nut up tight. Shift the transmission into first speed and install the cover assembly.

If the cover is to be disassembled, place the shift rails in the neutral position and remove the shift fork lock screws. Hold a hand over the lock ball holes to prevent the balls and springs from flying out as the rails are removed. As the parts are removed, place them on the bench in the proper sequence to assure correct assembly and to avoid the possibility of omitting some of the small locking parts.

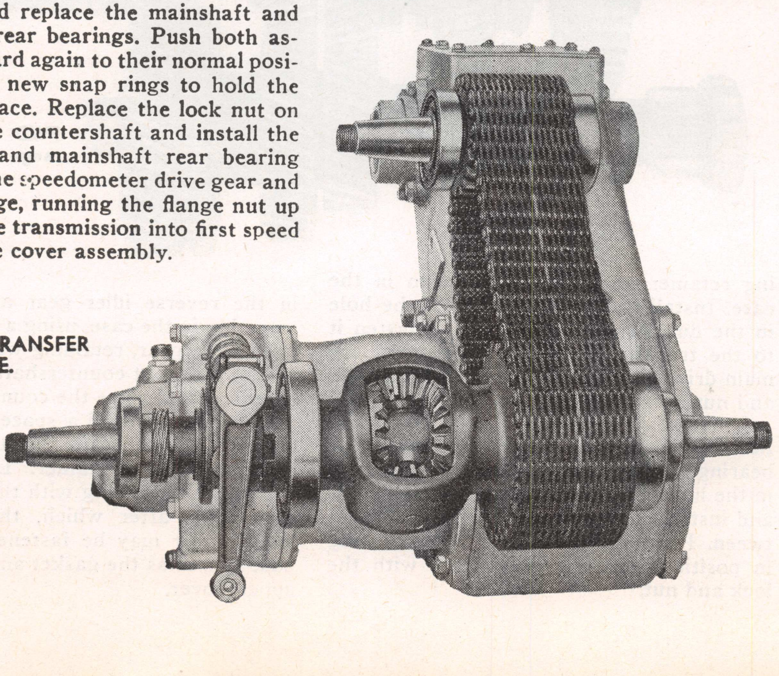
MODELS 8-A-86, 8-A-860, 8-B-86, 8-B-860, 8-C-86, 8-C-860, 8-D-86, 8-D-860, 8-AM-86, 8-AM-860, 8-BM-86, 8-BM-860, 8-CM-86, 8-CM-860, 8-DM-86, 8-DM-860.

These Transmissions are Eight Speed Units Consisting of Two Sections; the Front Section being a Four-Speed Unit Corresponding to those Models Designated as 4-A-86, etc., while the Rear Section is a Two-Speed Auxiliary Unit Corresponding to those Models Designated as 2-A-86, etc. AM, BM, CM and DM Models are Amidship Transmissions. Models having the 0 Suffix are Overdrive Units.

NOTE—To dismantle these transmissions, it is first necessary to disassemble the rear section and detach its case from the front section. When the rear section is dismantled, if work is required on the front section, follow the instructions as given for the four-speed transmissions listed under models 4-A-86, etc.

Disassemble: Disconnect the auxiliary shifting rod, remove the cover screws and lift off the cover. If the control tower is to be disassembled, remove the lock screw from the shifting yoke, drive the shift yoke rail from the cover, take out the bolt from the inside short shift lever, move this lever to one side, pull out the key and withdraw the shifting shaft.

To remove the mainshaft, take off the mainshaft and countershaft rear bearing covers, lock the gears and unscrew the countershaft rear bearing retaining nut. Jerk the mainshaft sharply to the rear to dislodge the pilot bearing, withdraw the mainshaft through the rear of the case, leaving the pilot bearing and mainshaft gears inside the case. Lift the mainshaft gears out of the case. The mainshaft may then be stripped by taking off the rear bearing, spacer, sleeve and snap ring.



FWD "M". TRANSFER CASE.

To remove the main drive gear, lock the main case gears and unscrew the retaining nut from the end of the mainshaft inside the drive gear pilot bearing bore. Use a puller to remove the drive gear from both the shaft and the bearing.

To remove the countershaft on 8-A-86 and 860, and 8-B-86 and 860, move the countershaft far enough to the rear to permit the rear bearing to be removed, then tilt the front end of the assembly up and lift it out of the case. If required, the drive gear may be pressed from the shaft after removing the front bearing and gear retaining snap ring.

On models 8-C-86 and 860, 8-D-86 and 860, block the rear end of the countershaft, then force the low speed gear and rear bearing backward and remove both halves of the split spacer. Move the drive and low speed gears to the center of the countershaft and take off the rear bearing snap ring and the gear retaining snap ring. Withdraw the countershaft through the gears, then lift the gears out of the case.

To disconnect the rear case from the front case, remove the connecting cap screws, nuts and lockwashers from the inside of the rear case. Take off the rear case and remove the drive gear bearing.

NOTE—At this point, if service on the main case is required, follow the instructions as described under the 4-A-86, etc. The rear section is assembled in the reverse order of disassembly.

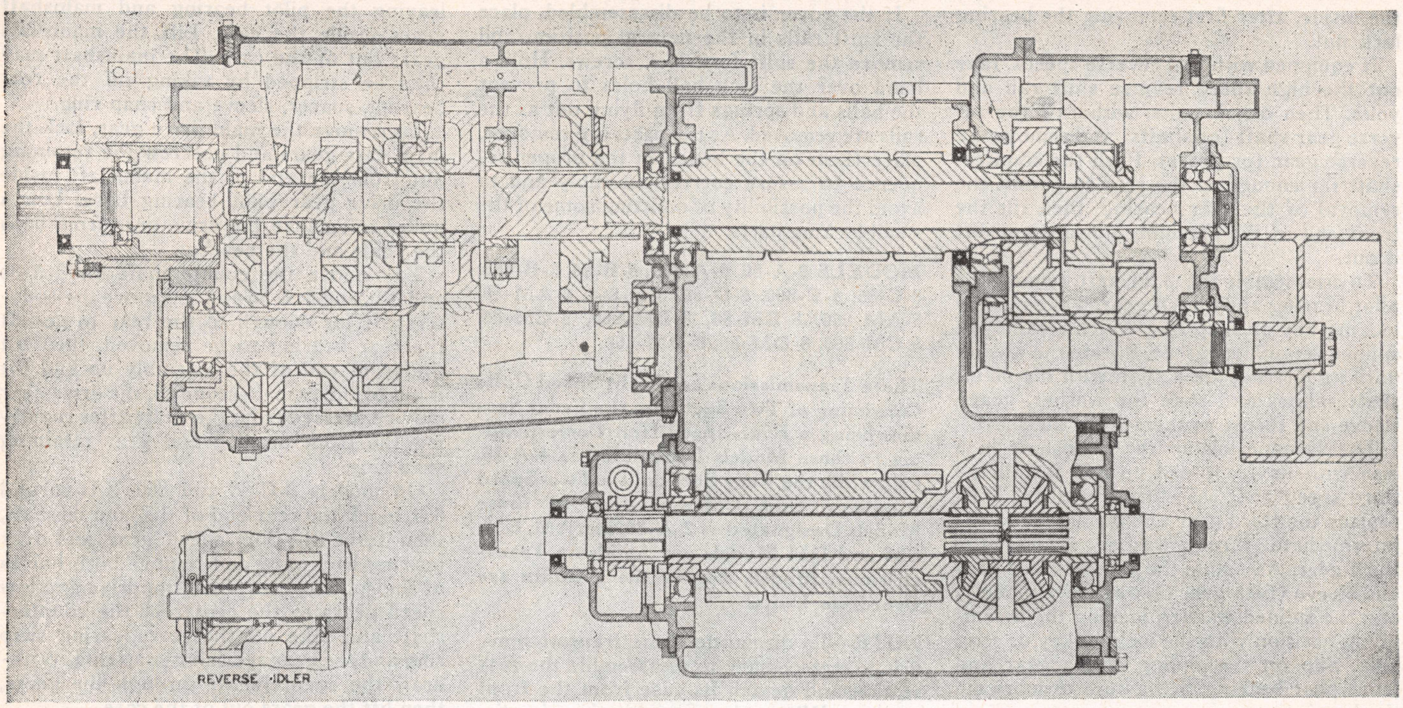
FWD

MODEL "M"

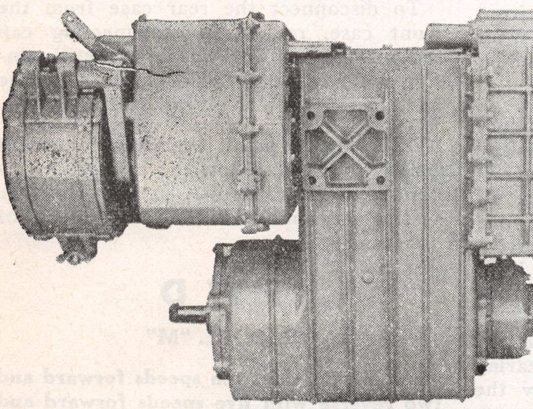
This unit provides ten speeds forward and two reverse with five speeds forward and one reverse in the main case and a two-speed auxiliary having a direct drive in high, with a 2.1 to 1 ratio in low gear.

NOTE—The main transmission, transfer case and the two-speed auxiliary are combined to make a large, compact unit. Due to its large size, the assembly is so designed that it is possible to overhaul the complete unit without removing it from the vehicle. The following instructions are for the assembly of the unit. To disassemble, reverse the order of this procedure.

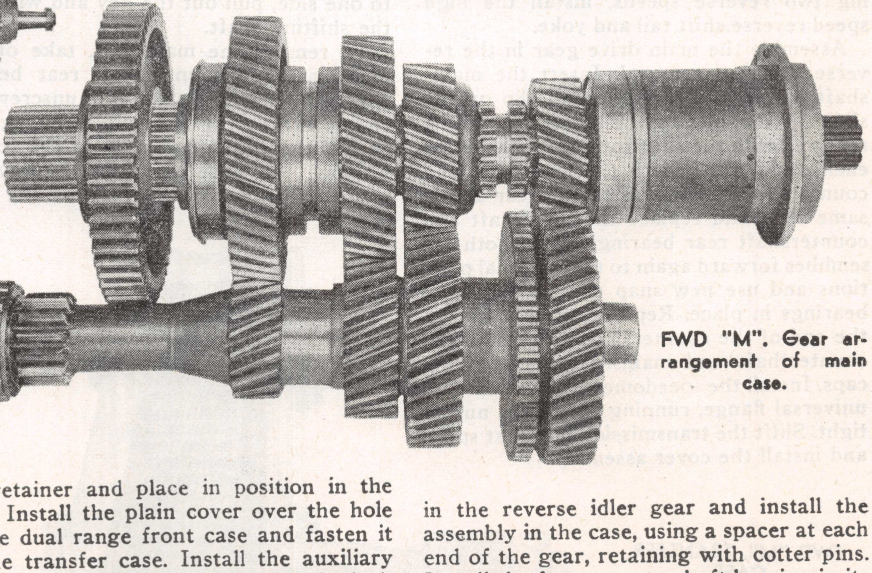
Mainshaft: Press the intermediate bearing on the mainshaft, slide the bearing lock to the end of the spline and lock it in place with the key. Hang the bearing retainer ring on the shaft, slip on the low and reverse gear, being sure it slides freely on the spline. Place the second speed gear on the mainshaft and install the two keys in the keyways. Press the splined clutch sleeve on the shaft, after which, install the second and third speed clutch. Install the third speed gear, being sure the second gear and third gear clutch locks are facing each other so that the clutch can engage either gear. Install the Woodruff key and



FWD "M". Side cross section.



FWD "M". Right side view.



FWD "M". Gear arrangement of main case.

the mainshaft collar, after which, place the fourth speed clutch gear on the mainshaft collar. Finally, after replacing the mainshaft lock and key, install the fourth and fifth speed clutch, checking for freedom of movement on the splines.

Countershaft: Slip the long key in the countershaft and install the third speed gear. Assemble the fourth speed gear with its shoulder toward the front and then the power take-off gear with its shoulder facing the fourth speed gear. Slip in the short key and install the countershaft drive gear with its shoulder facing the power take-off gear. Drive the bearing race into the rear lower bearing container and slide it on the shaft, after which, drive the bearing on the shaft and lock it in place with the washer and screws.

Transfer Case Upper Sprocket: Install the oil seal in the front end of the sprocket and the bearing on the sprocket. Bolt the transmission and transfer cases together, being sure the gasket between these cases is in good condition. Assemble the sprocket in the case, slip the oil seal into the rear bearing retainer and place in position in the case. Install the plain cover over the hole in the dual range front case and fasten it to the transfer case. Install the auxiliary main drive gear and fasten it with the lock and nut.

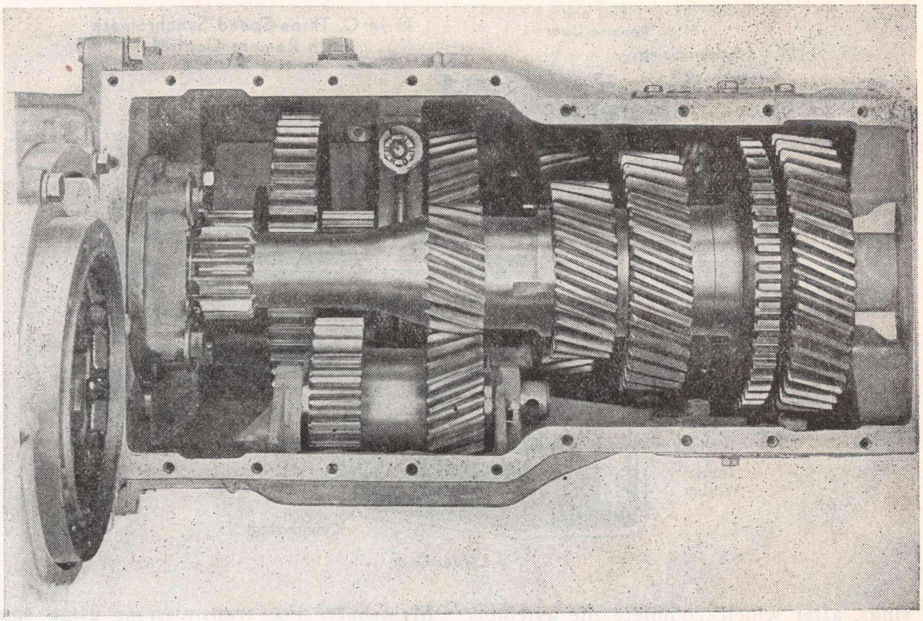
Main Drive Gear: Install the drive gear bearing on the shaft and place the assembly in the housing. Slip the spacer on the shaft and install the cover, using a gasket in between. Place the drive gear front bearing in position, securing it in place with the lock and nut.

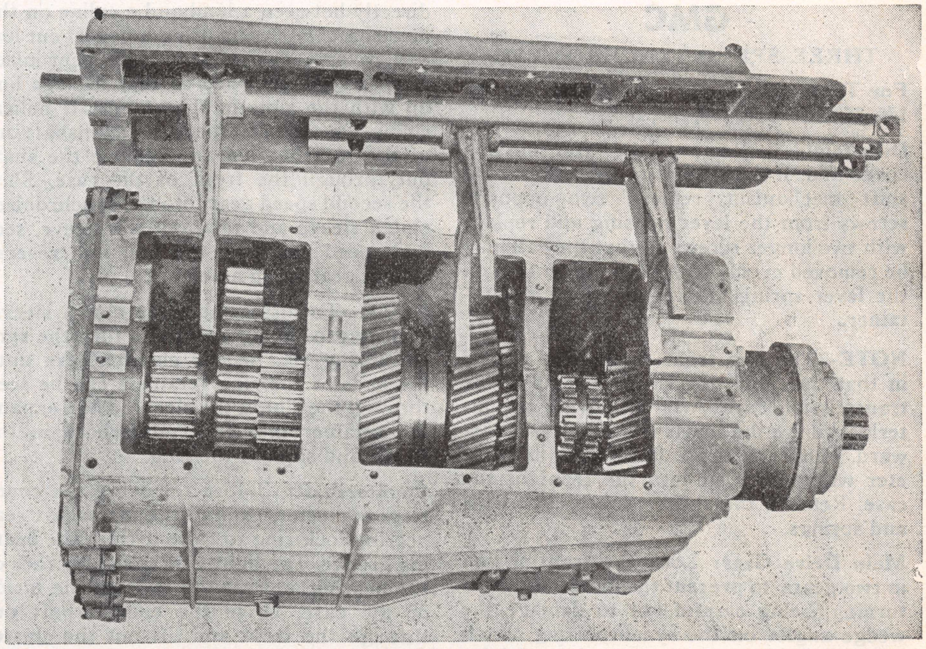
Transmission, Assemble: Assemble the rear bearing and rear bearing bushing and install both in the rear of the transmission. Remove the cap and install the mainshaft assembly in the case, being sure to place the bearing retainer ring in position before replacing the cap. Install the bearing in the main drive gear housing and place the housing in the main case, using a gasket between. Assemble the bearings and spacer in the reverse idler gear and install the assembly in the case, using a spacer at each end of the gear, retaining with cotter pins. Install the front countershaft bearing in its container and place the countershaft in the transmission. Install a spacer on the front end of the shaft, replacing the gasket and front bearing container. Lock the rear countershaft bearing with the washers and capscrews, after which, the gasket and lower cover may be fastened to the gear box, as well as the gasket and transmission upper cover.

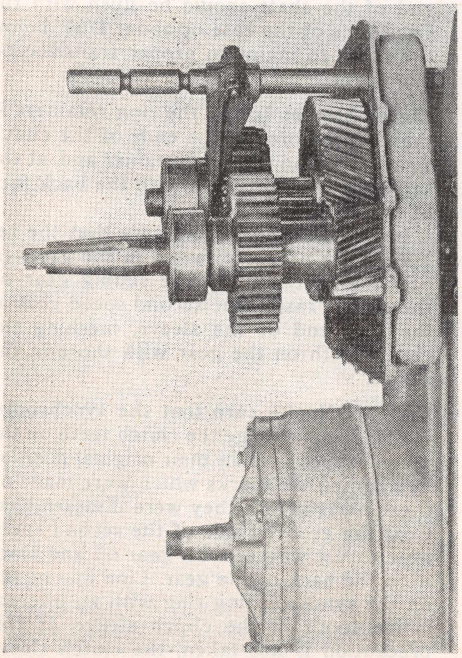
Auxiliary Unit: Install the transfer case mainshaft through the center of the sprocket. Install the drive gear, spacer and low speed gear on the countershaft, with the shoulders of the gears facing the rear. Install the front bearing and place the countershaft assembly in the case. Slip the sliding gear on the mainshaft and replace the rear case with two or three bolts and line-ream the holes for the shifter shaft. Then remove the case and install the shifter rod and fork, after which, bolt the rear case to the front case, using a gasket between the two. Install the countershaft rear spacer and replace the rear bearing, securing it with the lock and nut. Complete the assembly of the auxiliary unit by installing the rear bearing and lock nut; gasket and bearing cover, brake support and oil seal, brake wheel, and brake bands, after which, adjust the bands.

Chain & Transfer Case Parts, Assemble: Slip the key in the differential case shaft and press on the lower sprocket. Place the key in position and press the differential lock sleeve on the case shaft, placing the bearing on the sleeve. Assemble the differential thrust washers and side gears in the differential case, and place the spider gears on the spider, installing these parts in the case, after which, bolt the differential case halves together.

Install the bearing on the differential case. Place the thrust buttons in the end of each shaft, slip the bearing on the short shaft, placing the assembly in the bearing housing. Slip the drive chain over the upper sprocket, install the bushing and pin, riveting the pin securely. Assemble the differential in the chain in the transfer case. Assemble 5 gaskets on the bearing housing and install in the case with the clamp ring, **leaving all the bolts loose.** Place the large ball bearing on the long jackshaft, slip the Woodruff key in the shaft and install the speedometer drive gear, after which, slip the long shaft in the housing. Screw the studs in the fork and install the fork in the housing with the shaft, locking the assembly with the taper pins.


FWD "M". Showing gear arrangement in main case.


FWD "M". Cover forms a split bearing for the shifter rods.

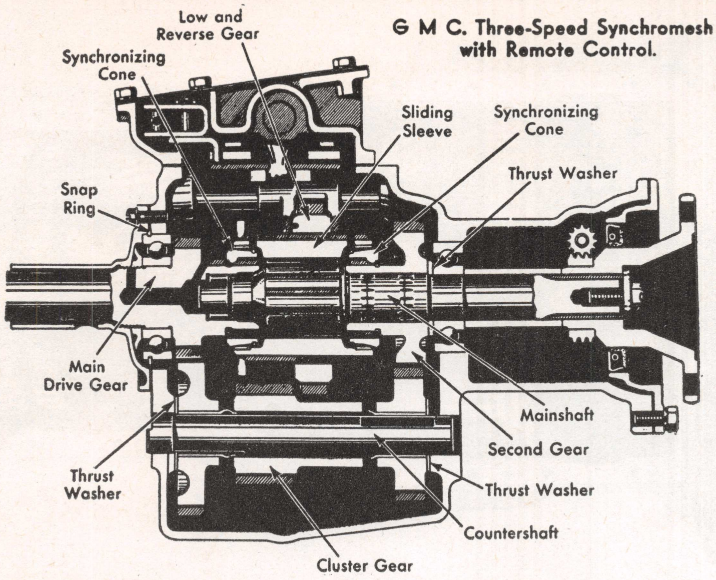

FWD "M". Showing two-speed auxiliary with brake wheel and rear cover removed.

Place the clutch fork blocks on the studs and slide the center differential clutch on the shaft, entering the block in the clutch, being sure they work freely. Place two gaskets on the outer housing and bolt this housing to the front bearing housing. Install the lower front assembly to the transfer case, using five gaskets between the front cover and transfer case, locking in place with the clamp ring, **but leaving the bolts loose.** Install the oil seals on both the front and rear jackshafts.

NOTE—Check the drive chain slack by forcing it toward the outer side of the transfer case. A normal amount of slack is not objectionable but it shouldn't be so great that the chain strikes the side of the transfer case. If there is too much slack in the chain, remove the locking bolts, which were installed loosely on the clamp rings, and turn the bearing housings to a higher number. These covers are eccentric and each number advanced compensates for about ¼" of chain slack.

IMPORTANT—The arrows on both the front and rear covers must always be set on the same numbers.

When the chain is adjusted properly, replace and tighten the bolts in the clamp



G M C. Three-Speed Synchromesh with Remote Control.

rings, after which, complete the assembly by installing the gasket and top cover.

GMC

THREE-SPEED SYNCHROMESH

For Truck Series, 14, 15, 145, 155; AC-100, 150, 250; CC-100, 150, 250, 260.

Disassemble: Remove the transmission cover and, if necessary to disassemble the shift mechanism, remove two opposite screws from the lever housing and replace with two longer screws so that they all may be removed evenly to relieve the tension on the lever spring before taking off the retainer.

NOTE—The two front screws are special in that they lock the shifter shafts in the transmission case. After removing the interlock, drive the shafts from the case rearward. These shafts are .003" larger in diameter where they fit into the front of the case. Remove the shifter yokes, lock balls and springs.

Main Drive Gear: Lock the transmission in two gears, to prevent the mainshaft from turning, being careful not to damage the wedge angles on the synchronizing clutch mechanism. Disconnect the universal joint and slide the joint and spacer from the mainshaft. Remove the main drive gear bearing retainer, but before removing the gear, mark the relationship between the clutch gear and the second speed gear with their rings so that they may be assembled in the same relative position. Using a suitable puller, screw the threaded sleeve of the puller onto the shaft in a counter-clockwise direction and take off the main drive gear and bearing. Remove the needle bearings from the pocket of the main drive gear.

NOTE—To disassemble the main drive gear, take off the retaining nut and oil slinger—which is a one-piece assembly with a left-hand thread and is locked in place by being staked into the hole provided for that purpose. Use a press to remove the bearing from the shaft.

Mainshaft: For transmissions using spur cut low and reverse gear, turn the front synchronizer ring so that one lug lines up directly between a land and a spline on the mainshaft. For units using a helical cut low and reverse gear, the front synchronizer ring should be turned so that its lugs line up with the slots in the mainshaft helical spline. On all units, force the mainshaft out of the rear bearing and remove the shaft out through the front of the case. Shift the second speed gear into the synchronizer clutch sleeve and take out the sleeve, second speed gear and the first and reverse sliding gear as an assembly.

NOTE—To disassemble the clutch sleeve, remove the sliding gears and turn the synchronizing ring in the clutch sleeve until the ends of the ring retainers can be seen through the slot in the sleeve. Then expand the retainer into the counterbore in the sleeve and slip out the ring.

Countershaft: Before removing the countergear cluster, expand the mainshaft rear bearing lock ring to raise it from the bearing groove. Tap lightly on the outer race of the bearing and remove it from the inside of the case. Drive the countershaft out through the front and lift out the cluster gear and thrust washers.

Reverse Idler: Drive out the reverse idler gear expansion plug from the inside of the case. Drive the reverse idler shaft lock pin into the shaft, being careful not to turn the shaft as the lock pin may drop down between the idler shaft bushings. Remove the shaft and lift out the gear and thrust washers.

Inspection: See that the synchronizing cones are not loose in the clutch sleeve. If the cones are damaged, it will be necessary to replace the clutch sleeve assembly and both synchronizing rings. The rings must be smooth and must not rock in the cones, as excessive rocking affects proper synchronizing of the gear when shifting.

Normally, it should not be necessary to replace the synchronizer energizing springs. However, should this be required, the spring is assembled in its groove with its **offset end between the second and third** clutch teeth of any bank of teeth on units using spur cut low and reverse gears, or between the fourth and fifth clutch teeth of either bank of teeth for transmission with helical cut low and reverse gears. This procedure is for the purpose of preventing the springs from turning in the grooves. Whenever removed, these springs should always be replaced with new ones, and when doing so, care should be exercised to prevent distortion when expanding the spring over the clutch teeth.

The countergear and idler gear bushings are not serviced separately as they are a pressed fit and accurately bored to assure proper alignment with their gears as well as proper mesh of the gears. If the clearance between these bushings and their shafts is in excess of .004", the gear and bushing assembly should be replaced.

ASSEMBLE

Reverse Idler: Hold the idler gear in position in the case and install the idler shaft, being sure that the lock pin hole in the shaft lines up with the hole in the case. Using a new lock pin, drive it in about 1/16" below the case and peen the hole slightly to provide a tight fit and to prevent an oil leak. Install the idler shaft expansion plug.

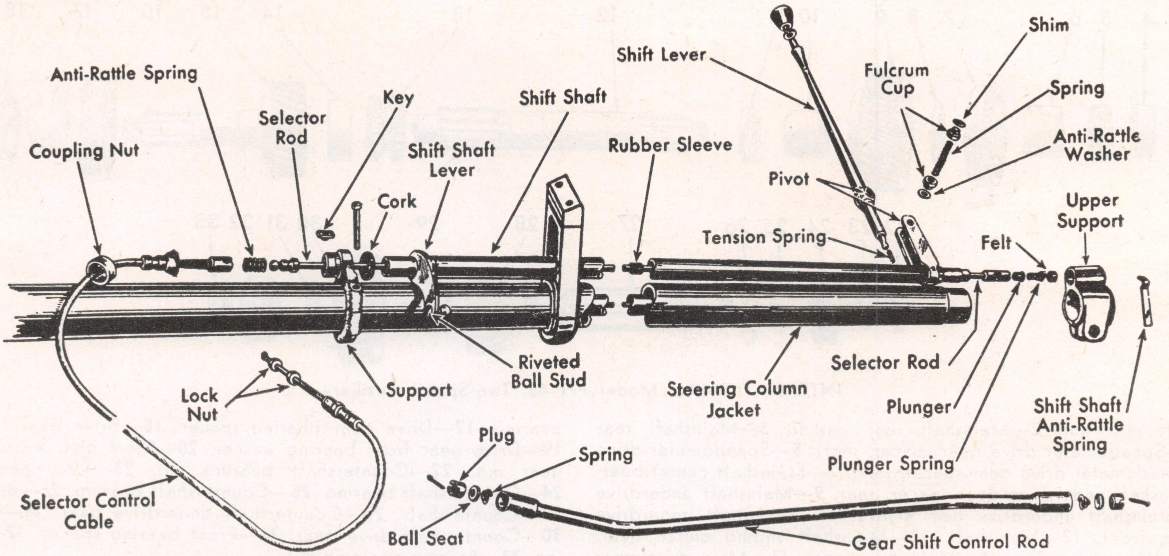
Countershaft: Place the countergear assembly into the case. Dip the countershaft thrust washers in transmission lubricant and place them in their proper position at each end of the gear. Use a suitable tool to pick up and align the gear and thrust washers with the holes in the case and drive the countershaft in from the front.

CAUTION—The flat on the front end of the shaft should be in a horizontal position and facing upward, otherwise it will not engage the clutch housing. The step on this end of the shaft should be flush with the front face of the case or about 1/64" below the face—to maintain proper transmission alignment.

Clutch Sleeve: Install the ring retainers in the counterbores in the ends of the clutch sleeve. Expand the ring retainer and, at the same time, hold it flush with the back face of the cone.

Install the rings, being sure that the retainers are properly seated in the grooves. Slip the first and reverse sliding gear on the sleeve. Install the second speed gear at the rear end of the sleeve, meshing the clutch teeth on the gear with those in the sleeve.

CAUTION—Be sure that the synchronizing ring lugs engage the clutch teeth on the second speed gear in their original position by aligning the marks which were made on these parts before they were disassembled. Coat the grooved side of the second speed gear thrust washer with gear oil and place it on the back of the gear. Line up one lug on the synchronizing ring with an internal spline tooth in the clutch sleeve. If this precaution is not taken, the clutch sleeve splines and the mainshaft splines will be burred when installing the mainshaft.



G M C. Remote Control Shifter Mechanism.

Mainshaft: When installing the mainshaft, lubricate that portion of the shaft upon which the second speed gear fits. The proper seating of the mainshaft shoulder against the inner race of the rear bearing can be checked by the end play of the second speed gear, which should be .010".

Shifter Mechanism: Install the shift yoke lock balls and springs in the transmission case. Install the shift yokes, placing the first and reverse yoke in its sliding gear channel and the second and high yoke over the ring on the sliding clutch sleeve. Install the shift shafts from the front—the longer one being for first and reverse—then line up the lock holes in the shaft with the cover holes in the top of the case. Place the shifter interlocks in the slots in the yokes with the pins pointing upward and with the hole nearer to the second and high shift shaft. Assemble the cover to the case, being sure to use the two special cap screws at the front.

THREE-SPEED SYNCHROMESH WITH REMOTE GEARSHIFT CONTROL

NOTE—This transmission is serviced in the same manner as described for units with floor-type gearshift, therefore only the gearshift control service will be covered.

Assuming that the transmission has not been removed from the chassis, disassemble the cover in the following manner: Remove the outer nut and spacer and disconnect the selector cable from the yoke. Disconnect the cable housing from the cover. Remove the cotter pin, plug, ball seat and spring at the rear end of the control rod and disconnect the shift control rod from the shift shaft outer lever. Unbolt the cap screws which fasten the cover to the transmission and lift it off. The selector cable yoke may be removed after releasing the hairpin cotter pin from the yoke stud. Remove the nut, washer and inner lever from the shift shaft and take out the shaft.

Assemble in the reverse order, being sure to observe the following: Check the selector plate and shift bar to be sure they are not warped. The shift bar pins must not bind in the notches of the selector plate. When assembled, be sure that the selector cable is not twisted.

Selector Cable, Adjust: Remove the plate from the transmission case cover and turn the adjusting nuts on each side of the selector cable yoke until the distance between the top of the steering wheel to the center of the shift lever knob is 5¼" with the lever in neutral position.

NOTE—Turn the nuts toward the end of the cable to bring the shift lever nearer to the steering wheel; turning them away from the end of the cable, moves the shift lever away from the wheel.

Engagement Position, Adjust: Loosen the lock nut on the eccentric ball stud located in the transmission case outer lever. Turn the eccentric ball stud until the end of the shift lever knob is 2½" ahead of the center line of the steering column.

Shift Control Rod Ends, Adjust: With all parts assembled, screw the end plugs firmly against their seats and back off from ⅛ to ⅜ turn and lock in place with cotter pins.

Lubrication: If the shift control has been removed, Lubriplate should be applied to threads, plugs, plunger and bearings in the upper end of the shift control shaft; the lower end of the rod and bearings in the lower end of the shift shaft, and the anti-rattle spring at the upper end of the shift shaft.

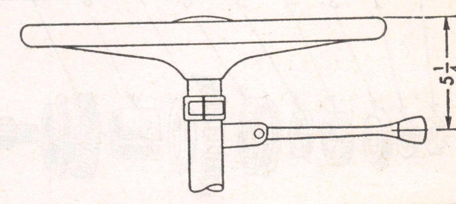
CAUTION—Do not lubricate the selector rod rubber sleeve.

INTERNATIONAL

MODEL FPP-45

Two-Speed Forward Auxiliary Transmission.

Disassemble: Take off the cover plate. Remove the shift fork lock screw and the grease retainer from the front end of the rail. Pull the rail out through the front, holding a hand over the lock ball hole to prevent the poppet ball and spring from flying out. Disconnect both mainshaft and both countershaft bearing retainers.



G M C. Gearshift Lever Adjustment.

Pull the main drive gear out through the front. Slip the sliding clutch gear from the front of shaft, withdraw the mainshaft through the front and lift the underdrive gear out through the top. Unscrew the nuts from the front and rear end of the countershaft. Push the shaft to the rear far enough to permit the rear bearing and spacer to be removed. Pull the assembly back to free it from the front bearing, then lift the shaft and gears out through the top. If required, remove the bearings and oil seals from the mainshaft retainers.

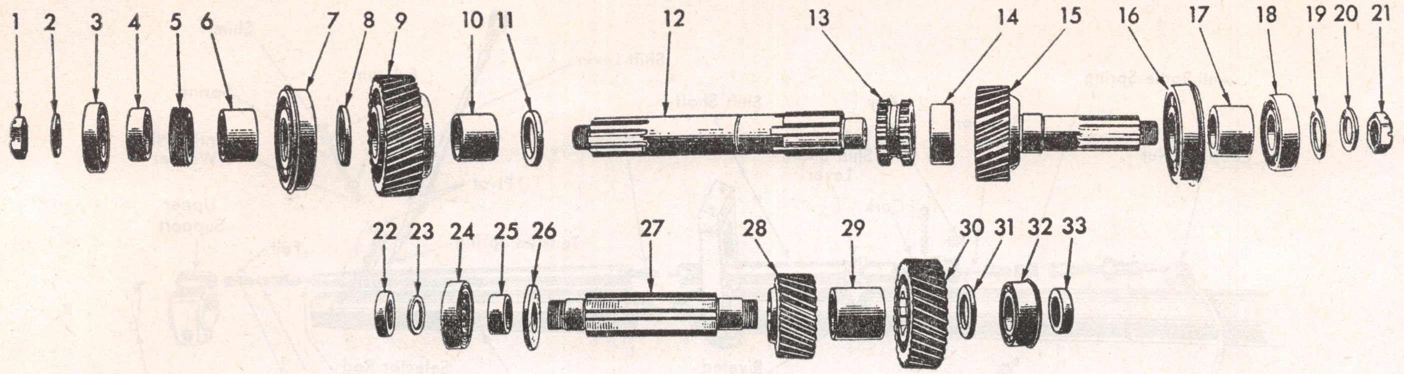
Assemble in the reverse order, using new gaskets and oil seals if necessary.

MODEL HDS

Three Speeds Forward and One Reverse.

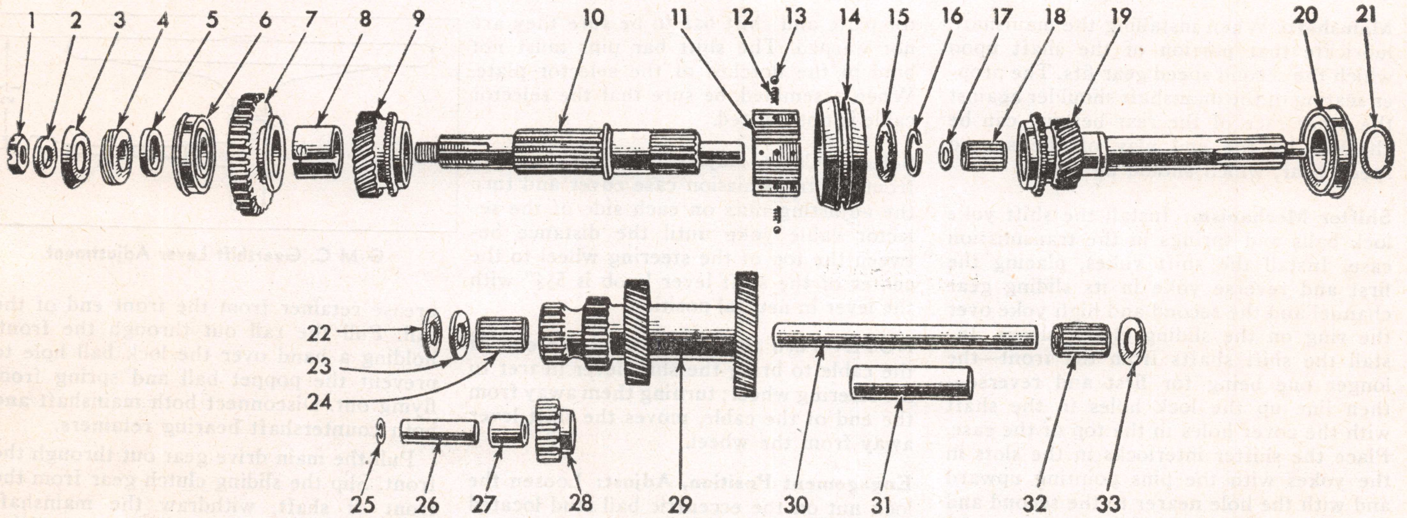
Disassemble: Take off the transmission cover and shifter assembly. Lock the transmission in two gears to prevent the mainshaft from turning and unscrew the universal flange nut. Use a puller if necessary, to remove the flange. Remove the speedometer driven gear and front and rear bearing retainers. Drive the countershaft out rearward.

Pull out the main drive gear assembly from the front. Remove the mainshaft front pilot bearing and push the mainshaft



INTERNATIONAL. Model FPP-45, Two-Speed Auxiliary.

1—Mainshaft rear nut. 2—Mainshaft rear washer. 3—Mainshaft rear bearing. 4—Speedometer drive gear spacer, short. 5—Speedometer drive gear. 6—Speedometer drive gear spacer, long. 7—Mainshaft center bearing. 8—Mainshaft underdrive gear spacer, rear. 9—Mainshaft underdrive gear. 10—Mainshaft underdrive gear sleeve. 11—Mainshaft underdrive gear spacer, front. 12—Mainshaft. 13—Mainshaft sliding clutch gear. 14—Mainshaft front bearing. 15—Main drive gear. 16—Main drive gear bearing. 17—Drive gear bearing spacer. 18—Drive gear front bearing. 19—Drive gear front bearing washer. 20—Drive gear washer. 21—Drive gear nut. 22—Countershaft bearing nut. 23—Rear bearing washer. 24—Countershaft bearing. 25—Countershaft bearing. 26—Bearing spacer. 27—Countershaft 28—Countershaft underdrive gear. 29—Gear spacer. 30—Countershaft drive gear. 31—Front bearing spacer. 32—Front bearing. 33—Bearing retaining nut.



INTERNATIONAL. Model HDS, Three-Speed Synchromesh.

1—Mainshaft nut. 2—Mainshaft nut washer. 3—Mainshaft oil slinger. 4—Speedometer drive gear. 5—Speedometer drive gear spacer. 6—Mainshaft rear bearing. 7—Mainshaft low gear. 8—Second gear bushing. 9—Second gear. 10—Mainshaft. 11—Synchronizer clutch gear. 12—Synchronizer spring. 13—Synchronizer ball. 14—Synchronizer sleeve. 15—Second gear thrust washer. 16—Second gear lock ring. 17—Pilot bearing spacer. 18—Mainshaft pilot bearing. 19—Main drive gear. 20—Drive gear bearing. 21—Drive gear bearing lock ring. 22—Countershaft rear thrust washer, bronze. 23—Steel thrust washer. 24—Countershaft rear bearing. 25—Idler shaft snap ring. 26—Idler gear shaft. 27—Idler gear bushing. 28—Reverse idler gear. 29—Cluster gear. 30—Countershaft. 31—Bearing spacer. 32—Countershaft front bearing. 33—Front thrust washer.

far enough to the rear to permit the speedometer drive gear and rear bearing to be pulled off the shaft. Lift the mainshaft and gears out through the top. Take out the cluster gear assembly. Drive the reverse idler shaft out through the rear and lift out the gear.

Mainshaft: To disassemble, slide the low speed gear from the shaft. Slip the synchronizer assembly from the shaft, being careful not to allow it to come apart. Release the snap ring and take the second speed gear, bushing and thrust washer from the shaft. Assemble in the reverse order.

Synchronizer: Before disassembling the unit, mark the relationship of the clutch gear with the sleeve so that assembly may be made in the original position. Wrap a cloth around the assembly to avoid losing the balls and springs and push the gear out of the sleeve.

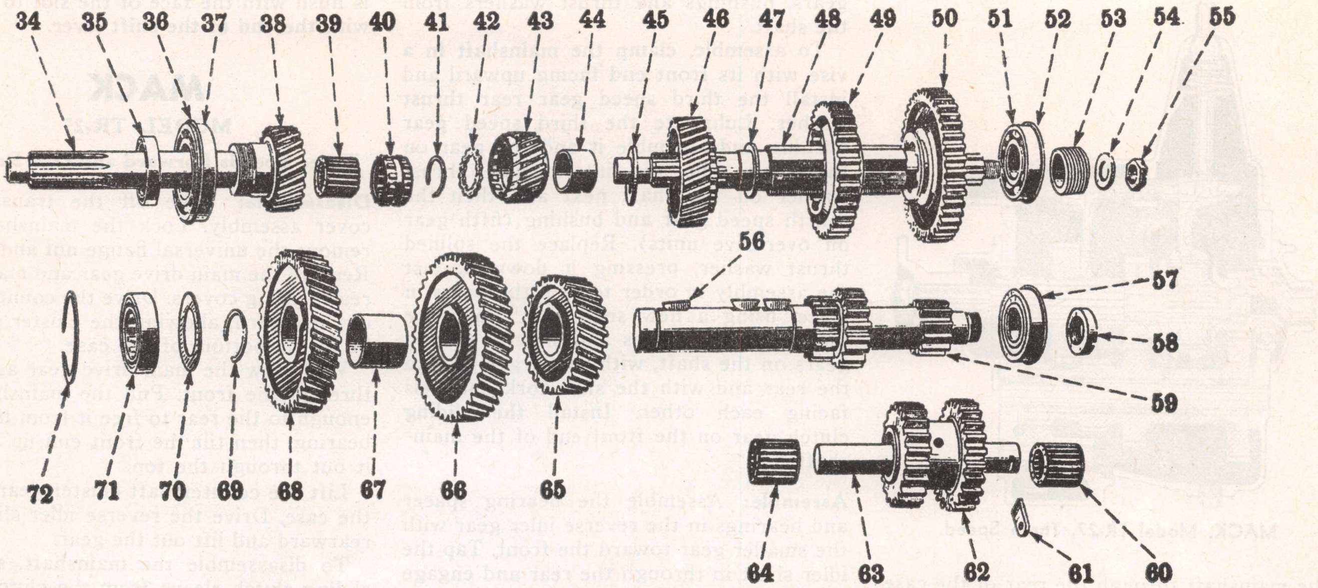
Assemble in the reverse order and use a piston ring compressor-type clamp to assemble gear and ball assembly in the sleeve.

Shifter Mechanism: Remove the lock screws and drive the rails out of the cover. Hold a hand over the lock ball holes to prevent the balls and springs from flying out as the rails are removed. Tag the rails as they are removed to assure correct assembly.

NOTE—Assemble the cover in the reverse order, being sure to lubricate the balls and springs before replacing and make certain that the two interlock plungers and spacer are installed correctly between the rails.

Assemble: Assemble the reverse idler gear by pushing the shaft in through the rear. Place the countergear assembly in the bottom of the case and use grease to hold the thrust washers in position. Assemble the mainshaft and gears in the case and install the rear bearing, using a new snap ring to hold the bearing in position. Lubricate the mainshaft front pilot bearing and place it over the end of the mainshaft, first being sure to install the spacer.

Assemble the main drive gear through the front, using a new snap ring to hold the bearing in place. Align the countergear assembly and drive the shaft in through



INTERNATIONAL. Typical of all Models H-7, F-51, F-52, F-54, Five Speed.

34—Main drive gear. 35—Drive gear bearing nut. 36—Drive gear bearing snap ring. 37—Drive gear bearing. 38—Main drive gear. 39—Mainshaft pilot bearing. 40—Mainshaft sliding clutch gear. 41—Thrust washer snap ring. 42—Thrust washer. 43—Fourth (or fifth) mainshaft gear. 44—Sleeve. 45—Third gear washer, front. 46—Third gear. 47—Third gear washer, rear. 48—Mainshaft. 49—Second gear. 50—First speed gear. 51—Rear bearing. 52—Bearing snap ring. 53—Speedometer drive gear. 54—Washer. 55—Nut. 56—Gear key. 57—Countershaft rear bearing. 58—Rear bearing nut. 59—Countershaft. 60—Idler gear rear bearing. 61—Idler shaft lock. 62—Reverse idler gear. 63—Idler shaft. 64—Idler gear front bearing. 65—Countershaft third gear. 66—Countershaft fourth (or fifth), gear. 67—Gear spacer. 68—Countershaft main drive gear. 69—Snap ring. 70—Bearing washer. 71—Front bearing. 72—Bearing snap ring.

the rear. Replace the mainshaft rear bearing retainer and lock the countershaft by rotating the retainer until it fits in the countershaft slot. Replace the speedometer drive gear spacer, the drive gear and oil slinger to the end of the mainshaft and install the universal flange, fastening the assembly securely with the lock nut. Install the transmission cover assembly.

MODELS H-41, H-42

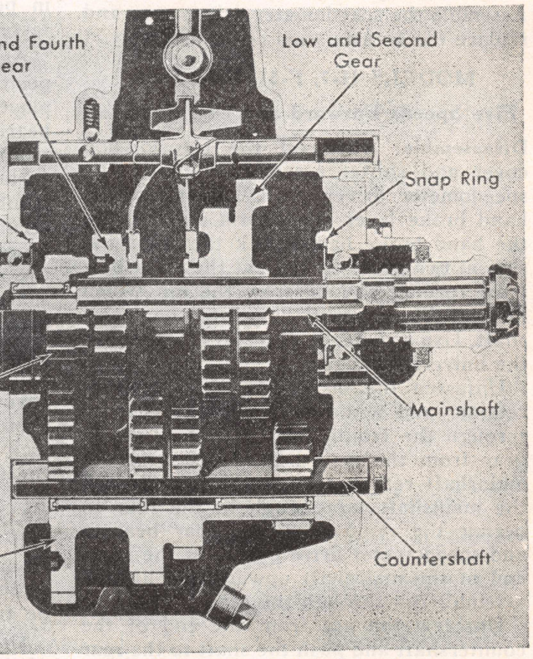
Four Speeds Forward and One Reverse

Disassemble: Set the gearshift lever in neutral, remove the cover screws and lift off the transmission cover and shifter assembly. Remove the universal flange nut and pull off the flange. Detach the bell housing and take off the main drive gear bearing retainer. Pull the drive gear and bearing assembly out through the front.

Unfasten the mainshaft rear bearing retainer and pull off the speedometer drive gear and spacer. Tap the mainshaft bearing out through the rear of the case. Grasp the sliding gears and withdraw the mainshaft out through the rear and lift the gears out through the top. Remove the countershaft lock plate, drive the shaft out through the rear and lift out the cluster gear assembly. Remove the reverse shift rail and fork. Tap the reverse idler gear shaft out rearward and lift out the gear.

To disassemble the cover, place the rails in neutral position and remove the shift fork lock screws. Drive the rails out through the rear, forcing the expansion plugs out at the same time.

CAUTION—Hold a hand over the lock ball holes to prevent the balls and springs from flying out as the rails are removed.



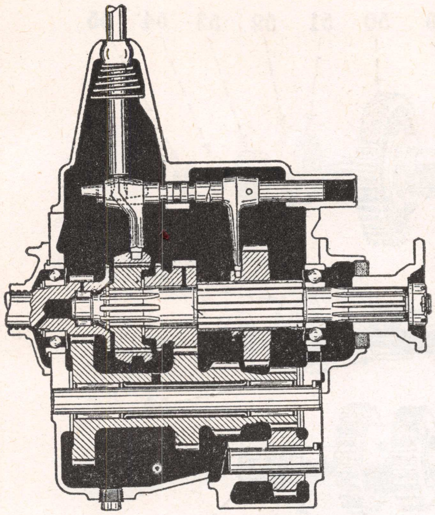
INTERNATIONAL. Models H-41, H-42 Four Speed.

As soon as each rail is taken out, it should be tagged to assure correct assembly.

Drive the expansion plug from the side of the cover and tip the cover up on edge to allow the interlock plungers to drop out. Disassemble the reverse shifter plunger.

Assemble the cover in the reverse order, lubricating all balls and springs before replacing. Be sure to replace the interlock plungers correctly in the center rail. See that the points of all lock screws are engaged in the rail holes before wiring the screws in place. Check the reverse shifter plunger for freedom of operation, and when assembled, turn the adjusting nut so that the plunger is flush with the face of the slot to line up with the end of the shift lever.

Assemble: Assemble the reverse idler gear by tapping the shaft in through the rear. Place the countergear assembly in the case and replace the reverse rail and fork. Install the countershaft through the rear and assemble the lock plate and screw. Insert



MACK. Model TR-27, Three Speed.

the mainshaft through the rear of the case and slip on the sliding gears. Replace the mainshaft rear bearing, using a new snap ring to lock it in place. Install the main drive gear assembly through the front and fasten the drive gear bearing retainer to the case. Replace the speedometer drive gear spacer and gear and the mainshaft rear bearing retainer. Install the universal flange and tighten the lock nut securely. Assemble the speedometer driven gear and replace the transmission cover assembly.

MODELS H-7, F-51, F-52, F-54

Five Speeds Forward and One Reverse.

Disassemble: Take off the transmission cover and shifter assembly. Remove the speedometer driven gear. Disconnect the hand brake lever mechanism and remove the hand brake band. Lock the transmission in two gears to prevent the mainshaft from turning and unscrew the nut which fastens the universal flange to the mainshaft. Use a puller if necessary, to remove the universal flange.

Unfasten the main drive gear bearing retainer and withdraw the gear assembly through the front. Slip the sliding clutch gear from the mainshaft. Disconnect the mainshaft rear bearing retainer and push the mainshaft far enough to the rear to permit the removal of the rear bearing and speedometer drive gear. Tilt the front end of the mainshaft upward and lift the assembly out through the top.

Unscrew the nut from the end of the countershaft and push the shaft to the rear and remove the rear bearing. Tilt the front end of the assembly upward and lift it out of the case. Release the snap ring and tap the front countershaft bearing and expansion plug out through the front of the case. Remove the lock and tap the reverse idler shaft out rearward and lift out the gear and bearings.

To disassemble the mainshaft, slip the sliding gears from the shaft. Expand the snap ring at the front end of the mainshaft and slide it from the shaft. Align the teeth of the thrust washer with the splines on the mainshaft and slide the gears, bushings and thrust washers from the shaft.

To assemble, clamp the mainshaft in a vise with its front end facing upward and install the third speed gear rear thrust washer. Lubricate the third speed gear bushing and assemble it and the gear on the shaft. Slip the intermediate thrust washer on the shaft next and then the fourth speed gear and bushing (fifth gear on overdrive units). Replace the splined thrust washer, pressing it down against the assembly in order to lock the gears in place, using a new snap ring. Lubricate the mainshaft splines and slip the sliding gears on the shaft, with the larger gear to the rear and with the shift fork channels facing each other. Install the sliding clutch gear on the front end of the mainshaft.

Assemble: Assemble the bearing spacer and bearings in the reverse idler gear with the smaller gear toward the front. Tap the idler shaft in through the rear and engage the slot in the locking plate and bolt it securely. The helical gears on the countershaft may be replaced by pressing them off one at a time, and when installed, be sure the three keys are a tight fit and stake them in place with a prick-punch. Assemble the countershaft front bearing and expansion plug, using a new snap ring to lock it in place. Place the countershaft assembly in position and install the rear bearing, fastening the assembly with the lock nut.

Assemble the mainshaft and gears in position and insert the rear bearing. Replace the speedometer drive gear and rear bearing retainer. Lubricate the mainshaft front pilot bearing and place it in position. Install the drive gear assembly through the front and replace the retainer, fastening it securly to the case. Complete the assembly by replacing the universal flange, fastening the nut securely to the end of the mainshaft, then assemble the transmission cover assembly.

To disassemble the cover, drive the expansion plugs out of the front end of the cover. With all the rails in the neutral position, remove the shift fork and lug lock screws and drive the rails out toward the front.

CAUTION—Hold a hand over the lock ball holes to prevent the balls and springs from flying out as the rails are removed; as soon as each rail is taken out, it should be tagged to assure correct assembly.

Drive the expansion plug from the side of the cover and tip the cover up on edge to allow the interlock plungers to drop out. Disassemble the reverse shifter lug plunger.

Assemble the cover in the reverse order, lubricating all balls and springs before replacing. Be sure the interlock plungers are installed correctly in the center rail. See that the points of all lock screws engage the holes in the shift rails before wiring the screws in place. Check the operation of the reverse shifter lug plunger to be sure it works freely, and when assembled, turn the adjusting nut so that the plunger is flush with the face of the slot to line up with the end of the shift lever.

MACK

MODEL TR-27

Three Speeds Forward and One Reverse.

Disassemble: Take off the transmission cover assembly. Lock the mainshaft and remove the universal flange nut and flange. Remove the main drive gear and mainshaft rear bearing covers. Drive the countershaft out rearward, allowing the cluster gear to lie in the bottom of the case.

Withdraw the main drive gear assembly through the front. Pull the mainshaft far enough to the rear to free it from the pilot bearing, then tilt the front end up and lift it out through the top.

Lift the countershaft cluster gear out of the case. Drive the reverse idler shaft out rearward and lift out the gear.

To disassemble the mainshaft, slip the sliding clutch sleeve from the clutch gear. Remove the snap ring from in front of the clutch gear and turn the thrust washer to align its lugs with the mainshaft splines, then strip the mainshaft.

Assemble the transmission in the reverse order.

MODELS TR-11, TR-28

Four Speeds Forward and One Reverse.

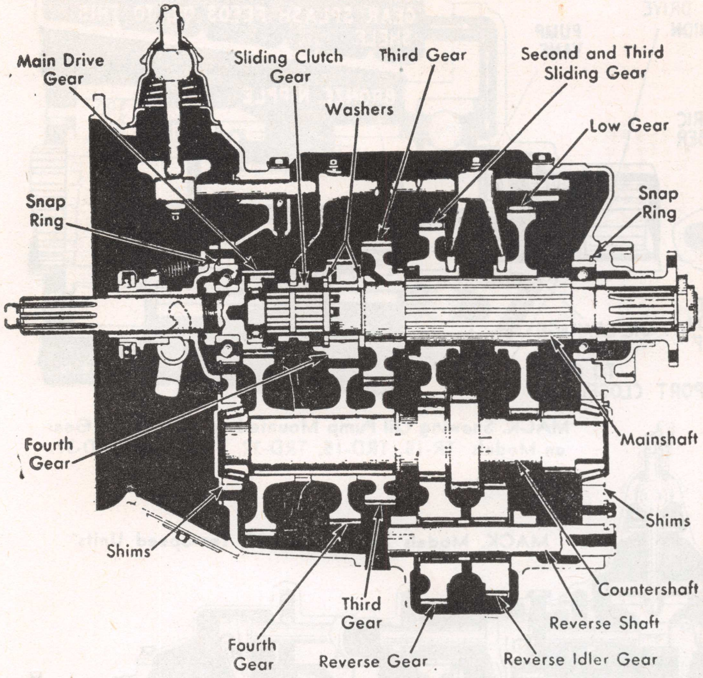
Disassemble: Set the gears in neutral, remove the cover screws and lift off the cover. Lock the mainshaft in two gears and unscrew the universal flange nut. Pull off the brake drum and universal flange. Remove the bell housing and the main drive gear bearing retainer, then withdraw the main drive gear assembly through the front. Remove the mainshaft rear bearing retainer, oil seal and speedometer drive gear.

NOTE—Before removing the mainshaft, mark the relationship of the mainshaft splines with the mating splines of the sliding gears. As these gears are a selective fit on the shaft splines, it is important that the same position be maintained.

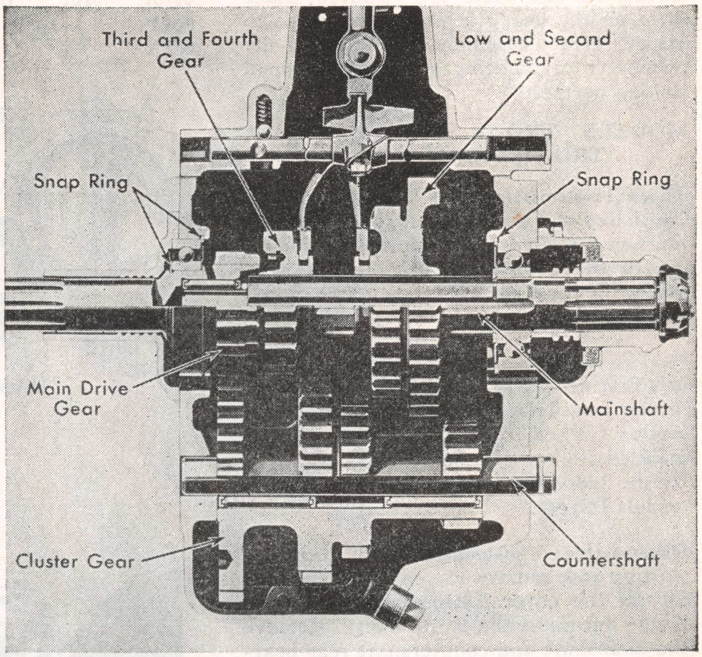
Grasp the mainshaft sliding gears and withdraw the mainshaft through the gears and out through the rear, then lift the gears out through the top. Remove the countershaft lock plate, tap the shaft out through the rear and lift out the gear. Pull out the cotter pin from the front end of the reverse shift rail, drive out the rail and lift out the fork. Tap the reverse idler shaft out rearward and lift out the gear.

If the cover is to be disassembled, unscrew the shift lever housing cap. Remove the reverse latch spoon, the reverse latch and slide the springs and washers from the lever. Unfasten the shift fork lock screws and drive the shift rails out through the rear, forcing the expansion plugs out at the same time.

Assemble: Assemble the reverse idler gear by tapping the shaft in through the rear. Place the countergear assembly in the case with the bearings and spacer in position.



MACK. Models TR-30, TR-31, Five Speed.



MACK. Models TR-11, TR-28, Four Speed.

then replace the reverse rail and fork, locking the rail in place with a cotter pin. Tap the countershaft in through the rear and replace the lock plate and screw.

Install the mainshaft through the rear of the case, slipping on the sliding gears, being sure that the marked splines of the gears and shaft are meshed. Install the speedometer drive gear and rear bearing retainer. Assemble the main drive gear and bearing through the front of the case.

Complete the assembly by installing the main drive gear bearing retainer and mainshaft rear bearing retainer, then replace the universal flange, brake drum, bell housing and transmission cover assembly.

MODELS TR-12, TR-15, TR-17, TR-30, TR-31, TR-32, TR-37

Five Speeds Forward and One Reverse with Direct on Either Fourth or Fifth. An Additional Fast Reverse Speed is Available. On most Models, an Oil Pump is Employed to Provide Positive Oil Pressure to the Third and Fourth Gear Bushings and Consists of a Rotating Vane which Oscillates in an Eccentric Housing Mounted on the Main Drive Gear Shaft.

Disassemble: Shift the transmission into first speed, disconnect the hand brake lever, remove the cover screws and lift off the transmission cover and shifter assembly. Remove the universal flange nut and pull off the flange. Take off the mainshaft and countershaft rear bearing covers, lock the gears and unscrew the countershaft rear bearing nut (if equipped).

Push both the mainshaft and countershaft to the rear at the same time until the mainshaft rear bearing is clear of the case and pull off the bearing. Tilt the front end of the mainshaft upward, grasp the sliding gears and lift the mainshaft with the stationary gears out through the top; remove the sliding gears from the case.

To remove the main drive gear, take off the clutch release mechanism and the drive gear bearing cover, then withdraw the drive gear assembly out through the front. The drive gear and bearing may be separated by unscrewing the bearing retaining nut.

If equipped with two reverse speeds, remove the high speed reverse shift rail and yoke. Then on all units, withdraw the reverse gear shaft (or shafts) and remove the reverse gear (or gears). Push the countershaft far enough to the rear to permit the removal of the rear bearing, then tilt the front end of the assembly upward and lift it out.

To disassemble the mainshaft, slip off the pilot bearing and clutch gear. Take out the locking key or snap ring which retains the gear retaining washer, then strip the mainshaft by removing successively, the washer, gears, sleeve and thrust washer.

To assemble, clamp the mainshaft in a vise with its front end up and replace the third speed gear and bushing, then the intermediate thrust washer against the third speed gear. Assemble the fourth gear and sleeve (fifth gear on overdrive units), then the front washer, locking the assembly in position with the locking key or snap ring. Slip on the sliding clutch gear and pilot bearing, being sure to lubricate the bearing.

NOTE—If new bushings are required on the mainshaft stationary gears, it is necessary that they be sized and broached in place; if the broaching equipment is not available, and a bushing is fitted by hand, allow at least .004" clearance between the sleeve and bushing.

Assemble: Install the countershaft front bearing and bearing cover. If required, the countershaft helical gears and power take-off gears may be replaced by pressing them off one at a time, and when installed, be sure the keys are a tight fit. Place the countershaft assembly in the case but do not install the rear bearing until after the mainshaft is in place.

Assemble the reverse gear shaft (or shafts) through the gear (or gears) through the rear of the case. For units having two reverse speeds, install the high speed reverse shift rail and yoke.

Assemble the main drive gear in the reverse order of removal, being sure the oil pump channels are thoroughly clean. Insert the mainshaft partly into the case and slip on the sliding gears, placing the larger gear to the rear and with the shift fork channels facing each other. Push both the mainshaft and countershaft assemblies to the rear at the same time and replace the mainshaft and countershaft rear bearings. Push both assemblies forward again to their normal positions.

NOTE—On units equipped with a nut at the rear countershaft bearings, install the nut and replace the countershaft and mainshaft rear bearing caps. If not equipped with a locking nut, eliminate end play in the countershaft by removing shims from behind the bearing cover.

Install the speedometer drive gear and universal flange, fastening the flange nut securely. Shift the transmission into first speed and replace the transmission cover assembly.

If the cover is to be disassembled, place the shift rails in neutral and remove the shift fork lock screws. Hold a hand over the lock ball holes to prevent the balls and springs from flying out as the rails are removed. As the parts are removed, place them on the bench in proper sequence to assure correct assembly and to avoid the possibility of omitting some of the small locking parts.

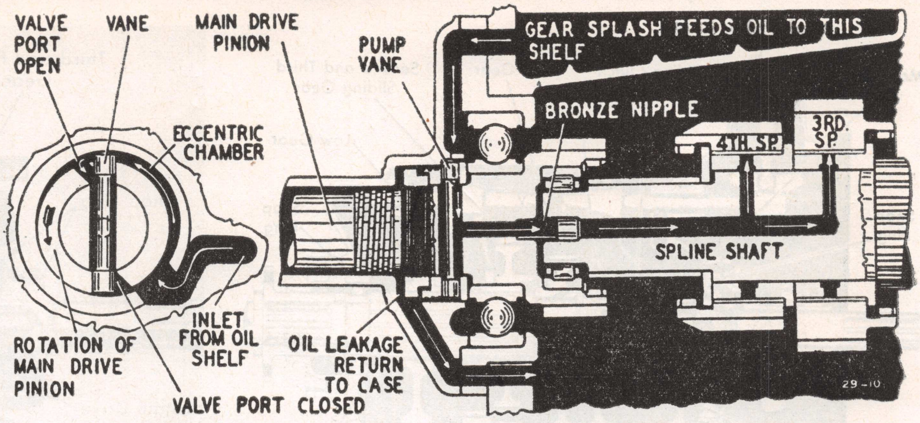
MODELS TRD-12, TRD-15, TRD-17, TRD-31, TRD-32, TRD-37

These Transmissions are Ten-Speed Units Consisting of Two Sections; the Front Secton being a Five-Speed Unit Corresponding to those Models Designated as TR, etc., while the Rear Section is a Two-Speed Auxiliary Unit.

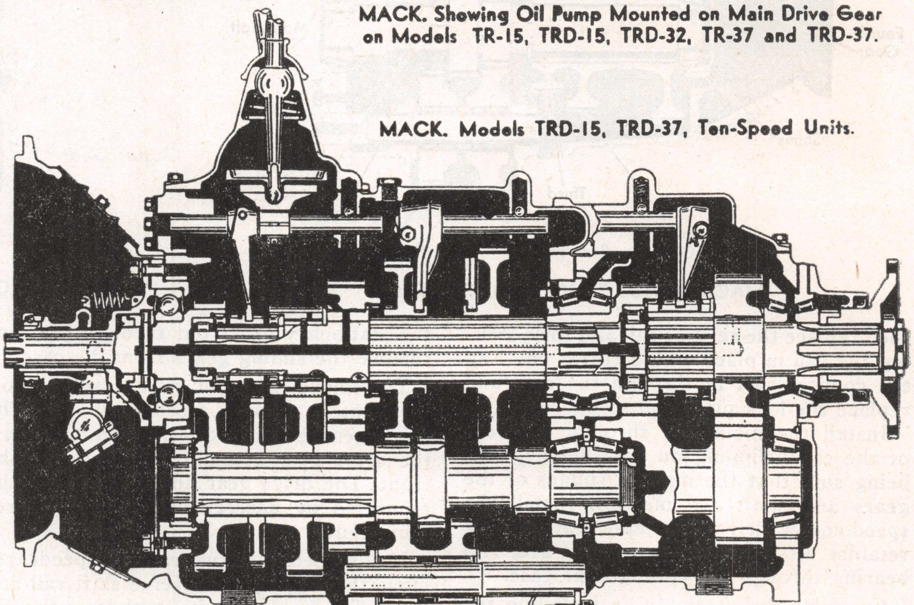
NOTE—To dismantle these transmissions, it is first necessary to disassemble the rear section and detach its case from the front section. When the rear section is dismantled, follow the instructions as given for the five-speed transmissions listed under models TR, etc.

Disassemble: Disconnect the auxiliary shifting rod, remove the cover screws and lift off the cover. Unscrew the universal flange nut and pull off the flange. Remove the mainshaft and countershaft rear bearing covers, noting the thickness of shims used behind the countershaft bearing cover. Disconnect the auxiliary case from the main case and lift off the rear case.

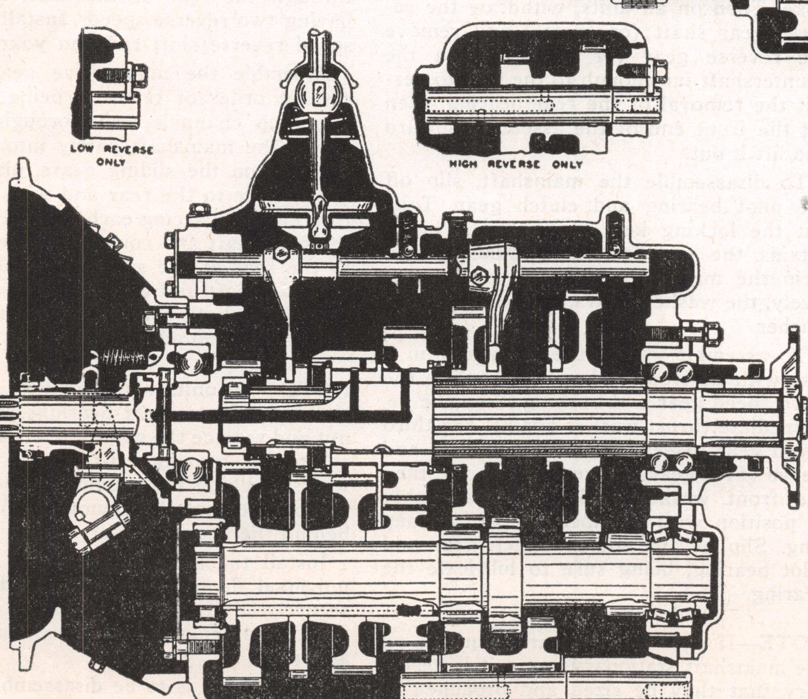
Remove the mainshaft and countershaft rear bearings and strip the gears from the mainshaft. The main drive gear and countershaft gear may then be pulled from the main case shafts. At this point, if the main case is to be serviced, proceed as already described for these units without the rear section.



MACK. Showing Oil Pump Mounted on Main Drive Gear on Models TR-15, TRD-15, TRD-32, TR-37 and TRD-37.



MACK. Models TRD-15, TRD-37, Ten-Speed Units.



MACK. Models TR-15, TR-37, Five Speed.

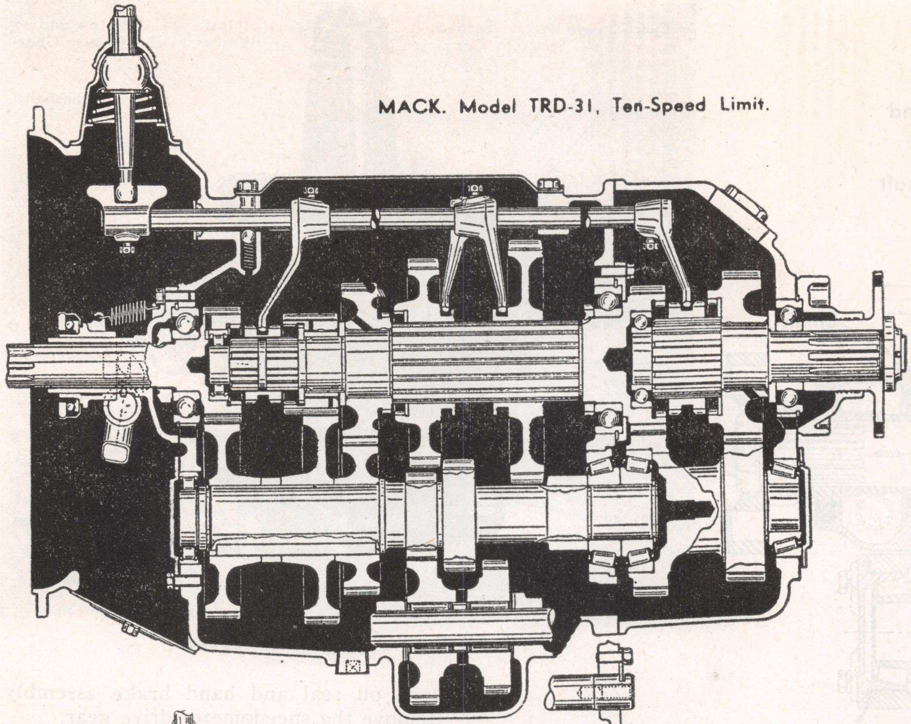
MACK JR. & REO

Four Speeds Forward and One Reverse.

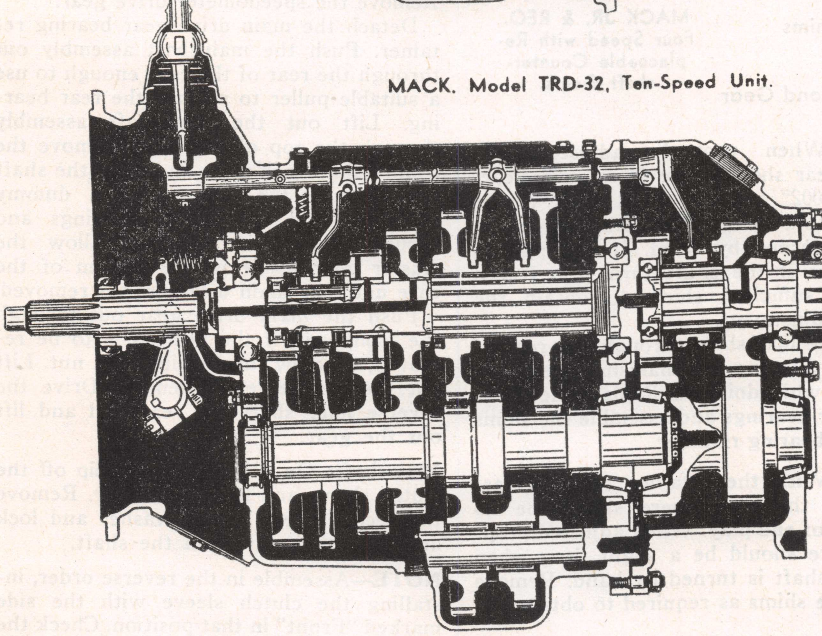
Disassemble: Take off the transmission cover and shifter assembly. Lock the mainshaft and unscrew the universal flange nut. Pull off the universal flange and speedometer drive gear. Disconnect the mainshaft rear bearing retainer, pull the mainshaft and rear bearing out through the rear and lift the gears out through the top.

Remove the main drive gear bearing retainer and pull the drive gear assembly out through the front. The drive gear and its bearing may be separated after unscrewing the retaining nut. Remove the countershaft rear bearing retainer, being sure to collect the bearing adjusting shims so the original thickness can be noted. Force the countershaft to the rear until the rear bearing is clear of the case and lift the gear out through the top by its front end. Pull the reverse idler gear shaft our rearward and lift out the gear.

If necessary to disassemble the cover, remove the shift fork lock screws and drive the rails out, holding a hand over the lock



MACK. Model TRD-31, Ten-Speed Limit.



MACK. Model TRD-32, Ten-Speed Unit.

ball holes to prevent the balls and springs from flying out. As each rail is removed, it should be tagged to assure correct assembly.

When assembling, lubricate the balls and springs before replacing, and see that the lock screws engage the holes in the shift rails before wiring them in place. Be sure the interlock plungers are correctly assembled.

Assemble: Assemble the reverse idler gear and push the shaft in through the rear. Install the front countershaft bearing, place the countergear in the case and replace the rear bearing.

NOTE—Assemble the original quantity of shims and fasten the countershaft rear bearing retainer firmly in place. When properly adjusted, there should be a slight drag when the shaft is turned by hand. If the shaft turns too easily or if end play is evident, shims of various thicknesses are available to obtain the correct adjustment.

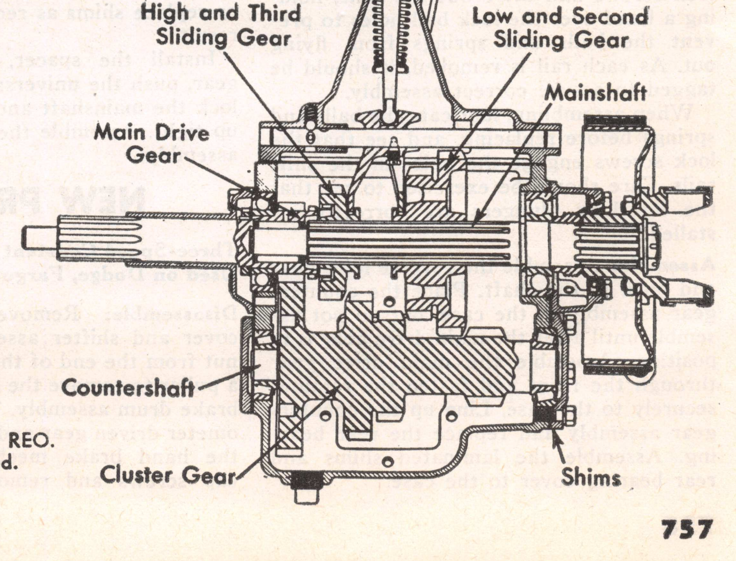
Assemble the main drive gear and install it through the front of the case, using a new snap ring in the bearing groove. Replace the drive gear bearing retainer. Lubricate the mainshaft pilot bearing and insert it in the drive gear pocket. Pass the mainshaft in through the rear of the case, assembling the gears on the shaft while doing so.

Install the mainshaft rear bearing, using a new snap ring. Fasten the rear bearing retainer to the case, being sure the oil seal is in good condition. Assemble the speedometer drive gear and universal flange, lock the transmission in two gears and fasten the flange nut securely. Replace the speedometer driven gear and the transmission cover assembly.

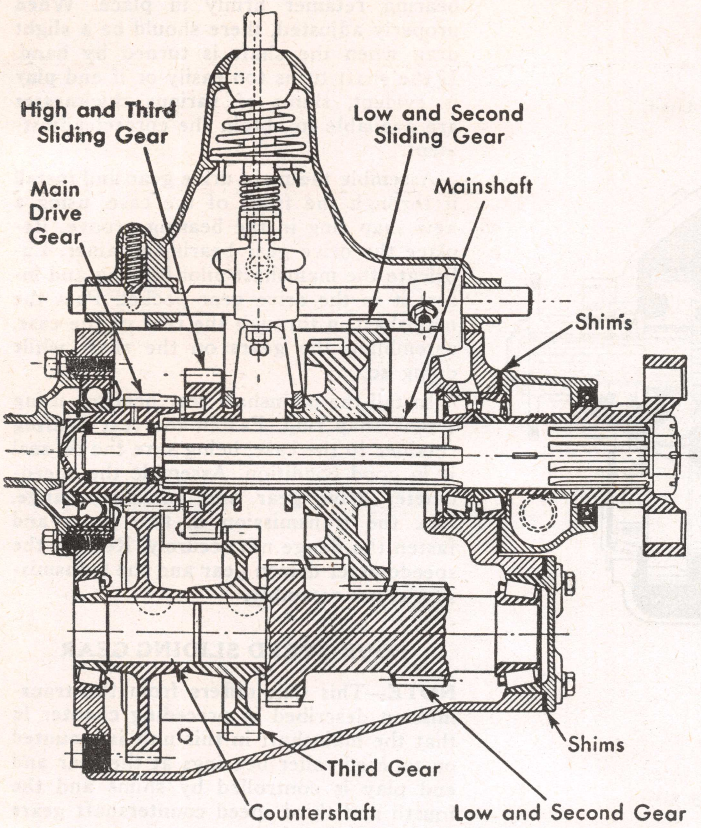
FOUR-SPEED SLIDING GEAR

NOTE—This unit differs from the transmission described in preceding chapter in that the mainshaft in this unit is mounted on tapered roller bearings at the rear and end play is controlled by shims and the fourth and third speed countershaft gears may be replaced.

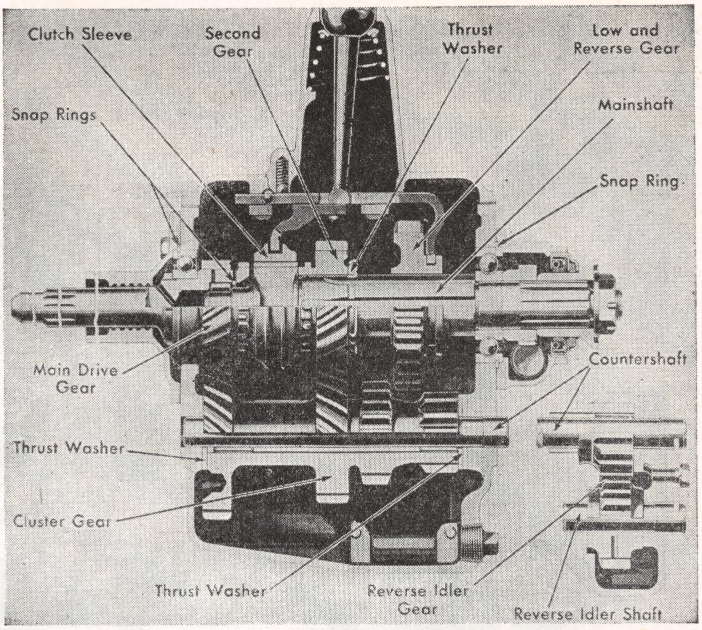
Disassemble: Take off the transmission cover and shifter assembly. Lock the mainshaft and unscrew the universal flange nut. Pull out the universal flange, the spacer and speedometer drive gear. Disconnect the mainshaft rear bearing retainer, being sure to collect the adjusting shims. Pull the mainshaft and rear bearings out through the rear and lift the gears out through the top.



MACK JR. & REO.
Four Speed.



MACK JR. & REO. Four Speed with Replaceable Countershaft Gears.



NEW PROCESS. Three Speed.

Disconnect the countershaft rear bearing and remove the retainer and shims. Force the countershaft to the rear until the fourth speed gear is out of mesh with the main drive gear. Disconnect the drive gear bearing retainer and pull the main drive gear assembly out through the front. Remove the countershaft rear bearing and lift the countergear out through the top by its front end.

NOTE—The fourth and third speed gears may be removed by pressing them from the shaft one at a time, and when installed, be sure keys are a tight fit. Pull the reverse idler shaft out and lift out the gear.

Shifter Mechanism: If necessary to disassemble the cover, remove the shift fork lock screws and drive out the rails, holding a hand over the lock ball holes to prevent the balls and springs from flying out. As each rail is removed, it should be tagged to assure correct assembly.

When assembling, lubricate the balls and springs before replacing, and see that the lock screws engage the holes in the shift rails. Care should be exercised to see that the interlock plungers are correctly installed.

Assemble: Assemble the reverse idler gear and push in the shaft. Place the countergear assembly in the case, but do not assemble until after the main drive gear is in position. Assemble the main drive gear through the front and fasten the retainer securely to the case. Line up the countergear assembly and replace the rear bearing. Assemble the laminated shims and rear bearing cover to the case.

NOTE—When properly adjusted, the countergear should have from zero clearance to .002" preload, or, in other words, there should be a slight drag when the shaft is turned by hand. If end play is evident or if the shaft turns too freely, peel off sufficient shims to obtain the desired adjustment.

Pass the mainshaft through the rear of the case, slipping the mainshaft gears on the shaft while doing so. Replace the mainshaft rear bearings and assemble the shims and rear bearing retainer.

NOTE—With the retainer securely fastened to the case, there should be no evidence of end play. When adjusted properly, there should be a slight drag when the mainshaft is turned by hand. Remove or replace shims as required to obtain this result.

Install the spacer, speedometer drive gear, push the universal flange in position, lock the mainshaft and run the flange nut up tight. Assemble the transmission cover assembly.

NEW PROCESS

Three-Speed Constant Mesh Transmission Used on Dodge, Fargo and Plymouth.

Disassemble: Remove the transmission cover and shifter assembly. Unscrew the nut from the end of the mainshaft and use a puller to remove the universal flange and brake drum assembly. Take out the speedometer driven gear and oil seal. Disconnect the hand brake mechanism. Unbolt the cap screws and remove the brake support, oil seal and hand brake assembly. Remove the speedometer drive gear.

Detach the main drive gear bearing retainer. Push the mainshaft assembly out through the rear of the case enough to use a suitable puller to remove the rear bearing. Lift out the mainshaft assembly through the top of the case. Remove the countershaft lock plate and drive the shaft out through the rear, using a dummy shaft to hold the needle bearings and thrust washers in position. Allow the cluster gear to lie in the bottom of the case until the main drive gear is removed.

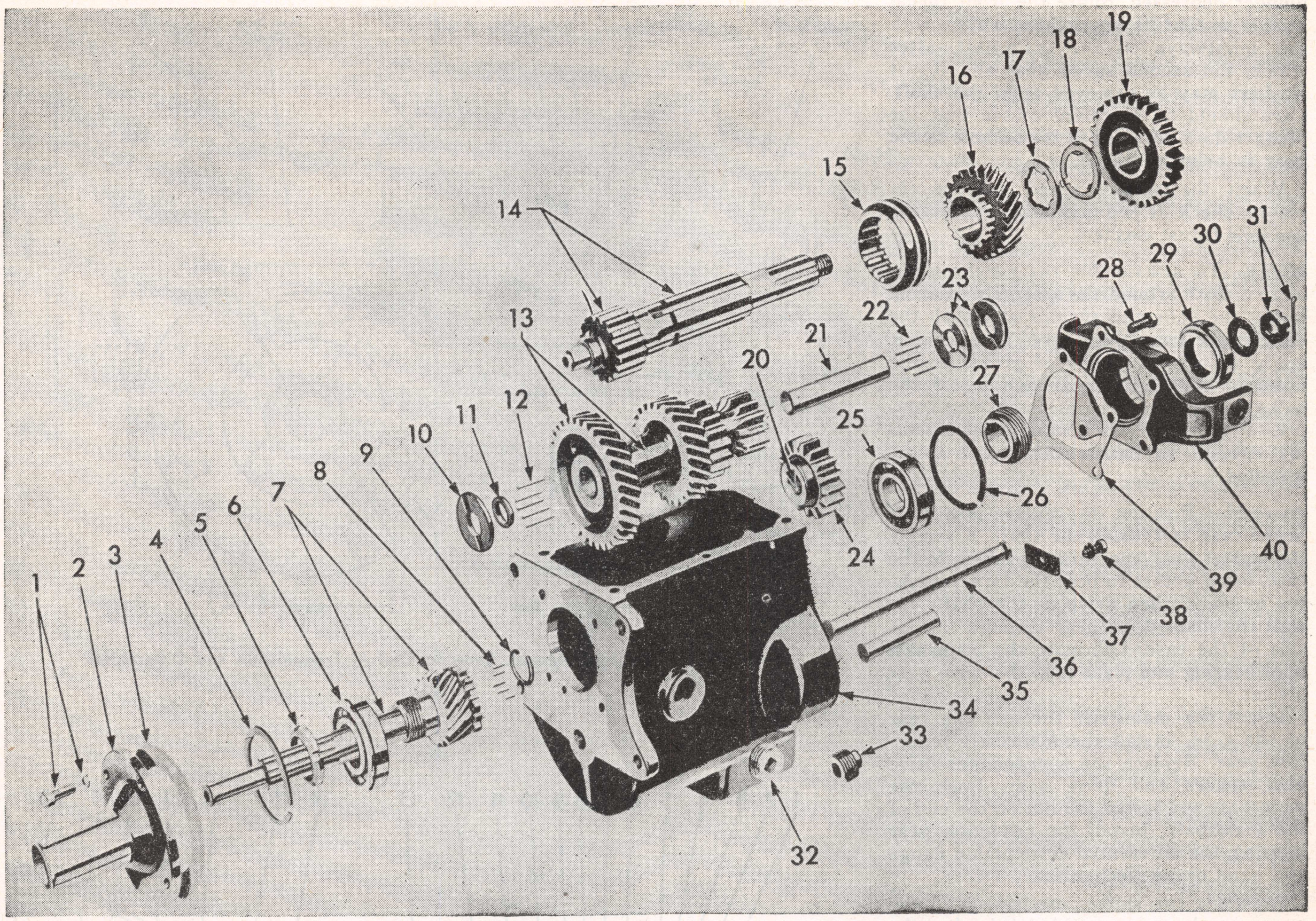
Push the main drive gear out through the front, and if the bearing is to be removed, unscrew the bearing lock nut. Lift out the countergear assembly. Drive the reverse idler shaft out rearward and lift out the gear.

Mainshaft: On 1937-40 trucks, slip off the clutch sleeve and low speed gear. Remove the second speed thrust washer and lock and slide the gear from the shaft.

NOTE—Assemble in the reverse order, installing the clutch sleeve with the side marked "Front" in that position. Check the end play of the second speed gear which should be from .003" to .008". Thrust washers of several thicknesses are available to establish this end play.

For 1941-42 units, before removing the synchronizer assembly, mark the relationship of the synchronizer rings with the clutch sleeve so that installation may be made in the original position. Then remove the rings, unhook the spreader springs from the shifting plates and slide the clutch sleeve from the clutch gear.

NOTE—When assembling, one of the turned out ends of each spring should be inserted in opposite ends of the same shifting plate. The balance of the mainshaft assembly is the same as described for 1937-40 models.



NEW PROCESS. Three Speed.

1—Retainer screw and washer. 2—Bearing retainer. 3—Gasket. 4—Snap ring. 5—Bearing lock nut. 6—Drive gear bearing. 7—Main drive gear 8—Mainshaft pilot bearing rollers. 9—Pilot bearing retainer ring. 10—Countershaft thrust washer. 11—Countershaft bearing spacer. 12—Countershaft bearing rollers. 13—Cluster gear. 14—Mainshaft. 15—Clutch gear sleeve. 16—Second speed gear. 17—Second gear thrust washer. 18—Thrust washer lock. 19—Low and reverse gear. 20—Idler gear washer. 21—Countershaft bearing spacer. 22—Countershaft bearing rollers. 23—Thrust washers. 24—Reverse idler gear. 25—Mainshaft rear bearing. 26—Bearing snap ring. 27—Speedometer drive gear. 28—Retainer screw. 29—Rear bearing oil seal. 30—Flange nut washer 31—Nut and cotter pin. 32, 33—Drain plug. 34—Transmission case 35—Idler shaft. 36—Countershaft. 37—Lock plate. 38—Lock plate screw 39—Gasket. 40—Bearing retainer and brake support.

Assemble: Assemble the reverse idler by driving the shaft in through the rear. Place the countershaft gear assembly in the bottom of the case but do not install the shaft until the main drive gear is in place. If the mainshaft front pilot bearings have been removed, assemble them in the pocket of the main drive gear and lock them in place with the snap ring, then replace the main drive gear through the front, locking the bearing in place with a new snap ring. Install the drive gear bearing retainer, using a new gasket. Install the countergear assembly by driving the dummy shaft out through the front, locking the assembly with the lock plate.

NOTE—End play of the countershaft should be from .004" to .015", which can be established by using thrust washers of the required thickness. Place the mainshaft into the case and out through the rear bearing hole, then install the rear bearing on the shaft. Push the mainshaft forward to its normal position.

Complete the assembly by assembling the speedometer drive gear, brake support and brake assembly; connect the brake mechanism; install the speedometer driven gear and oil seal, and the brake drum and flange assembly. Finally, place the clutch sleeve and low speed gear in neutral position and replace the cover.

PAK-AGE-CAR

Stutz Model.

Disassemble: Take off the transmission top cover. Remove the shift fork lock screws and pull out the shift rails, being careful not to lose the poppet balls and springs. Disconnect the hand brake mechanism and pull off the differential drive pinion flange. Remove the reduction gear housing.

Lock the transmission in two gears to prevent the mainshaft from turning and unscrew the nut which retains the mainshaft reduction gear to the end of the mainshaft. Remove the speedometer drive gear and spacer. Pull the reduction gear from the mainshaft. Withdraw the mainshaft assembly through the rear of the case.

Push the main drive gear into the transmission and lift it out through the top The drive gear bearing may then be removed after releasing the retaining snap ring. Remove the countershaft lock pin, drive the countershaft out of the case and lift out the gear and thrust washers. Remove the reverse idler shaft lock, drive out the shaft and lift out the gear.

Mainshaft: To disassemble, slip off the sliding gear. Mark the relationship of the synchronizer sleeve with the synchronizer clutch gear and also, its position on the mainshaft, so that the original assembly may be maintained. Slide the synchronizer unit from the mainshaft. Use a suitable pointed tool to depress the second speed gear thrust washer plunger. With the plunger depressed, rotate the front thrust washer so that its internal teeth align with the splineways on the mainshaft, after which, the second speed gear and thrust washers may be removed from the shaft. Care should be exercised to see that the plunger does not stick in the oil hole as the gear is being removed.

When the second speed gear is replaced, check its end play and, if excessive, use new thrust washers.

NOTE—To disassemble the synchronizer, wrap a cloth around the assembly to avoid losing the balls and springs and push the clutch gear from the sleeve. To assemble, apply a liberal quantity of grease to the holes in the clutch gear and insert the balls and springs. Use a piston ring compressor type clamp to compress the assembly enough to enable the sleeve to be installed.

Assemble: Position the reverse idler gear in the case and install the shaft. Assemble the cluster gear and thrust washers in the case, using grease to hold the thrust washers in place, then drive in the shaft. Install the main drive gear through the inside of the case. Lubricate the mainshaft pilot bearing and place it in the drive gear pocket.

Insert the mainshaft through the rear of the case. Install the mainshaft reduction gear. Replace the speedometer drive gear spacer and drive gear. Lock the mainshaft and fasten the nut on the end of the mainshaft. Install the reduction gear housing, the differential drive pinion flange and hand brake mechanism.

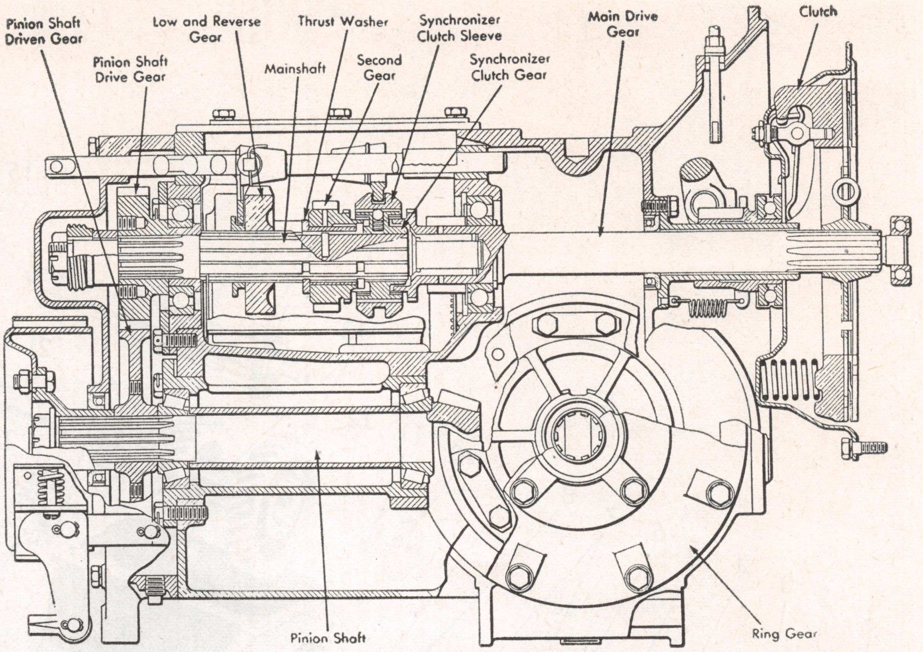
Assemble the shifter mechanism in the reverse order of removal, lubricating the poppet balls and springs, and see that the lock screws engage the holes in the rails before wiring them in place. Replace the transmission top cover.

Diamond T Model.

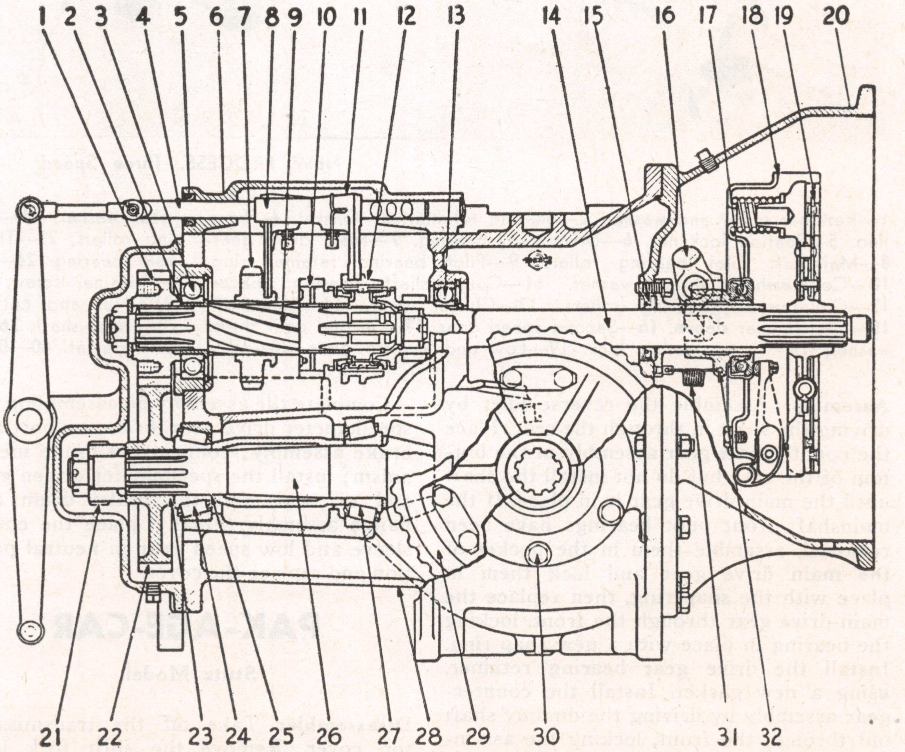
Disassemble: Disconnect the shift lever from the shift rail and remove the transmission cover assembly. Loosen the shift fork lock screws and drive the rails out rearward, driving the expansion plugs out of the cover at the same time. Remove the reduction gear housing. Set the transmission in two gears to prevent the mainshaft from turning and unscrew the nut which retains the reduction gear on the mainshaft. Use a suitable puller to remove the mainshaft reduction gear. Withdraw the mainshaft assembly through the mainshaft bearing bore.

Remove the main drive gear by pushing it into the transmission and lift it out through the top. The drive gear bearing is then removed after releasing the snap ring.

To remove the countershaft, use a dummy shaft which is the same length as the cluster gear and thrust washers combined and drive the countershaft out, allowing the dummy shaft to remain in the cluster to hold the needle bearings in place. Drive out the reverse idler gear shaft and lift out the gear.

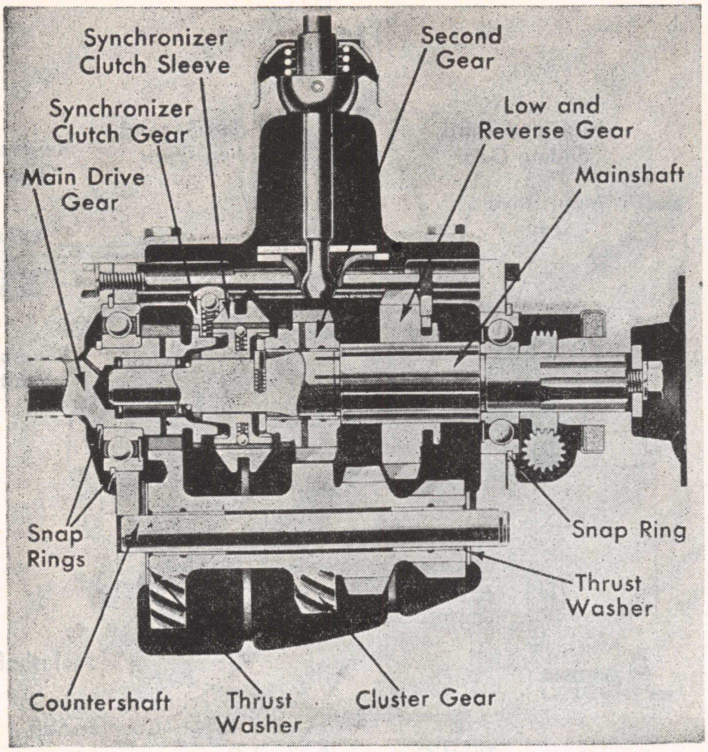


PAK-AGE-CAR. Stutz Model. Showing Clutch, Transmission and Differential.

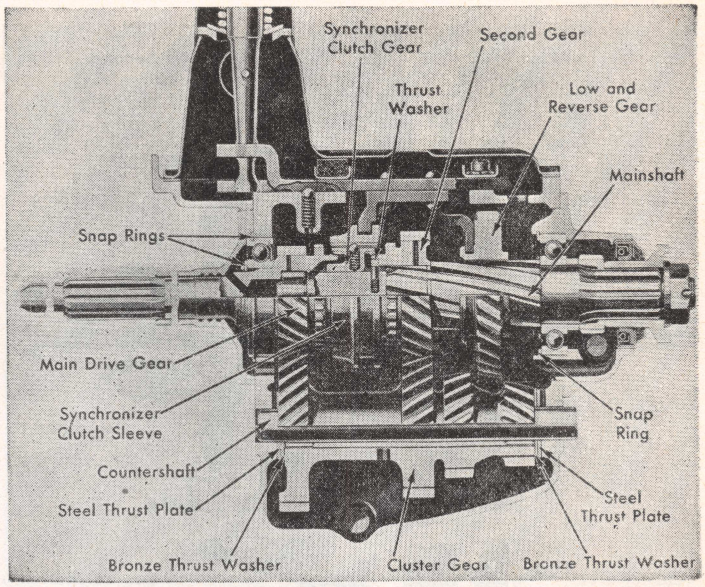


PAK-AGE-CAR. Diamond T Model. Showing Clutch, Transmission and Differential.

1—Pinion shaft drive gear. 2—Shim. 3—Transmission mainshaft bearing. 4—Shift rail. 5—Shift rail seal. 6—Transmission cover. 7—Mainshaft low and reverse gear. 8—Shift fork. 9—Mainshaft. 10—Mainshaft second speed gear. 11—Shift fork. 12—Synchronizer assembly. 13—Main drive gear bearing. 14—Main drive gear. 15—Drive gear oil seal. 16—Clutch throwout yoke. 17—Clutch throwout bearing. 18—Clutch. 19—Clutch driven disc. 20—Clutch housing. 21—Speedometer drive gear. 22—Pinion shaft driven gear. 23—Shim. 24—Pinion shaft bearing. 25—Shim. 26—Pinion shaft. 27—Pinion shaft bearing. 28—Housing. 29—Ring gear. 30—Ring gear screw. 31—Clutch throwout bearing spring. 32—Clutch throwout bearing carrier.



WARNER. Model T84, Three-Speed, Synchromesh.



WARNER. Model T86, Three-Speed, Synchromesh.

Mainshaft: To disassemble, slip the low speed gear and synchronizer assembly from the shaft. Remove the second speed gear thrust washer and take off the gear. Mark the relationship of the synchronizer clutch sleeve with the clutch gear so that assembly may be made in the original position, then push the gear out of the sleeve.

NOTE—When assembled, be sure the synchronizer friction spring engages the notches in the center of the clutch sleeve teeth. When installed on the mainshaft, the straight portion of the synchronizer sleeve should face the second speed gear.

Assemble: Install the reverse idler gear and shaft. If the cluster gear has been disassembled, insert the dummy shaft and pack the ends of the cluster gear with grease to hold the needle bearings in place when they are installed. Assemble the thrust washers, using grease to hold them in place also, then place the assembly in the case, driving the dummy shaft out with the regular countershaft.

Install the main drive gear bearing, using a new snap ring. Insert the drive gear through the inside of the transmission. Lubricate the mainshaft pilot bearing and place it in the drive gear pocket. Insert the mainshaft through the mainshaft bearing bore, being sure to use a new snap ring in back of the mainshaft bearing.

Install the mainshaft reduction gear, lock the mainshaft and fasten the nut securely. Replace the reduction gear housing. Assemble the shift rails and forks in the reverse order of removal, lubricating the balls and springs before replacing; see that the lock screws engage the holes in the rails before wiring them in place.

NOTE—New expansion plugs should be used, and if the shift rail oil seal shows evidence of wear, install a new one. Replace the transmission cover and connect the shift lever to the shift rail.

WARNER

MODEL T84

Three-Speed Synchromesh Used on Willys.

Disassemble: Take off the transmission cover. Remove the shift rail retainer screws and lift out the shift rail and fork assembly, being sure to collect the poppet balls and springs. Lock the transmission in two gears to prevent the mainshaft from turning and remove the bolt from the end of the mainshaft. Use a puller if necessary, to take off the universal flange. Remove the speedometer driven gear and disconnect the mainshaft rear bearing retainer from the case.

Remove the lock plate and drive the countershaft out through the rear, allowing the cluster gear to lie in the bottom of the case. Remove the main drive gear bearing retainer and pull the gear and bearing assembly out through the front. Tap the mainshaft toward the rear until the rear bearing is clear of the case and pull off the bearing. Lift the mainshaft and gear assembly out through the top. Remove the countershaft gear assembly out of the transmission. Drive the reverse idler shaft out rearward and lift out the gear.

Mainshaft: To disassemble, slip the synchronizer and low speed sliding gear from the mainshaft. Use a pointed tool to push the lock plunger down to permit the second speed gear thrust washer to be turned so that its splines align with the grooves on the mainshaft, after which, the washer and gear may be removed.

Synchronizer: Before disassembling the unit, mark the relationship between the clutch gear and the sleeve so that assembly may be made in the original position. Wrap a cloth around the assembly to avoid losing the balls and springs and push the gear out of the sleeve.

NOTE—To assemble, apply a liberal quantity of grease in the holes in the clutch gear and install the balls and springs. Use a piston ring compressor-type clamp to compress the assembly enough to slide the clutch sleeve in position.

Assemble: Assemble the reverse idler gear by driving the shaft in through the rear. Place the countershaft gear assembly in the bottom of the case, using grease to hold the thrust washers in place. Assemble the mainshaft gears in the reverse order of removal and install the assembly in the case. Replace the mainshaft rear bearing, speedometer drive gear and sleeve.

Attach the rear bearing retainer to the case and install the universal flange. Install the bolt and washers to the rear of the mainshaft. Replace the main drive gear and bearing assembly through the front and attach the bearing retainer. Align the countergear assembly and drive the countershaft in through the rear, locking the idler shaft and countershaft in position with the lock plate and bolt. Assemble the shifter mechanism and replace the cover.

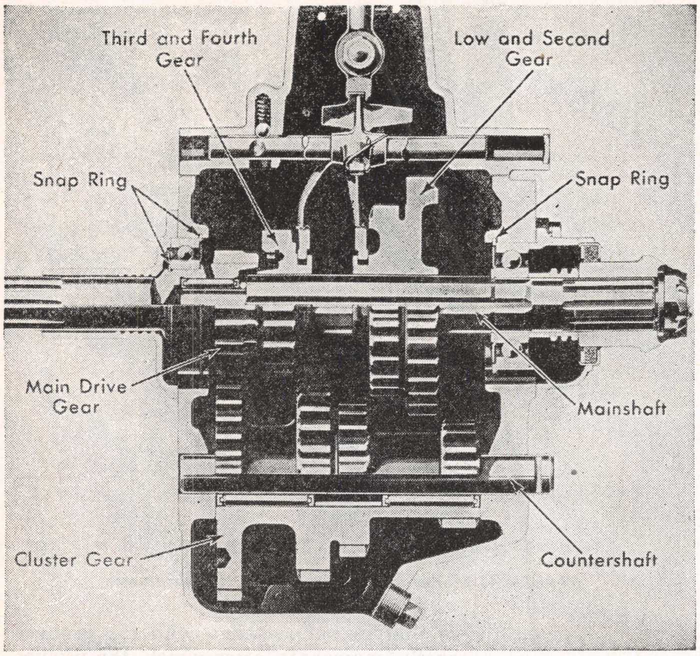
MODELS T86, T88

Three-Speed Synchromesh.

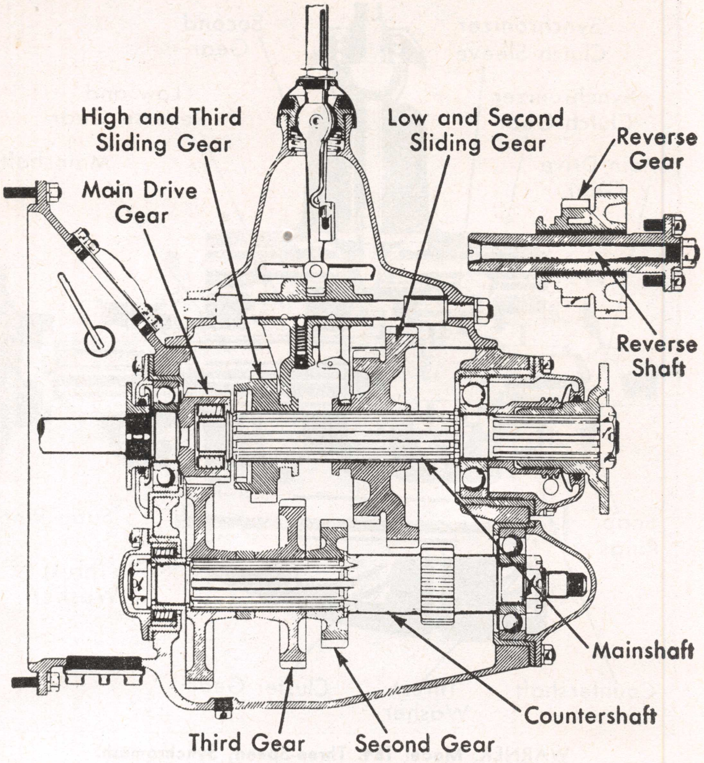
Model T86 used in Dodge and Plymouth; Model T88 on Studebaker.

DISASSEMBLE

Shift Mechanism: Remove the shift rail retainer screws and lift out the shift rail



WARNER. Models T9, T9A, Four Speed.



WHITE. Models 3B, 4B, 5B, Four Speed.

and fork assemblies. Take out the balls and springs from the front end of the case under the shift rails.

Mainshaft: Lock the transmission in two gears to prevent the mainshaft from turning. Using a suitable puller, take off the transmission companion flange and brake drum assembly. Withdraw the mainshaft assembly through the rear of the case, being careful not to damage the synchronizer.

NOTE—Before disassembling the mainshaft, mark the relationship of the synchronizer clutch sleeve with the clutch gear so that, if disassembled, assembly may be made in the original position.

Slip the synchronizer from the mainshaft. Remove the second speed gear by using a suitable pointed tool through a hole in the second speed gear thrust washer and depress the spring plunger. Turn the washer until its splines align with the grooves on the mainshaft, after which, the washer and second speed gear can be removed from the shaft.

NOTE—After installing the second speed gear, check its end play by inserting a feeler gauge between the back face of the gear and the butt end of a spline on the mainshaft. End play should be from .003″ to .008″ and if not within these limits, thrust washers of several thicknesses are available to obtain this clearance.

Synchronizer: To disassemble this unit, wrap a cloth around the assembly to avoid losing the balls and springs; then separate the clutch sleeve from the gear.

NOTE—To assemble the unit, apply a liberal quantity of grease in the holes in the clutch gear, and also to the balls and springs. Position the balls and springs in the clutch gear. Use a clamp—similar to a ring compressor—to compress the assembly enough to enable the sleeve to be installed.

CAUTION—When replacing the synchronizer assembly on the mainshaft, be sure that the hub portion of the gear and the tapered portion of the sleeve are toward the front.

Main Drive Gear: NOTE—Before this assembly can be removed, the countershaft must be driven out, allowing the countergear cluster to lie in the bottom of the case.

Take off the main drive gear bearing retainer and, after removing the snap ring, pull the main drive gear assembly out rearward.

NOTE—Before installing the gear, be sure to place the countergear assembly in the bottom of the case, but **do not** install the countershaft until after the main drive gear is in position.

Countershaft: Remove the countershaft locking plate and, using a dummy shaft (or arbor) to hold the needle bearings in place, drive the shaft out rearward, allowing the countergear assembly to lie in the bottom of the case until the main drive gear is removed—as already explained.

NOTE—To install the assembly: Insert the bearing spacer into the gear and then, install the dummy shaft (or arbor) which was used when removing the assembly. Apply a liberal amount of cup grease at each end of the gear and insert the needle bearings. After the needle bearings are properly inserted, place a steel thrust plate at each end of the gear, and a bronze thrust washer at each end of the assembly, using cup grease to hold them in position. Place the entire assembly into the case and, before installing the regular countershaft, replace the main drive gear assembly. Position the countergear assembly and drive the dummy out by installing the regular countershaft through the rear.

The end play of the countershaft should be from .002″ to .008″ and can be checked by forcing the assembly toward the front. Then insert a feeler gauge between the thrust washer and the case at the rear. Thrust washers are available in several thicknesses to obtain this clearance.

Reverse Idler: Lift the reverse idler out of the case after driving the shaft out through the rear.

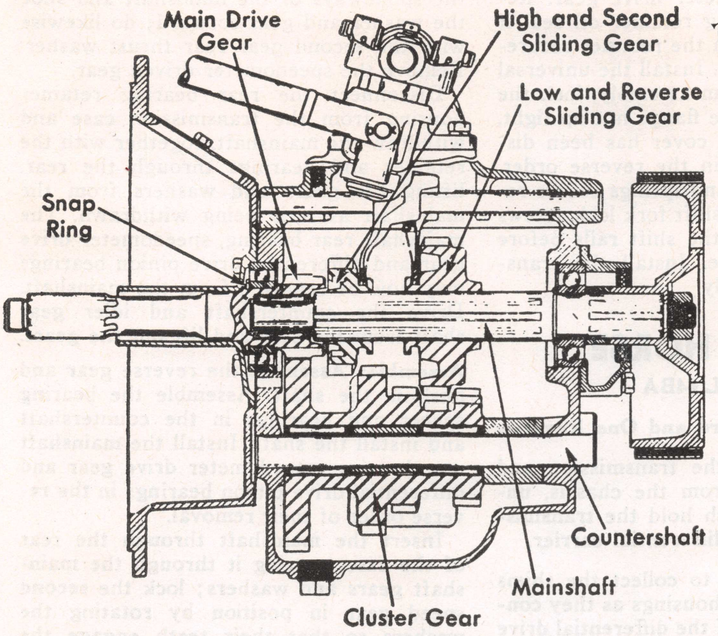
Assemble: Reverse the order of removal to assemble the transmission. To insure a proper fit in their grooves, snap rings which have been removed should be replaced with new ones.

MODELS T9, T9A

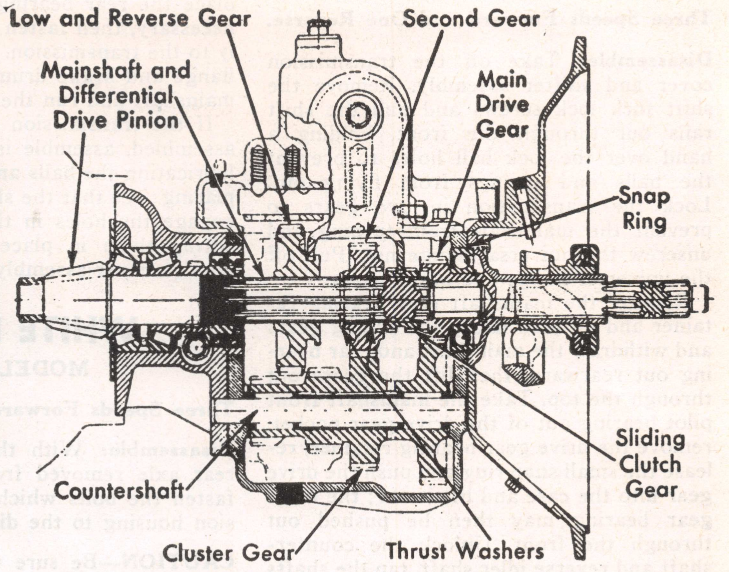
Four-Speed Sliding Gear.

NOTE—The following instructions also apply to White models 18A, 18BA, 45B, 46B.

Disassemble: Set the gearshift lever in neutral, remove the cover screws and lift off the transmission cover and shifter assembly. Unscrew the nut from the universal flange and take off the hand brake



WHITE. Model 60B, Three Speed.



WHITE HORSE. Model 64BA, Three Speed.

band, brake drum and universal flange. Remove the bell housing and disconnect the main drive gear bearing retainer and remove the gear and bearing through the front. Take off the mainshaft rear bearing retainer, oil seal and speedometer drive gear.

NOTE—Before removing the mainshaft, mark the relationship of the mainshaft splines with the matching splines in the sliding gears so that assembly may be made in the original position, as these gears are a selective fit on the shaft splines.

Grasp the mainshaft gears and withdraw the shaft and rear bearing out through the rear and lift the gears out through the top. Remove the countershaft lock plate, tap the shaft out through the rear and lift out the cluster gear. Pull out the cotter pin from the front end of the reverse shift rail, drive out the rail and lift out the fork. Tap the reverse idler shaft out rearward and lift out the gear.

Shifter Mechanism: Press down on the shift lever housing cap and take out the lock pins. On some units, the cap is screwed to the housing. Remove the shift lever ball. Remove the reverse latch spoon by taking out the bolt and nut located directly under the shift rail. Remove the reverse latch and slide the springs and washers from the lever. Unfasten the shift fork lock screws and drive the shift rails out through the rear, forcing out the expansion plugs at the same time. Be sure to collect the poppet balls and springs as the rails are being removed.

Assemble in the reverse order, being sure to install new expansion plugs and, after tightening the shift fork lock screws, wire them securely.

Assemble: Assemble the reverse idler gear by tapping the shaft in through the rear. Place the countergear assembly in the case with the bearings and bearing spacer in position, then replace the reverse rail and fork, locking the rail in place with a cotter pin. Assemble the countershaft through the rear and replace the lock plate and screw.

NOTE—Install the mainshaft through the rear of the case, slipping on the sliding gears, being sure that the marked splines of the gears and shaft are meshed. The larger gear belongs at the rear and shift fork channels must face each other.

Assemble the speedometer gear and rear bearing retainer. Install the main drive gear and bearing assembly through the front, using a new snap ring. Fasten the main drive gear bearing retainer in place, using a new gasket. Complete the assembly by replacing the universal flange and brake drum, brake band, the transmission cover assembly and the bell housing.

WHITE

MODELS 3B, 4B, 5B

Four Speeds Forward and One Reverse.

NOTE—For service instructions on other White units, see index.

Disassemble: Take off the transmission cover and shifter assembly. Remove the pins from the shift forks, take out the screws and allow the balls and springs to drop out. Unscrew the nuts from the rear end of the rails and pull the rails out forward. Lock the transmission in two gears to prevent the mainshaft from turning and unscrew the universal flange nut. Pull off the flange, remove the speedometer driven gear, disconnect the rear bearing retainer from the case and take off the speedometer drive gear.

Grasp the mainshaft sliding gears and withdraw the shaft, together with the rear bearing and bearing sleeve through the rear of the case. Remove the main drive gear companion flange, disconnect the drive gear bearing from the case and pull the drive gear, together with its bearing and sleeve out through the front.

Remove the front and rear countershaft bearing retainer caps, unscrew the nuts from the ends of the countershaft, push the shaft to the rear until the rear bearing and sleeve can be removed and lift the countershaft assembly out of the case by its front end. Unscrew the bolts which retain the reverse gear shaft, pull out the shaft and lift out the gear.

Assemble: Assemble the reverse gear with the large gear to the rear and push in the shaft, fastening it securely in place with the cap screws. Install the countershaft front bearing and sleeve in the case and place the countershaft assembly in position, after which, the rear bearing and sleeve may then be assembled. Install the front and rear nuts to the countershaft, locking them securely in place, then replace the bearing retainers.

Assemble the main drive gear, being sure the oil seal is in good condition and install the assembly through the front of the case. Lubricate the main shaft front pilot bearing and place it in the drive gear pocket. Pass the mainshaft through the rear of the case, installing the sliding gears on the shaft as it is being inserted. Replace the mainshaft rear bearing and sleeve, slip the speedometer drive gear on the shaft and fasten the rear bearing retainer securely in place, being sure the oil seal is in good condition. Install the universal flange, lock the mainshaft and run the flange nut up tight. Assemble the transmission cover in the reverse order of removal and install the cover to the transmission.

MODEL 60B

Three Speeds Forward and One Reverse.

Disassemble: Take off the transmission cover and shifter assembly. Remove the shift fork lock screws and pull the shift rails out through the front, holding a hand over the lock ball holes to prevent the balls and springs from flying out. Lock the transmission in two gears to prevent the mainshaft from turning and unscrew the universal flange nut. Pull off the universal flange and brake drum.

Remove the mainshaft rear bearing retainer and oil seal. Grasp the sliding gears and withdraw the mainshaft and rear bearing out rearward, then lift the gears out through the top. Take the mainshaft front pilot bearing out of the drive gear pocket, remove the drive gear bearing retainer, release the small snap ring and push the drive gear into the case and lift it out; the drive gear bearing may then be pushed out through the front. Unlock the countershaft and reverse idler shaft, tap the shafts out rearward and lift out the gears.

Assemble: Assemble the reverse idler gear and push the shaft in through the rear. Install the bearing spacer and roller bearings in the countergear, using grease to hold them in position, then drive the countershaft in through the rear. Install new snap rings in the drive gear and rear mainshaft bearing bores. Insert the main drive gear bearing in its bore and replace the drive gear through the inside of the case. Lock the drive gear in position by installing a new snap ring in the groove in front of the bearing. Fasten the drive gear bearing retainer securely to the case.

Lubricate the mainshaft pilot bearing and place it in the drive gear pocket. Insert the mainshaft through the rear of the case, passing the sliding gears on the shaft at the same time. Install the mainshaft rear bearing and speedometer drive gear. Replace the rear bearing retainer oil seal if necessary, then fasten the retainer securely to the transmission. Install the universal flange and brake drum assembly, lock the mainshaft and run the flange nut up tight.

If the transmission cover has been disassembled, assemble in the reverse order, lubricating the balls and springs before replacing; see that the shift fork lock screws engage the holes in the shift rails before wiring them in place. Install the transmission cover assembly.

WHITE HORSE

MODEL 64BA

Three Speeds Forward and One Reverse.

Disassemble: With the transmission and rear axle removed from the chassis, unfasten the bolts which hold the transmission housing to the differential carrier.

CAUTION—Be sure to collect the shims separating these two housings as they control the adjustment of the differential drive pinion.

Remove the transmission cover and shifter assembly. Take out the shift fork lock screws and pull the shift rails out through the front of the cover, holding a hand over the lock ball holes to prevent the balls and springs from flying out. Remove the clutch release mechanism, the bell housing and the main drive gear bearing retainer. Pull the main drive gear and bearing assembly out through the front and take out the mainshaft pilot bearing from the drive gear pocket. The drive gear and bearing may be separated after removing the retaining snap ring.

Slip the sliding clutch gear from the mainshaft and pull it out through the front. Rotate the second speed gear front thrust washer so that its teeth align with the splineways of the mainshaft and slide the washer and gear forward; do likewise with the second gear rear thrust washer. Remove the speedometer driven gear.

Disconnect the rear bearing retainer housing from the transmission case and withdraw the mainshaft, together with the retainer and bearings through the rear, lifting the gears and washers from the mainshaft as it is being withdrawn. The mainshaft rear bearing, speedometer drive gear and differential drive pinion bearings may now be removed from the mainshaft. Drive the countershaft and idler gear shaft from the case and lift out the gears.

Assemble: Assemble the reverse gear and push in the shaft. Assemble the bearing spacer and bearings in the countershaft and install the shaft. Install the mainshaft rear bearing, speedometer drive gear and differential drive pinion bearings in the reverse order of their removal.

Insert the mainshaft through the rear of the case, passing it through the mainshaft gears and washers; lock the second speed gear in position by rotating the washers so that their teeth engage the splines of the mainshaft. Slip the sliding clutch gear in position on the shaft. Lubricate the mainshaft pilot bearing and place it in the drive gear pocket.

Assemble the drive gear and bearing, using new snap rings and install through the front. Fasten the drive gear retainer to the case, install the bell housing and clutch release mechanism. Assemble the transmission cover in the reverse order of removal, being sure to lubricate the lock balls and springs before replacing, then install the cover to the transmission.

NOTE—The transmission assembly is now ready to be attached to the differential, but if repairs are to be made to the carrier assembly, see the "Front and Rear Driving Axles" chapter.

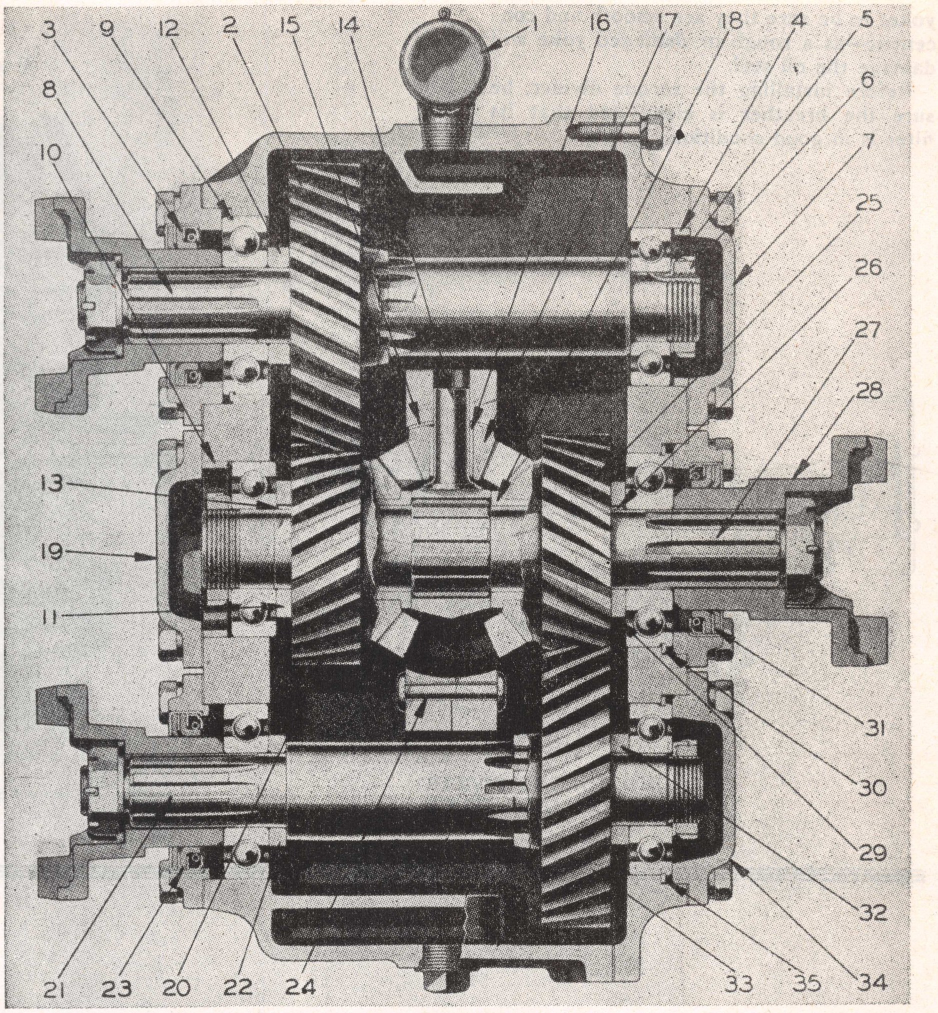
TORQUE DIVIDERS

TIMKEN

MODELS T-50, T-70

Model T-50 is a single-speed unit driven by the transmission through a propeller shaft connecting the two units. It consists of two output shafts, each of which is connected to one of the two rear driving axles. The center shaft, which is the main driving shaft, carries an inter-axle differential which distributes driving torque to the two output shafts in proportion to the traction available at the rear wheels.

Model T-70 is a two-speed torque divider, similar in construction to the T-50 model, except that an extra set of gears is incorporated within the case, providing an additional gear ratio. A sliding clutch on the center shaft is used to lock out the differential.



SINGLE-SPEED TORQUE DIVIDER, MODEL T-50

1—Breather. 2—Left output shaft drive gear. 3—Oil seal. 4—Spacing sleeve. 5—Lock plate. 6—Lock nut. 7—Front bearing cap. 8—Left output shaft. 9—Snap ring. 10—Spacing sleeve. 11—Mainshaft spacing washer. 12—Left output shaft spacing washer. 13—Spacing washer key. 14—Differential pinion spider. 15—Pinion gear thrust washer. 16—Pinion gear bushing. 17—Pinion gear. 18—Side gear bushing. 19—Mainshaft rear bearing cap. 20—Differential side gear. 21—Right output shaft. 22—Rear bearing spacer. 23—Oil seal. 24—Differential case rivet. 25—Differential side gear. 26—Spacing washer key. 27—Main drive shaft. 28—Driving yoke. 29—Mainshaft spacing washer. 30—Snap ring. 31—Oil seal. 32—Front bearing spacer. 33—Right output shaft drive gear. 34—Front bearing cap. 35—Snap ring.

TORQUE DIVIDER, OVERHAUL

NOTE—If the unit being serviced is equipped with ball bearings, it is important that the spacers on the mainshaft be suitably tagged as to their proper location so that when assembled, the edges of the constant mesh gears are flush with each other. Where tapered roller bearings are used, all bearing covers, shims and bearings should also be tagged so the original bearing adjustment is maintained and also for proper gear alignment.

Oil seals should be carefully inspected, and if the slightest indication of wear is apparent, they should be discarded and replaced with new parts. Failure to replace oil seals whenever the unit is overhauled may result in premature wear of more expensive parts.

Tapered roller bearings should be so adjusted as to eliminate any lateral movement of the bearings, but not so tight that a thrust load will be thrown on the bearings when the caps are drawn down tight against the shims. In other words, sufficient shims should be used behind the bearing caps so that the shaft is free-turning with end play not exceeding .004".

The edges of constant mesh gears should be flush with each other, and there should be clearance between the gears and the edge of the case to prevent the gears from rubbing against the case cover. To obtain the proper tooth contact when equipped with tapered roller bearings, remove or add shims under the bearing caps as required. Where no shims are used, spacers of the proper thickness should be installed to obtain the desired result.

NOTE—When shims are removed from behind one bearing cap for the purpose of aligning gears, an equal quantity and thickness of shims should be removed or added to the opposite bearing cap so as to maintain the proper bearing adjustment.

Disassemble: Unscrew the nuts from the ends of the shafts and pull off the universal flanges. Remove the output shaft bearing caps and, if ball bearing equipped, unscrew the shaft nuts. Take off the front cover, the top cover and the baffle plates; all the shafts may now be lifted from the case and stripped, tagging each gear, bearing and spacer as to their location to insure correct assembly.

To disassemble the differential, mark the relative position of the case halves so that assembly may be made in the same position. If the case is riveted, use a drill which is smaller than the rivet and drill through the heads to a depth just below the bottom of the rivet head. Then cut off the heads of the rivets with a chisel and punch the rivets out of the case. Separate the case and remove all parts.

Inspection: Helical gear backlash should be from .003" to .005". Clearance between the mainshaft and side gear bushings, .0016" to .0029"; between the main drive shaft and spider splines, .001" to .0025"; between the output shafts and gear splines, tight to .001"; between the spider and pinion bushings, .0016" to .0034".

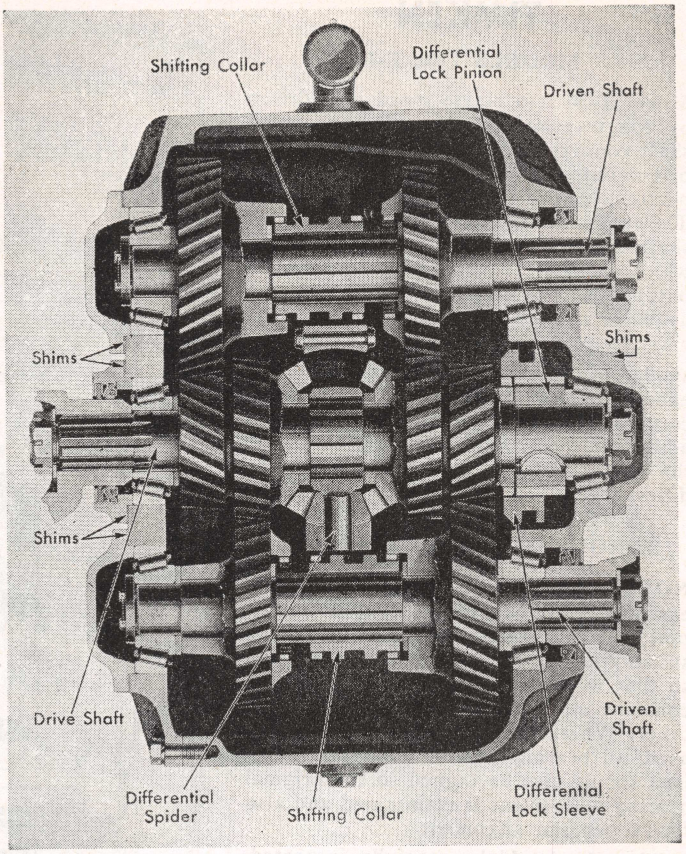
Assemble: Reverse the order of disassembly to assemble the unit, being sure the halves of the differential case are assembled according to the marks made before the unit was taken apart. It is recommended that a special riveting fixture be used when assembling the case to insure the correct seating of the two halves.

Make sure all gaskets are in good condition and of the original thickness, as leakage and misalignment is sure to result if improper gaskets are used. Check the sealing surface of the universal flange

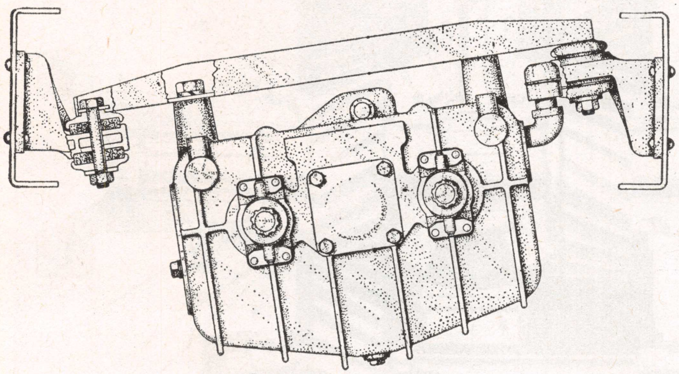
TORQUE DIVIDERS

yokes to be sure they are smooth and concentric—as a rough or damaged yoke will damage the oil seal.

Before installing the torque divider, be sure the breather is clean and that its filter is in good condition.


Shifting Collar
Differential Lock Pinion
Driven Shaft
Shims
Shims
Shims
Drive Shaft
Driven Shaft
Differential Spider
Shifting Collar
Differential Lock Sleeve

TWO-SPEED TORQUE DIVIDER, MODEL T-70



SHOWING TORQUE DIVIDER MOUNTED ON GMC TRUCK

TRANSFER CASE

A transfer case is either a single or two-speed unit—driven by the main transmission—which delivers power to two or three driving axles. The two-speed type is essentially an auxiliary transmission which provides a speed reduction within the case. The selection of the high or low-speed range is controlled by a lever, independent of the main transmission. The front axle declutching unit (when equipped) is supported in a carrier at the front end of the transfer case driven shaft, and its engagement and disengagement is accomplished by another lever. When operating in the high-speed range, the front axle may be declutched, and is engaged when operating in the low-speed range to provide additional power when operating up steep grades, hard pulling or "off-the-road."

Some transfer cases are equipped with a conventional type differential installed between the front and rear output shafts within the case.

The single-speed type is generally used on light four-wheel drive vehicles and delivers power to the front driving axle through the idler gear in the same manner as the two-speed unit. The front drive may be eliminated by sliding the driven gear out of mesh.

TRANSFER CASE, SERVICE

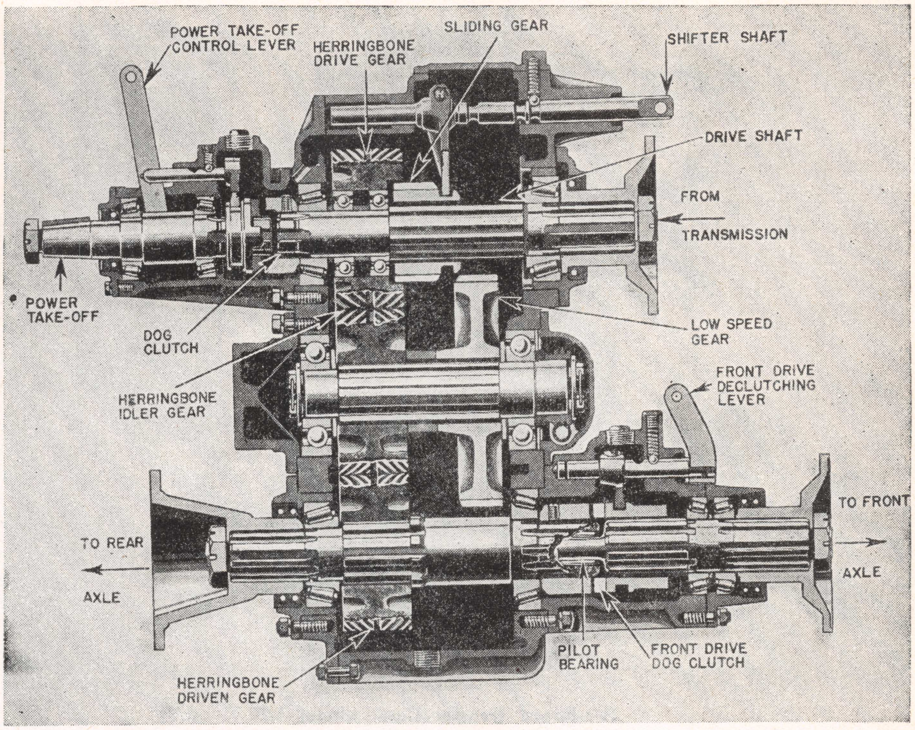
NOTE—Inasmuch as these units are similar in design, the following remarks regarding the inspection of parts when the unit is dismantled for overhaul purposes, as well as precautionary measures to observe relative to adjustments, etc., applies to all units, and distinctions are made only where variations occur.

Clean the case, covers, bearings and cages thoroughly, paying special attention to the oil passages at the bottom of the case in the front axle declutching unit (when equipped) and the main drive gear bearing cages. In addition, when a breather cap is used in the main drive gear bearing cage, it should be removed and cleaned thoroughly in gasoline or other cleaning solution.

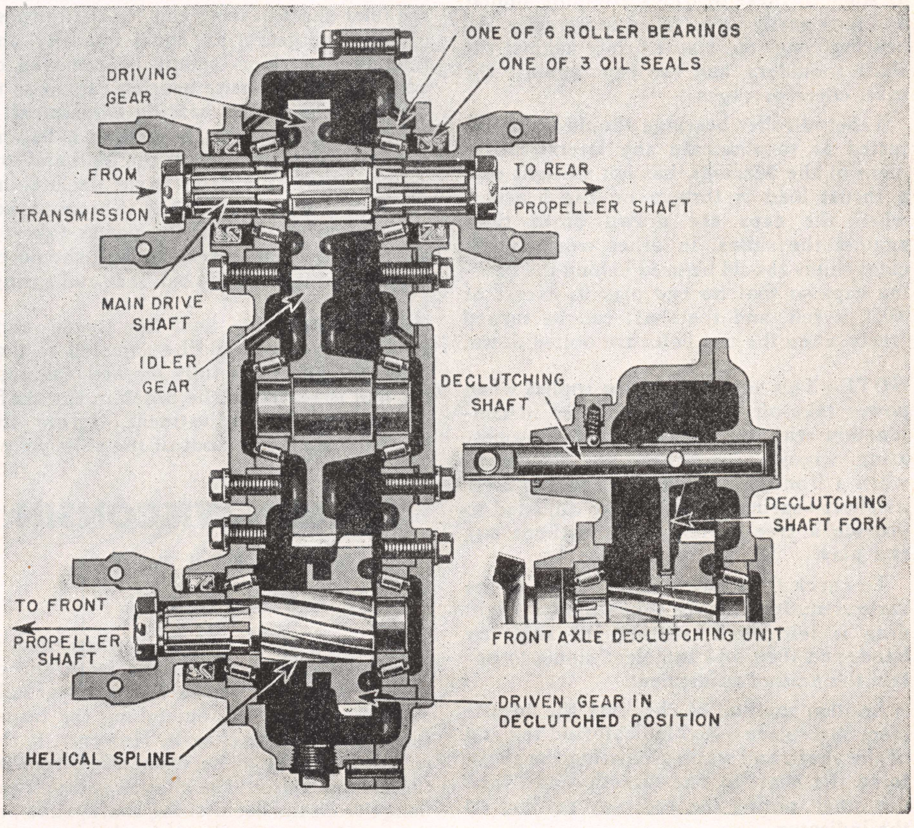
Oil seals should be carefully inspected, and if the slightest indication of wear is apparent, they should be discarded and replaced with new parts. Failure to replace oil seals whenever the case is overhauled may result in premature wear of more expensive parts through a loss of lubricant caused by worn oil seals.

Inspect the gears for evidence of wear, chipped or broken teeth. The mainshaft sliding gear and the declutch unit sliding gear should be checked for clearance between the gear and the shaft splines, and in either case, the clearance should not exceed .004".

Mainshaft drive gear thrust washers should be discarded and replaced with new parts if any indication of wear is evident. Clearance between the mainshaft and bushing should be from .0006" to .0019". Be sure the drilled oil hole in the gear and bushing is carefully cleaned.


POWER TAKE-OFF CONTROL LEVER
HERRINGBONE DRIVE GEAR
SLIDING GEAR
SHIFTER SHAFT
DRIVE SHAFT
FROM TRANSMISSION
POWER TAKE-OFF
DOG CLUTCH
LOW SPEED GEAR
FRONT DRIVE DECLUTCHING LEVER
HERRINGBONE IDLER GEAR
TO FRONT
TO REAR
AXLE
AXLE
PILOT BEARING
FRONT DRIVE DOG CLUTCH
HERRINGBONE DRIVEN GEAR

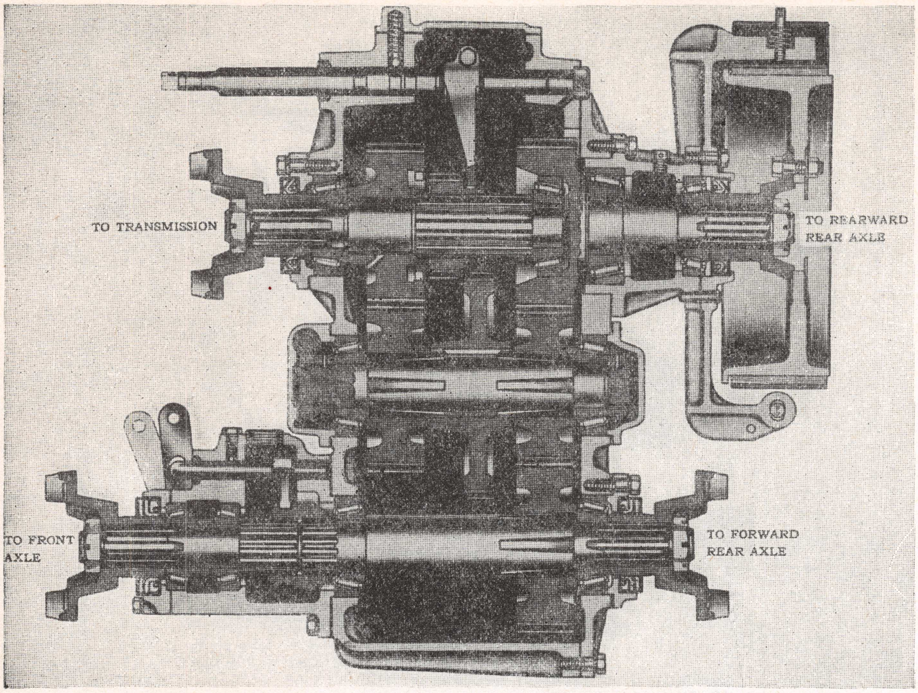
Two-Speed Transfer Case With Herringbone Gears and Power Take-Off


ONE OF 6 ROLLER BEARINGS
ONE OF 3 OIL SEALS
DRIVING GEAR
FROM TRANSMISSION
TO REAR PROPELLER SHAFT
MAIN DRIVE SHAFT
IDLER GEAR
DECLUTCHING SHAFT
DECLUTCHING SHAFT FORK
TO FRONT PROPELLER SHAFT
FRONT AXLE DECLUTCHING UNIT
DRIVEN GEAR IN DECLUTCHED POSITION
HELICAL SPLINE

Single-Speed Transfer Case

As each bearing cover is removed, the thickness and quantity of shims used should be noted and the cover and shims should be tagged to assure correct assembly. However, if new parts are to be installed, it may be necessary to make adjustments by adding or removing shims as required to obtain proper bearing adjustment.

TRANSFER CASE



Two-Speed Transfer Case, Model T-79

Each tapered bearing cone and cup should be replaced in its original location, as some of these bearings are quite similar and may easily be installed incorrectly. All bearing cones must seat firmly against the shaft shoulders, and the cups against the case, cover or cages.

Tapered roller bearings should be so adjusted as to eliminate any lateral movement of the bearings, but not so tight that a thrust load is thrown on the bearings when the caps are drawn down tight against the shims. In other words, sufficient shims should be used behind the bearing caps so that no end play in excess of .005" is felt, and the shaft can be turned freely when the cap bolts are bolted down.

NOTE—This adjustment also applies when power take-off equipment is used in conjunction with the transfer case for operating wreckers, winches, etc. However, when a front axle declutching unit is used, its shaft bearings should be so adjusted to provide a free-turning shaft without any end play.

To check the bearing adjustments of the various shafts, remove shims until a slight drag is felt when rotating the shaft by hand, and then add sufficient shims to obtain the desired adjustment.

Another method of checking the adjustment is to place a dial indicator on the end of the shaft, and while oscillating the shaft, force the shaft in one direction and then the other, noting the end play reading on the indicator.

The edges of constant mesh gears should be flush with each other, and there should be clearance between the gears and the edge of the case to prevent the gears from rubbing against the case cover. To obtain the proper tooth contact, remove or add shims under the bearing caps as required.

NOTE—If shims are removed or added to the idler shaft bearing cap for the purpose of aligning gears, an equal quantity and thickness of shims should be removed or added to the opposite bearing cap so as to maintain the proper bearing adjustment.

Be sure to replace the poppet balls and springs which are used at the high and low shifter shaft, the front axle declutching shaft (when equipped), and if power take-off equipment is used, the power take-off shift shaft. In all cases, the ball should be installed first, then the ball seat and spring.

NOTE—The high and low speed shift shaft and yoke should be adjusted so that when the gears are fully meshed, the poppet ball is seated in the notch in the shaft. To make this adjustment, screw the threaded shaft in or out of the shift yoke.

TIMKEN—WISCONSIN

MODELS T-2, T-7, T-76

DISASSEMBLE

Declutching Unit: This unit, when used, is supported in a carrier at the front end of the transfer case driven shaft and usually can be removed without taking the transfer case from the chassis. However, if the transfer case is to be dismantled, remove the assembly from the chassis and pull the flange from the declutching shaft. Take out the clevis pins holding the lever to the shift rail and unscrew the bolt which fastens the lever to the declutching unit. Take out the screw from the top of the carrier and turn the housing upside down to allow the poppet ball and spring to drop out. Unscrew the pipe plug from the housing and through this opening, loosen the set screw from the fork and pull the rail out of the front of the carrier, then lift out the fork. Remove the packing from the rail opening and take off the bearing cap and oil seal assembly. Take out the shaft and bearing assembly through the front of the carrier, stripping off the sliding clutch jaw.

Power Take-Off: This unit, when used, is usually mounted on the rear end of the transfer case drive shaft and is removed in the following manner: Pull the sprocket from the end of the shaft and remove the power take-off shift lever. Unscrew the pipe plug from the top of the case and through this opening, loosen the screw which holds the fork to the shift rod. Remove the set screw from the top of the case, turn the case upside down to allow the poppet ball and spring to drop out. Pull out the take-off shift rod and, while holding the shift fork to one side, slide the jaw clutch from the take-off shaft, then work out the fork. Remove the bearing cap from the end of the case and press the shaft, both bearing cones and rear cup out of the case as an assembly, pressing on the splined end of the shaft. If required, the bearing cones may then be removed from the shaft.

Transfer Case: To disassemble, lay the case on its flat side with the oil filler plug facing up. Remove the drive and driven shaft flange nuts and pull off the flanges. Take off the speedometer adapter from the idler shaft front bearing cover and lift out the speedometer driven gear.

CAUTION—Remove the cap screws which fasten the bearing covers to the case and lift off the covers one at a time, noting the quantity and thickness of the shim pack used with each cover. Lay each cover and its shim pack carefully aside so as not to disturb the original bearing adjustment. Remove and discard the oil seals from the drive shaft front cover and the driven shaft rear cover.

Remove the top cover from the case and take out the breather plate and gasket, then remove the poppet ball and spring. Loosen the shifting yoke clamp bolt and screw the threaded shaft out of the yoke. Remove the packing from the shift rail opening and pull the speedometer drive gear from the front of the idler shaft, take out the Woodruff key and slip off the speedometer gear spacer.

Take off the hand hole cover, and the cover from the rear of the case. The rear cover should be removed carefully, using puller screws in the tapped holes in the cover flange. Use a soft hammer to tap the shafts out of the case one at a time, tapping them out from the front side of the case.

On models using a declutching unit, loosen the set screw which holds the driving clutch to the driven shaft and pull the clutch from the shaft. Remove the bearings from each end of the mainshaft, after which, the sliding gear, direct drive gear, bearings and spacer may be removed from the shaft.

The idler shaft and driven shaft may then be stripped of gears, bearings, spacers and driven shaft differential (when used). If the differential is to be disassembled, be sure to mark the relationship of the case halves so that assembly may be made in the original location.

Assemble: Reverse the order of the disassembly procedure to assemble the unit but particular attention should be given to the remarks made at the beginning of the chapter regarding inspection, adjustments, etc.

MODEL T-79

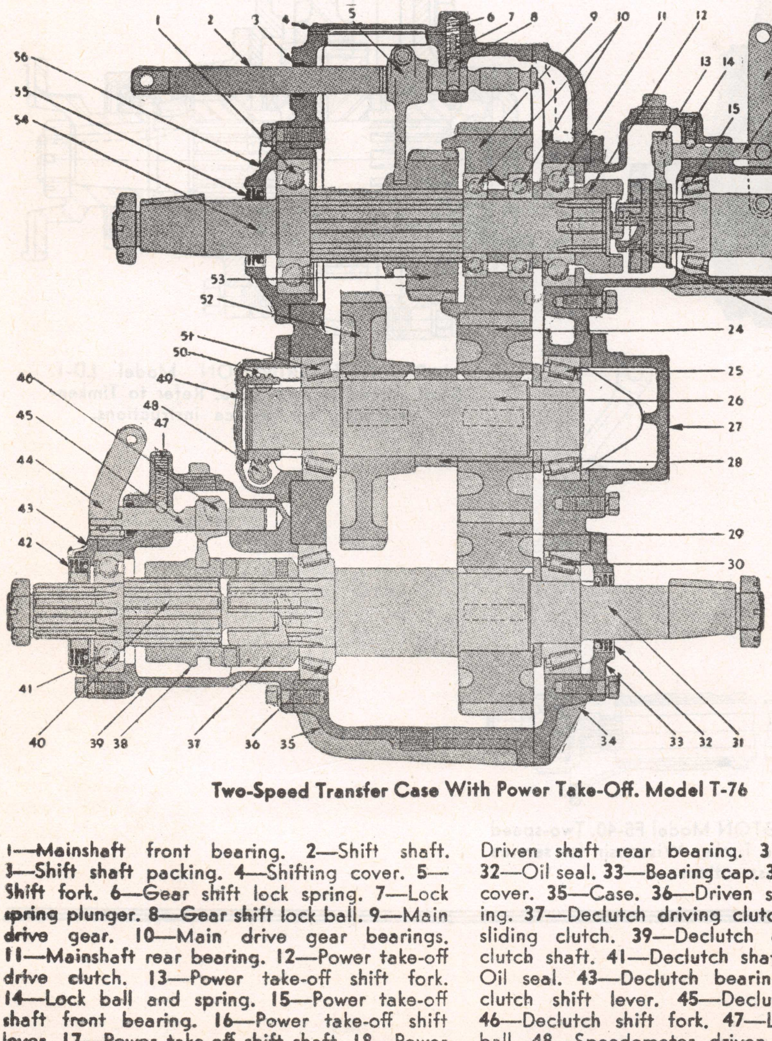
Disassemble: Take off the hand brake drum, unscrew the nuts from the propeller shaft flanges and pull off the flanges. Remove the speedometer driven gear at the front of the front idler bearing cap. Disconnect the mainshaft front bearing cap, the idler shaft front bearing cap and the cap from the front axle declutching unit.

Remove the brake spider from the rear of the main drive gear bearing cage, then take off the idler shaft rear cap and the driven shaft rear bearing cap. Take off the cover from the rear of the case. Remove the cap screws from the main drive gear bearing cage, then take out the bearings and cage as a complete assembly.

Remove the cover from the front end of the case and take out the high and low speed shift shaft poppet ball and spring. Loosen the shifting yoke clamp bolt and screw the threaded shaft out of the yoke. At this point, the mainshaft, idler shaft and driven shaft, together with the gears, may now be removed and stripped.

Mainshaft: To disassemble, push the shaft and gear out of the cage from the rear end, noting the thickness and quantity of shims behind the rear bearing cone. Use suitable pullers to remove the inner bearing cone and bearing cups.

Declutching Unit: To disassemble, remove the bearing cap and oil seal assembly, noting the thickness and quantity of shims. Unscrew the pipe plug from the housing, and through this opening, remove the set screw from the shift yoke. As the shift lever is removed from the cage, slip the shifter yoke and sliding gear over the end of the shaft.



Two-Speed Transfer Case With Power Take-Off. Model T-76

1—Mainshaft front bearing. 2—Shift shaft. 3—Shift shaft packing. 4—Shifting cover. 5—Shift fork. 6—Gear shift lock spring. 7—Lock spring plunger. 8—Gear shift lock ball. 9—Main drive gear. 10—Main drive gear bearings. 11—Mainshaft rear bearing. 12—Power take-off drive clutch. 13—Power take-off shift fork. 14—Lock ball and spring. 15—Power take-off shaft front bearing. 16—Power take-off shift lever. 17—Power take-off shift shaft. 18—Power take-off shaft rear bearing. 19—Oil seal. 20—Power take-off shaft. 21—Bearing cap. 22—Power take-off carrier. 23—Sliding jaw clutch. 24—Idler direct speed gear. 25—Idler shaft rear bearing. 26—Idler shaft. 27—Idler rear bearing cap. 28—Spacer. 29—Driven gear. 30—Driven shaft rear bearing. 31—Driven shaft. 32—Oil seal. 33—Bearing cap. 34—Transfer case cover. 35—Case. 36—Driven shaft front bearing. 37—Declutch driving clutch. 38—Declutch sliding clutch. 39—Declutch carrier. 40—Declutch shaft. 41—Declutch shaft bearing. 42—Oil seal. 43—Declutch bearing cap. 44—Declutch shift lever. 45—Declutch shift shaft. 46—Declutch shift fork. 47—Lock spring and ball. 48—Speedometer driven gear. 49—Idler front bearing cover. 50—Speedometer drive gear. 51—Idler shaft front bearing. 52—Idler low speed gear. 53—Mainshaft sliding gear. 54—Mainshaft. 55—Oil seal. 56—Mainshaft front bearing cap.

To remove the shaft and bearings from the cage, mount the assembly in a press, supporting the cage at the front end and applying pressure at the inner end of the shaft to force the shaft and bearings out of the cage. Use suitable pullers to remove the bearing cones and inner bearing cup from the shaft and cage.

Assemble: The assembly procedure is the reverse of disassembly but special attention should be given to the remarks made at the beginning of the chapter as regards maintenance and adjustments.

INTERNATIONAL

MODEL 630

Disassemble: Take off the case cover, loosen the lock nuts from the ends of the shift rails and remove the shift rail ends. Remove the gland nuts and packing from the high and low speed shifter rail and from the front axle output shaft. Loosen the set screws from the shifter forks, drive the shift rails out rearward, removing the thimbles from the case at the same time.

Mainshaft: Remove the rear retainer, and the oil seal retainer from the front mainshaft bearing. Unscrew the rear bearing lock nut, pull the mainshaft assembly far enough to the rear to permit the removal of the rear bearing and snap ring, using a puller to remove the bearing. Take the spacer from the shaft and push the mainshaft and gear assembly to the front to permit the front bearing to be pulled. Lift the mainshaft and gear assembly out through the top, after which, the shaft can readily be stripped of all gears, bearings, spacer and snap rings.

Output Shaft for Rear Axle: Remove the oil seal retainer and oil seal, and the front bearing retainer. Drive the shaft to the rear and take off successively, the lock nut, washer, snap ring, bearing and spacer. Drive the shaft toward the front and remove the front bearing, then lift the shaft and gear out of the case.

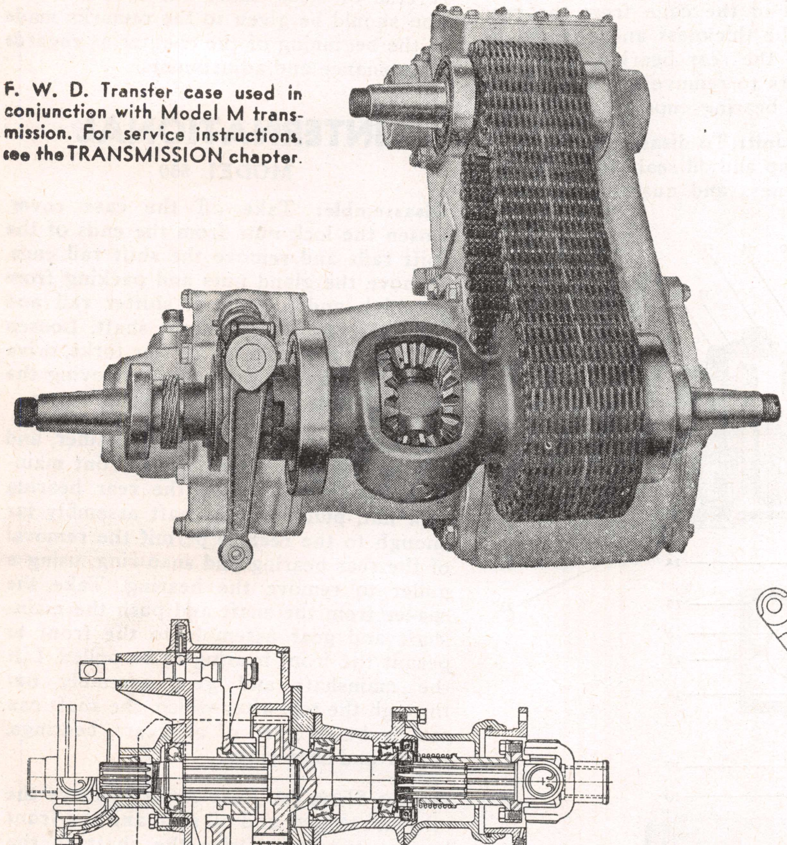
Idler Shaft: Remove the idler shaft front retainer and take off the lock nut, speedometer drive gear and spacer. Remove the rear bearing retainer, unscrew the lock nut and drive the shaft toward the rear and pull off the rear bearing. Drive the shaft toward the front and pull off the front bearing and snap ring, after which, withdraw the shaft out through the gears and case.

Front Axle and Forward Rear Axle Output Shafts: Remove the front and rear retainers and take out the oil seals. Drive the forward rear axle shaft toward the front and remove the bearing from the front axle shaft, then withdraw this shaft from the clutch gear and out of the case.

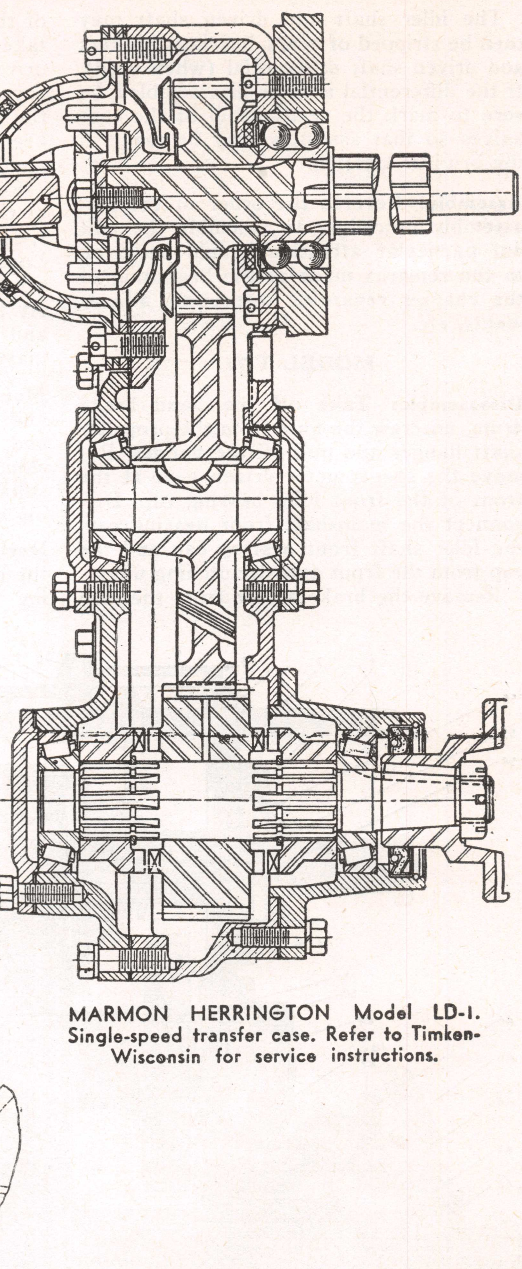
TRANSFER CASE

Drive the forward rear axle shaft into the case and lift the shaft and gear out of the case. The bearings may then be pressed from the shaft.

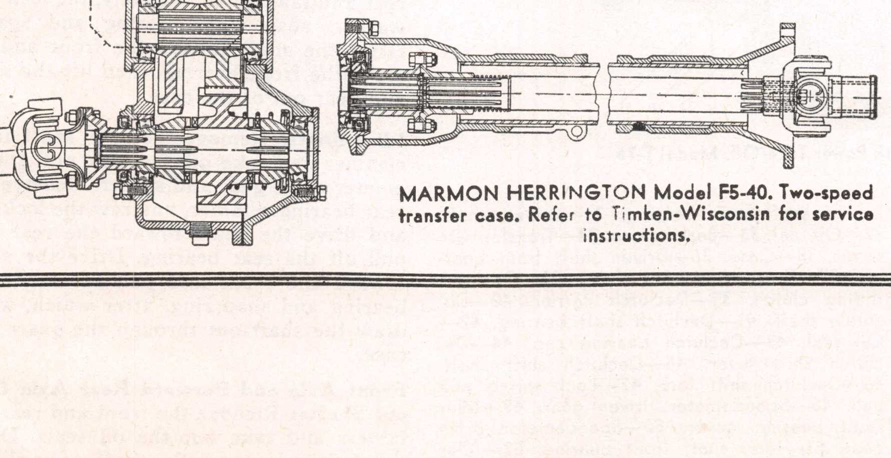
Assemble: Reverse the order of the above procedure to assemble the unit, building up the sub-assemblies on the bench as much as possible.



F. W. D. Transfer case used in conjunction with Model M transmission. For service instructions, see the TRANSMISSION chapter.



MARMON HERRINGTON Model LD-1. Single-speed transfer case. Refer to Timken-Wisconsin for service instructions.



MARMON HERRINGTON Model F5-40. Two-speed transfer case. Refer to Timken-Wisconsin for service instructions.

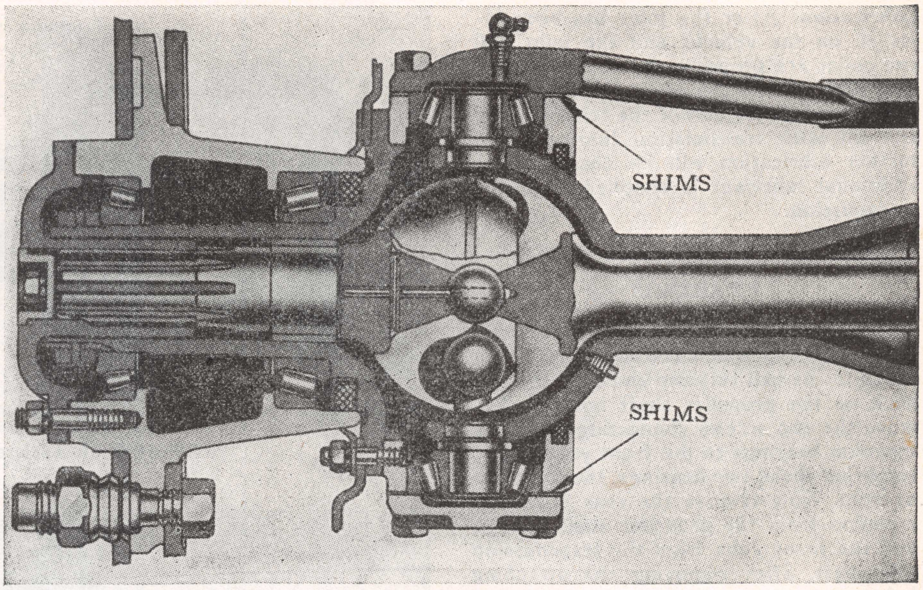
BENDIX-WEISS

This joint is of the constant velocity type consisting of two yokes having steel balls placed in non-concentric intersecting races cut in the yokes. Without any way of retaining the balls by a cage, retainer or other forcible means, the races cause the balls to roll angularly one-half the distance traveled by the yoke. The center ball is drilled and held in place by two pins.

Disassemble: Use a punch to drive out the cross pin which holds the ball pin in place in the shaft. Bounce the end of the shaft on a block of wood in such a manner to cause the center ball pin to drop down and release the center ball. Bend the joint at right angles and pick out the balls individually. After all balls are removed, the center pin can then be picked out of the yoke.

Assemble: Drop the center ball pin in the drilled passage of the yoke and place both yokes together in their relative positions. Bend the joint at right angles and insert the balls in their races. Place the center ball in its socket in a position to receive the retaining pin. Bounce the shaft on end so that it will jar the ball retaining pin into the hole of the center ball, then install the cross pin, prick-punching both ends to lock it securely in place.

Lubrication: The joint is lubricated through the upper fitting to the level of the lower plug. Use only the recommended type of lubricant.



BENDIX-WEISS

BLOOD

NEEDLE BEARING TYPE

MODEL N

Disassemble: The bearing assemblies and joint cross may be replaced without removing the joint assembly from the vehicle, and is accomplished in the following manner: Remove the cap screws which hold the bearing retaining plates in position and take off the plates. Push the bearing assemblies out of the yoke and slide the cross to one side to free it from the yoke. This is repeated on the opposite yoke and the disassembly is completed.

Assemble: Reverse the order of the above procedure to assemble the joint, but when installing the slip yoke on the shaft assembly, care must be used to see that the slip yoke bearings are in line with the bearings on the shaft yoke, as indicated by the arrows which are marked on the shaft and slip yoke for the purpose.

Lubrication: The joint cross has a tapped hole for a high pressure lubrication fitting through which oil may be introduced to the bearings. To prevent the possibility of damaging the oil seals, and to indicate when the joint is filled, a relief valve is provided. Oil having a consistency of SAE 140 should be used in these joints, and when completely filled, remove the fitting and install the plug.

PLAIN BEARING TYPE

MODEL BW

Service on these joints is the same as described for model N except that the lubricant which should be used contains a heavy bodied mineral oil, which is compounded to resist separation due to centrifugal action under high temperatures.

ROLLER BEARING TYPE

MODEL W

This type joint is serviced in similar fashion to the model N joint except that a heavy bodied gear oil, compounded for seepage control and for high film strength should be used. An SAE 140 Extreme Pressure gear oil is recommended.

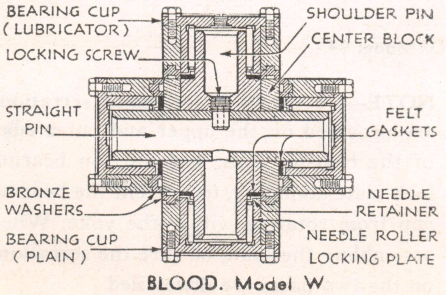
CHEVROLET & GMC

ENCLOSED TYPE WITH PLAIN BEARINGS

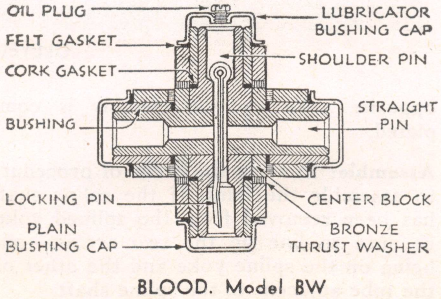
NOTE—The oil seal at the rear of the universal joint ball is adjustable, and is accomplished by a felt packing ring which is pressed against the end of the propeller shaft housing with two steel washers, one on each side of the packing. To compensate for wear, adjustment is made by turning the sleeve until a perfect seal is obtained.

Disassemble: To remove the joint, remove the speedometer gear and shaft from the joint ball retainer, which will eliminate the possibility of stripping the teeth of the gear. Separate the joint by removing the cap screws which hold the retaining collar to the ball retainer, and slide the ball back onto the propeller shaft housing. Split the joint by removing the nuts which hold the joint rings together. With a long shank wrench, remove the cap screw connecting the front yoke to the transmission mainshaft. Examine all parts and replace any that are found to be worn or damaged.

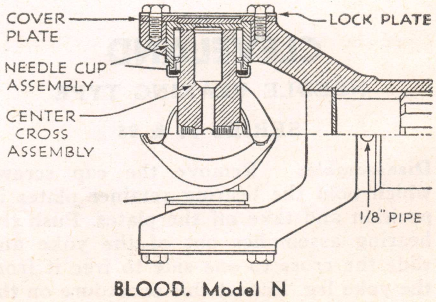
Assemble: The joint may be assembled in the reverse order except that care should be taken to see that the trunnion bearings are assembled to the yokes with their beveled side toward the inside of the yoke.



BLOOD. Model W



BLOOD. Model BW



BLOOD. Model N

Lubrication: After the joint has been installed on the vehicle, and the joint ball and collar are properly placed, remove the pipe plug on the top of the joint ball retainer on the rear end of the transmission, and fill with transmission lubricant. No further lubrication will be necessary, as additional lubricant is supplied from the transmission.

ENCLOSED TYPE WITH NEEDLE BEARINGS

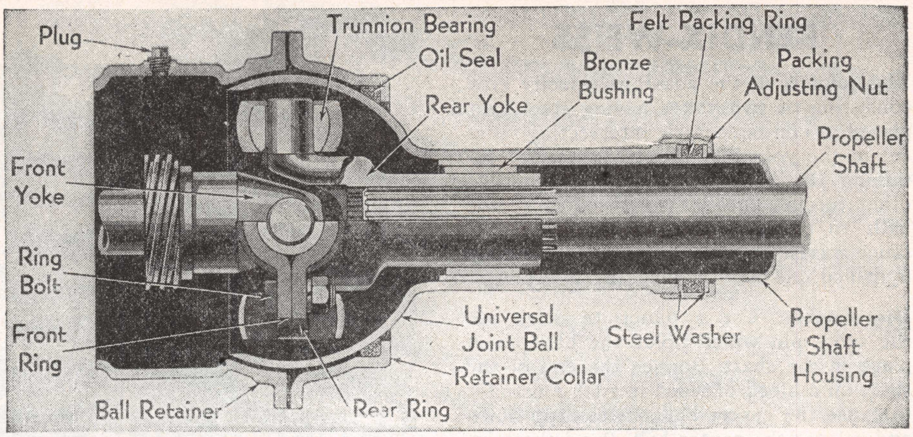
Disassemble: To remove the joint, remove the cap screws which fasten the retaining collar to the ball retainer and slide the ball back on the propeller shaft housing. Remove the cap screws connecting the front trunnion bearings to the front yoke. After removing these two bearings, the joint can be split. Now remove the rear yoke and trunnion from the propeller shaft splines, and the front yoke from the transmission mainshaft, after removing the attaching bolt.

Release the lock rings from the trunnion bearings and drive the caps from the yoke, using a drift punch in the center of the trunnion. After the trunnion has been driven down to the yoke, raise the trunnion and slip a 15/16" diameter washer under the bearing. Again drive the center of the trunnion until the bearing is free of the yoke. This procedure is necessary to eliminate the possibility of cocking the bearing which will result in damage to the yoke and bearing.

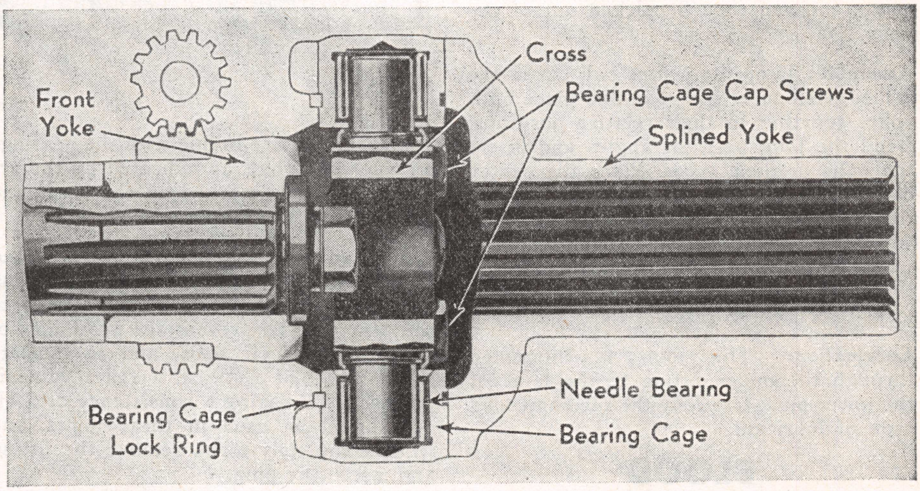
Assemble: To assemble the joint, install the front yoke to the transmission main shaft. Place the trunnion into the rear yoke. Coat the inside of the trunnion bearings with light cup grease and install the rollers. Start the bearings into the rear yoke, and at the same time, fit the ends of the trunnion into the bearings. Press each bearing into the yoke just far enough to install the snap ring. Install this assembly onto the propeller shaft splines.

Install the rollers into the front yoke trunnion bearings and place them on the ends of the trunnion. Line up the trunnion bearings with the front yoke, making sure that the pilots on the trunnions fit into the opening of the yoke, after which, install the cap screws securely.

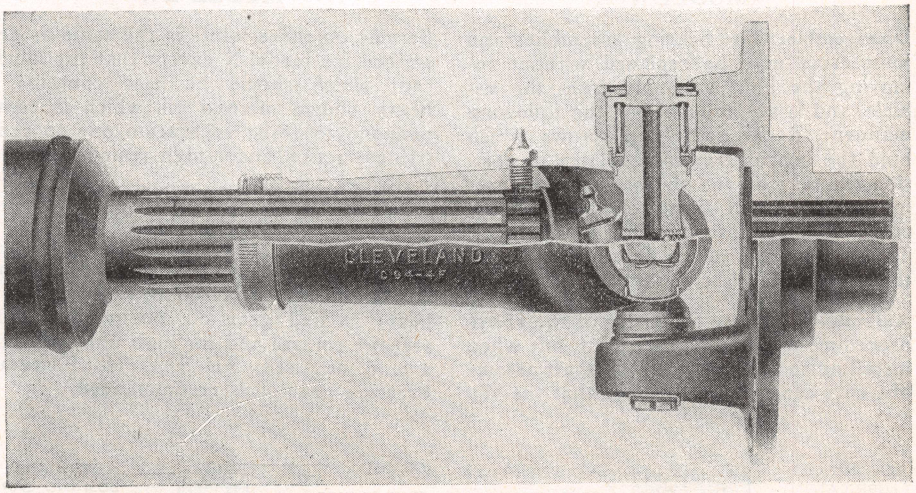
Slide the universal ball forward and attach the cap screws which fasten the retaining collar to the transmission. Fill the universal joint housing with transmission lubricant through the opening for the speedometer driven gear.


Plug
Trunnion Bearing
Felt Packing Ring
Oil Seal
Bronze Bushing
Packing Adjusting Nut
Rear Yoke
Propeller Shaft
Front Yoke
Ring Bolt
Front Ring
Universal Joint Ball
Steel Washer
Propeller Shaft Housing
Retainer Collar
Ball Retainer
Rear Ring

CHEVROLET. Enclosed Type With Plain Bearings


Cross
Front Yoke
Bearing Cage Cap Screws
Splined Yoke
Needle Bearing
Bearing Cage Lock Ring
Bearing Cage

CHEVROLET. Enclosed Type With Needle Bearings



CLEVELAND. Model 94

CLEVELAND

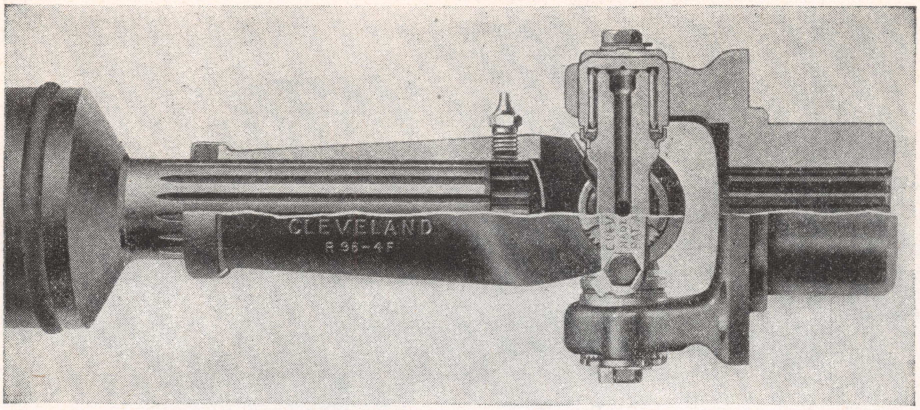
NEEDLE BEARING TYPE

SERIES 94 & 96

Disassemble: Remove the cap screws which hold the bearing retainer plates in position and take off the plates. Push the bearing assemblies out of the yoke and slide the cross to one side to free it from the yoke leg. Repeat this procedure on the opposite yoke and disassembly is completed.

Assemble: Reverse the order of procedure to assemble the joint. If the spline shaft has been removed from the splined yoke, be sure to line up the two arrows—one being on the spline yoke and the other on the tube adjacent to the spline shaft.

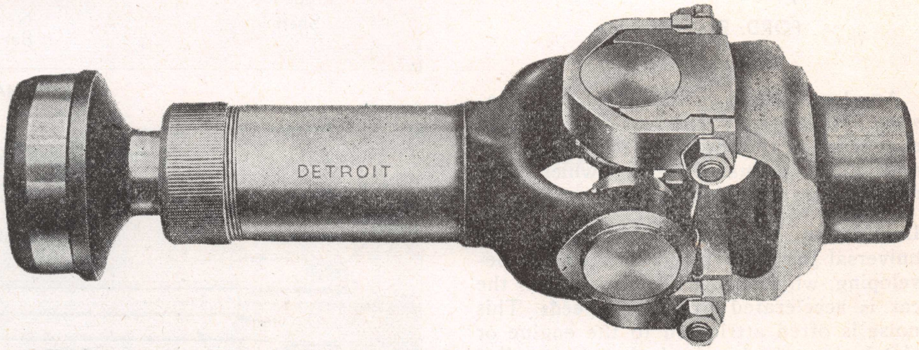
NOTE—On the 96 series joints, serrations are provided on the upper and outer edge of the bearing cups, and also on bearing lock plate stamping, to prevent the bearing cup from rotating within the yoke. When assembling the joint, be sure the serrations on the two parts are dovetailed.



CLEVELAND. Model 96

Lubrication: The joint cross has a tapped hole for a high pressure lubrication fitting through which oil may be introduced to the bearings. To prevent the possibility of damaging the oil seals, and to indicate when the joint is filled, a relief valve is provided. Oil having a consistency of SAE 140 or SAE 160 is recommended for these joints, but under certain conditions, a light grease may be used. In the selection of grease however, be sure it has good lubricating qualities and that it will resist separation due to centrifugal action under high temperatures.

Under favorable conditions, these joints need not be lubricated for 25,000 miles. However, under certain operating conditions, it is advisable to lubricate them more frequently, so as to flush out the old grease and replace with fresh lubricant.



DETROIT. Cross and Yoke Type

DETROIT

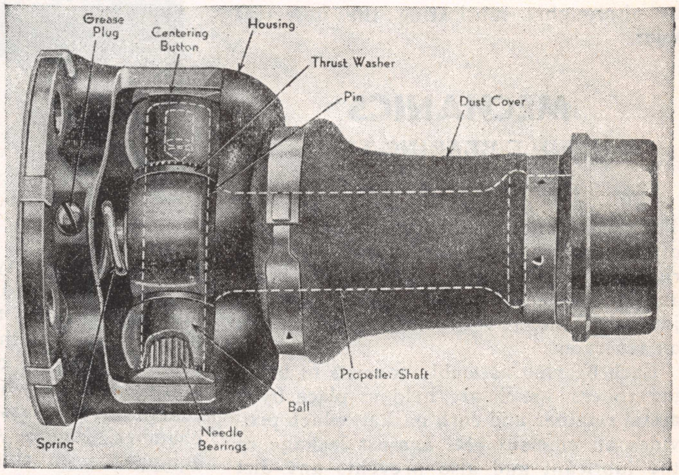
CROSS & YOKE TYPE

MODELS 5160 & 5360

Disassemble: Remove the bushing retainer ring link and pull out the retainer rings. Tap the bushing and roller assembly into the yoke, and at the same time force the bushing from the opposite side of the yoke. Remove the bearing assemblies, oil seals and retainers from the cross, then lift the cross up and out of the yoke.

Assemble: Reverse the order of procedure to assemble the joint, being sure the oil seals are in good condition, and that the retainer rings are installed properly.

Lubrication: This type joint is equipped with a high pressure lubrication fitting located in the center of the cross, and only the recommended type lubricant should be used.



DETROIT. Ball and Trunnion Type

BALL & TRUNNION TYPE

MODELS 4200 & 4400

Disassemble: Remove the bolts connecting the joint body to the universal flange. Straighten the clip of the metal cover at the end of the joint body so that the cover can be slipped from the body. Push the body toward the propeller shaft, and if necessary, pry the cover off the body with a screwdriver. Remove the centering buttons and springs from the end of the cross pins, using a screwdriver if necessary. The cross pin can now be pushed through the end of the propeller shaft.

Assemble: Assembly can be made in the reverse order except that the cross pin should be installed before the rollers. Lubricate the joint as specified by the car manufacturer by removing the grease plug and insert a grease fitting for the application of a pressure grease gun.

FORD

ENCLOSED TYPE

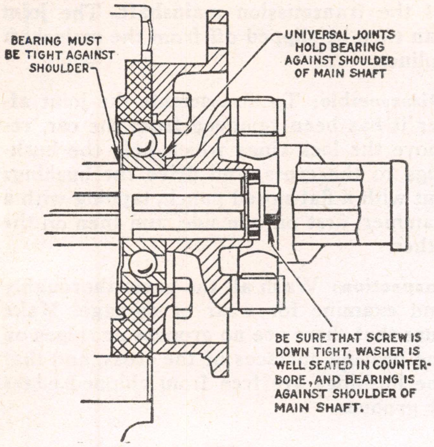
NOTE—To remove the joint it is necessary to remove the rear axle and propeller shaft assembly. When this has been accomplished, remove the bolt which holds the front yoke of the universal joint to the end of the transmission mainshaft. The joint can then be slipped off from the mainshaft splines.

Disassemble: To disassemble the joint after it has been removed from the car, remove the lock rings which hold the bushings to the cross, and drive the bushings out with a flat-nosed punch, tapping with a hammer, first on one side, and then on the other.

Inspection: Wash all the parts thoroughly and examine for wear or damage. Make sure that there are no grooves or ridges on the bearing surfaces of the cross, and that the bushings are free from chipped edges or grooves.

Assemble: Before re-assembling the universal joint, oil the bearing surfaces, as grease may not reach the internal parts of the joint for the first few revolutions. Use care when installing new bushings to see that they are driven in straight so that the edges will not mar the bearing surfaces. A soft-faced hammer should be used for this installation.

When installing the joint to the transmission mainshaft, make sure that the bolt which fastens the joint to the transmission mainshaft is drawn down tight, and that the washer is seated in the counterbore of the universal joint. When correctly assembled, the mainshaft rear bearing hub is against the shoulder of the mainshaft, and is held in this position by the universal joint without any end play. The outer race of the mainshaft bearing is held in position by the rear motor support.


BEARING MUST BE TIGHT AGAINST SHOULDER
UNIVERSAL JOINTS HOLD BEARING AGAINST SHOULDER OF MAIN SHAFT
BE SURE THAT SCREW IS DOWN TIGHT, WASHER IS WELL SEATED IN COUNTER-BORE, AND BEARING IS AGAINST SHOULDER OF MAIN SHAFT.

FORD. Enclosed Type

Any longitudinal movement of the mainshaft will permit the synchronizer to change its location with relation to the second speed mainshaft gear, which may result in transmission failure.

Lubrication: Lack of lubrication in the universal joint will result in a squeak developing, which is usually heard when the car is accelerated from low speeds. This noise is often attributed to the engine or clutch, but can be checked and remedied by thoroughly lubricating the universal joint.

MECHANICS

NEEDLE BEARING TYPE

SEE FIGURES A & B

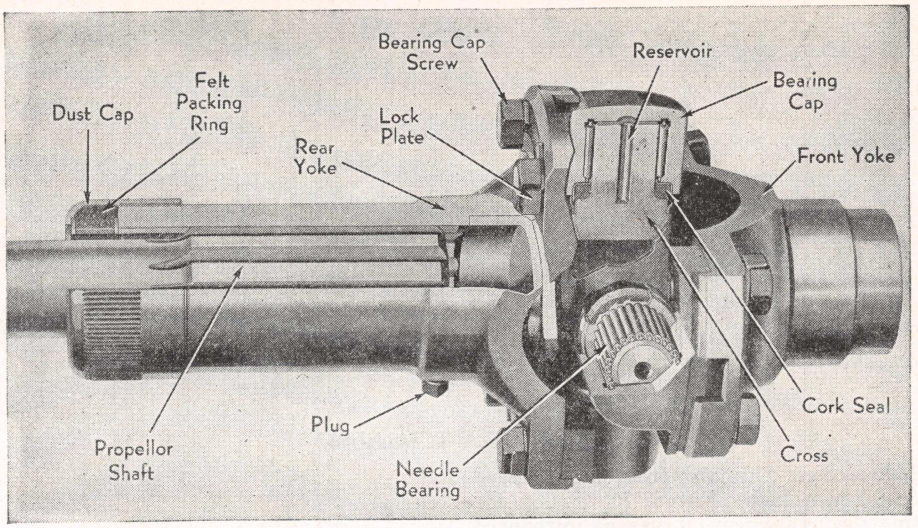
The construction of this type joint consists of two flanges which are assembled into a rigid unit consisting of a steel forged cross and four needle bearing assemblies. Each journal of the cross is drilled to provide an oil reservoir.

Each bearing assembly consists of bearing rollers, which are held in place by a metal retainer and cork gasket, which provides an efficient seal against leakage of the lubricant and also prevents any dirt from entering the bearings. The retainers also prevent the bearing rollers from falling out when disassembling the joint.

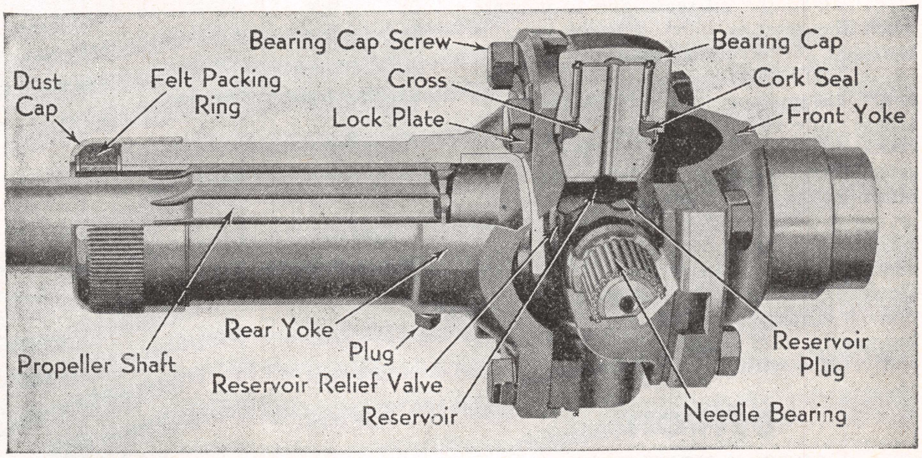
Disassemble: To remove the joint, it is necessary only to remove the cap screws that hold the journal caps to the yokes. If a joint is removed and is not to be disassembled, the opposite bearing retainers should be wired together to keep them in place on the journals of the cross.

To disassemble the joint after removal from the yokes, pull the retainers off the cross journals and remove the needle bearing assemblies.

Assemble: Before reassembling a joint, wash all parts thoroughly and blow out with compressed air to remove all traces of dirt and grit. Repack the bearings with the recommended lubricant and assemble in the reverse order.


Bearing Cap Screw
Reservoir
Bearing Cap
Felt Packing Ring
Dust Cap
Lock Plate
Rear Yoke
Front Yoke
Cork Seal
Cross
Plug
Propellor Shaft
Needle Bearing

MECHANICS. Figure A


Bearing Cap Screw
Bearing Cap
Dust Cap
Felt Packing Ring
Cross
Cork Seal
Lock Plate
Front Yoke
Rear Yoke
Plug
Propeller Shaft
Reservoir Relief Valve
Reservoir
Reservoir Plug
Needle Bearing

MECHANICS. Figure B

Lubrication: The type joint shown as Figure B is equipped with a high pressure lubrication fitting through which oil may be introduced to the bearings. To prevent the possibility of damaging the oil seals, and to indicate when the joint is filled, a relief valve is assembled in the central chamber. Figure A type joints are not equipped with this provision, therefore, when lubrication is required, the joint must be disassembled and packed.

On all joints, a good grade of SAE 140 gear oil is recommended, and the same type should be used when lubricating the splines, for which a fitting is provided for the purpose.

RZEPPA

This joint is of the constant velocity type consisting of two driving members separated by a close fitting ball cage, having spherical contact surfaces. Six balls assembled into corresponding ball grooves and a piloting device complete the assembly.

Disassemble: Remove the shaft retainer screws, pull out the drive shaft and remove the pilot pin. Tilt the inner ball race at an angle to the cage until one ball can be removed. Roll the inner race and cage around in order to remove the adjacent ball, and repeat until all balls are removed. Roll the cage upside down and take out the pilot.

Locate the cage and inner race at right angles with the outer race, so that the cage openings mesh with opposite teeth of the outer race, then withdraw the cage and inner race assembly. Turn the inner race until one tooth projects through an opening in the cage and roll the inner race out of the cage. Remove the pilot spring and plunger from the bore of the stem.

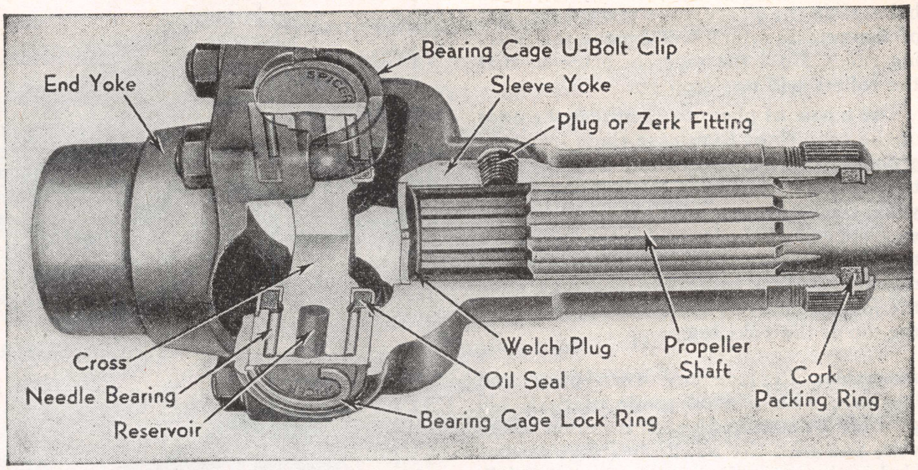
Assemble: Clean all parts thoroughly and apply a light film of lubricant. Fasten the outer race in a vise with the large opening facing upward. Fill the pilot plunger bore with lubricant and insert the spring and plunger, with the plunger on top. Insert one tooth of the inner race into an opening in the cage and roll the race in place checking to be sure the fit is free.

Install the inner race and cage assembly into the outer race, locating the cage openings so that the opposite teeth of the outer race will clear, then drop the cage in place, turning it into position, making sure the parts turn freely.

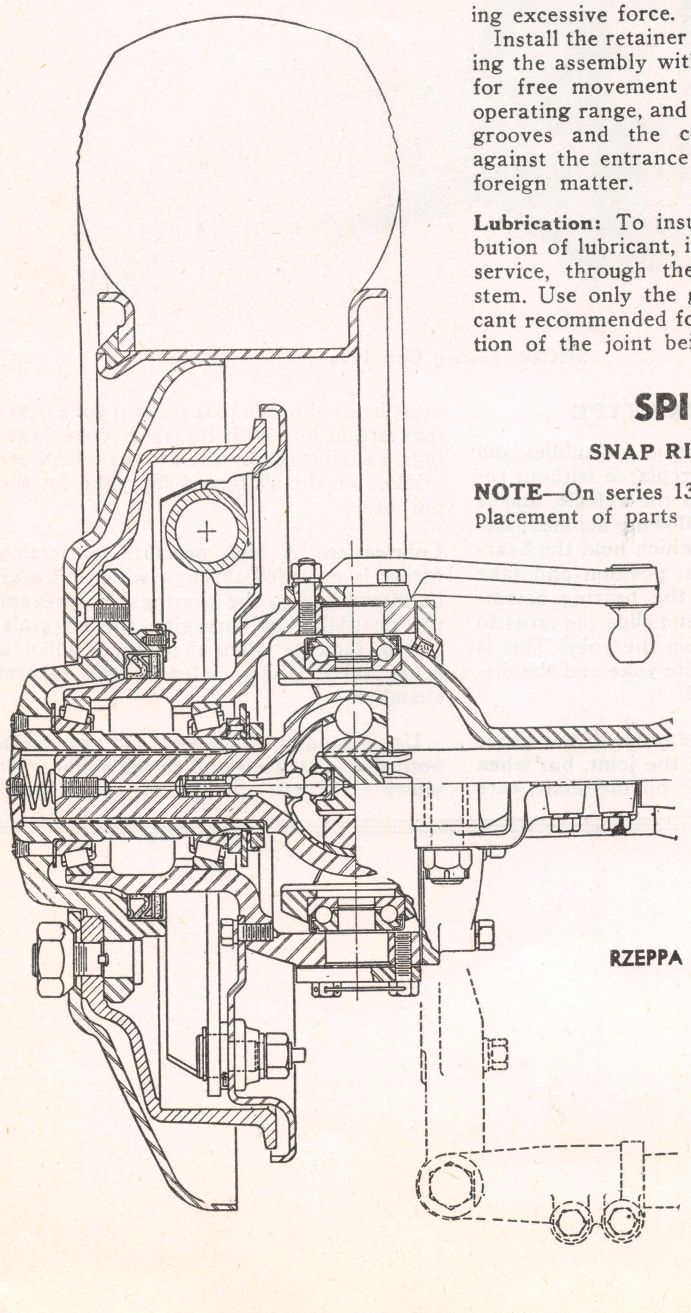
Insert the pilot with its face down and then, roll all the internal parts until the pilot is at the bottom of the outer race, with the tapped holes facing outward. Tilt the inner race and cage until one ball can be installed in the cage groove. Increase the angle of the inner race and roll all parts to the position for insertion of the next ball, and continue this procedure until all balls are installed.

Apply lubricant to the splined hole of the inner race, into the pilot cavity, then insert the pilot pin—small end down—until it contacts the spring plunger. Press the pilot seat into the recess in the shaft up to the shoulder, then insert the splined shaft into the inner race.

NOTE—When inserting the splined shaft, do so with a steady downward motion to insure the proper engagement of the pilot pin with its seat. If the head of the pilot pin does not readily engage the seat in the shaft, level the cage with the outer race and rock the shaft slightly, without applying excessive force.



SPICER. Snap Ring Type, Light Duty



RZEPPA

Install the retainer screws securely, locking the assembly with wire. Test the joint for free movement throughout its entire operating range, and apply lubricant to the grooves and the cover joint to guard against the entrance of dirt, grit or other foreign matter.

Lubrication: To insure the proper distribution of lubricant, it should be applied in service, through the drilled hole in the stem. Use only the grade and type lubricant recommended for the specific application of the joint being serviced.

SPICER

SNAP RING TYPE

NOTE—On series 1350, 1400 and 1410, replacement of parts may be accomplished without removing the propeller shaft assembly from the vehicle.

Disassemble: Use a pair of pliers to compress the ends of the snap rings and release them from the grooves. Tap the end of one bearing until the opposite bearing is pushed out of the yoke, then turn the joint over and tap the exposed end of the journal cross to remove the first bearing. When this operation is repeated for the other two bearings, slide the journal cross to one side and tip it over the top of the yoke lug.

Assemble: Replace any worn parts and lubricate with a good grade of SAE 140 gear oil. Be sure to fill each trunnion reservoir, and with the needle bearings assembled in the race, fill the race about 1/3 full. Always use new oil seals when assembling the journal cross.

Be sure to hold the bearings in a vertical position to prevent the rollers from dropping out of the race. When the assembly is completed, check the joint for freedom of operation, and if any evidence of binding is apparent, tap the lugs lightly to relieve any pressure.

When installing the propeller shaft spline into the joint, it is important that the lugs on the sleeve yoke lie in the same plane as the lugs on the stub ball yoke.

Lubrication: On series 1350, 1400 and 1410, a high pressure lubrication fitting is provided through which oil may be introduced to the bearings. To prevent the possibility of damaging the oil seals, and to indicate when the joint is filled, a relief valve is assembled in the central chamber. Joints which are not equipped with the lubrication fitting must be disassembled when lubrication is required.

On all joints, a good grade of SAE 140 gear oil should be used. The same type should be used when lubricating the splines, and a fitting is provided for the purpose.

U-BOLT TYPE

Disassemble: The complete propeller shaft assembly is readily removed after disconnecting the U-bolts from the transmission and axle end yokes. After removing the U-bolts, slide the sleeve yoke toward the rear of the vehicle which will expose the bearing races. Hold the races in place so that the rollers will not drop out.

Use a pair of pliers to compress the ends of the snap rings to release them from the grooves. Tap the end of one bearing until the opposite bearing is pushed out of the yoke, then turn the joint over and tap the exposed end of the journal cross to remove the first bearing. When this operation is repeated for the other two bearings, slide the journal cross to one side and tip it over the top of the yoke lug.

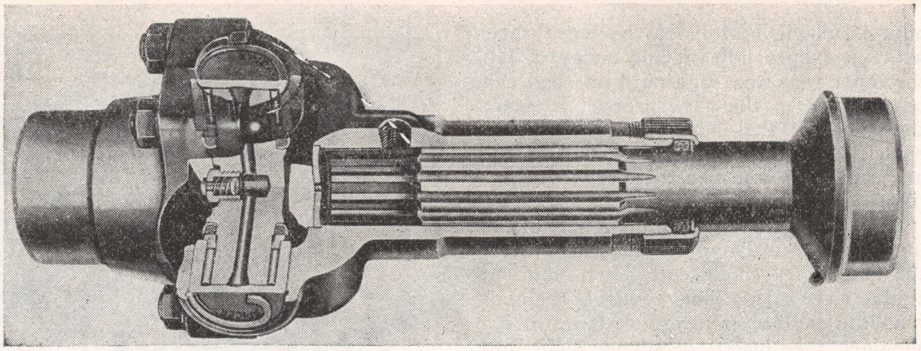
Assemble: Replace any worn parts and lubricate with a good grade of SAE 140 gear oil. Be sure to fill each trunnion reservoir, and with the needle bearings assembled in the race, fill the race about 1/3 full. Always use new oil seals when assembling the journal cross.

Be sure to hold the bearings in a vertical position to prevent the rollers from dropping out of the race. When the assembly is completed, check the joint for freedom of operation, and if any evidence of binding is apparent, tap the lugs lightly to relieve any pressure. When installing the propeller shaft flange into the joint, it is important that the lugs on the sleeve yoke lie in the same plane as the lugs on the stub ball yoke.

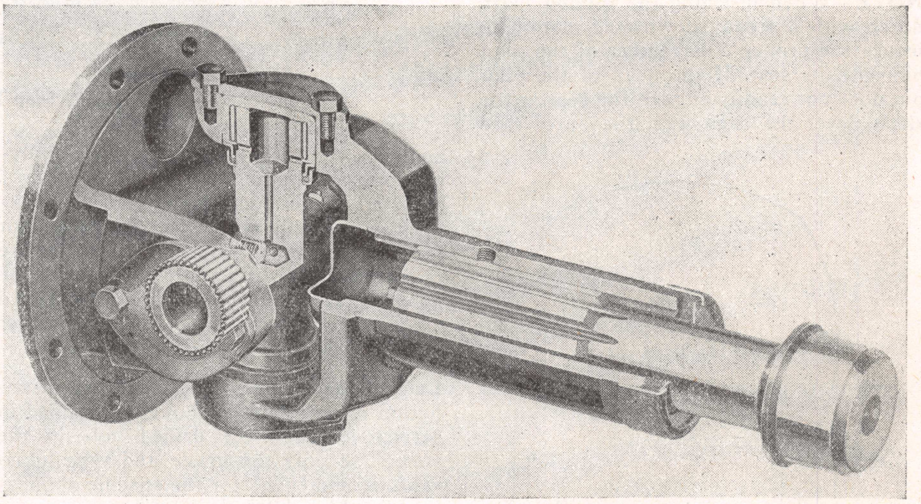
NOTE—When assembling the bearings into the end yokes, use a suitable "C" clamp over the extreme ends of the bearing races to draw the bearings into the correct position, seating them inside the bearing shoulders on the yokes.

Lubrication: On models 1310 (heavy duty), 1350 and 1410, a high pressure lubrication fitting is provided through which oil may be introduced to the bearings. To prevent the possibility of damaging the oil seals, and to indicate when the joint is filled, a relief valve is assembled in the central chamber. Joints which are not equipped with this fitting, must be disassembled when lubrication is required.

On all joints, a good grade of SAE 140 gear oil is recommended. The same type should be used when lubricating the splines, for which a fitting is provided.



SPICER. Snap Ring Type, Heavy Duty



SPICER, Bearing Cap Type

BEARING CAP TYPE

Disassemble: The bearing assemblies and journal cross may be replaced without removing the joint from the vehicle, and is accomplished in the following manner: Remove the cap screws which hold the bearing retaining plates in position and take off the plates. Push the bearing assemblies out of the yoke and slide the cross to one side to free it from the yoke. This is repeated on the opposite yoke and the disassembly is completed.

Assemble: Reverse the order of the above procedure to assemble the joint, but when installing the slip yoke on the shaft, care must be used to see that the slip yoke bearings are in line with the shaft yoke bearings, as indicated by the arrows which are marked on the shaft and slip yoke for the purpose.

Lubrication: A high pressure lubrication fitting is provided through which oil may be introduced to the bearings. To prevent the possibility of damaging the oil seals, and to indicate when the joint is filled, a relief valve is assembled in the central chamber.

Use a good grade of SAE 140 gear oil in both the joint itself and to the splines, for which a fitting is provided for the purpose.

NOTE:—Front Driving Axles have same adjustments as corresponding rear driving axles. Universals, page 771. Transfer cases, page 767.

INDEX

Make and Model	Type of Axle	Oil Capacity, Pints ①	Lubricant Recommended, SAE Number		Page Number
			Above 32° F.	Below 32° F.	
AUTOCAR					
C	DR	18	140	90	808
CG	DR	18	140	90	808
CGA	DR	18	140	90	808
DB	DR	12	140	90	808
DF	DR	12	140	90	808
DFA	DR	12	140	90	808
E	DR	14	140	90	808
F	DR	20	140	90	808
G	DR	18	140	90	808
N	DR	18	140	90	808
RC	DR	12	140	90	808
RL	DR	12	140	90	808
TF	DR	18	140	90	808
TG	DR	18	140	90	808
CHEVROLET					
½, ¾ ton	SF	4½	90 Hy	90 Hy	781
1936–40, 1½ ton	FF	11	90 Hy	90 Hy	779
1941–46, 1½ ton	FF	11	90 Hy	90 Hy	780
CLARK					
B373	SB	9	90	90	783
R650	SB	9	90	90	783
R750	SB	8	90	90	783
R950	SB	9	90	90	784
R1100	SB	9	90	90	784
R1300	SB	9	90	90	785
DODGE					
	SF	3¼	90 Hy	90 Hy	785
	SF	4½	90 Hy	90 Hy	787
	FF	8	140	90	789
	FF	10 or 11	140	90	790
EATON					
1280	2 Speed	16	90 EP	90 EP	791
1300	2 Speed	16	90 EP	90 EP	791
1350	2 Speed	13	90 EP	90 EP	791
1600	2 Speed	18	90 EP	90 EP	791
16050	2 Speed	18	90 EP	90 EP	791
17000	2 Speed	17	90 EP	90 EP	791
18000	2 Speed	17	90 EP	90 EP	791
20000	2 Speed	20	90 EP	90 EP	791
FORD					
	¾ F	3	140 EP	90 EP	791
Tonner, ¾ ton	FF	3	140 EP	90 EP	803
Truck, COE	FF	7	140 EP	90 EP	803
FOUR WH. DRIVE					
H	SB	5 front 5 rear	140 EP	90 EP	793
SU	SB	8 front 8 rear	140 EP	90 EP	793
GMC					
	SF	4½	90 Hy	90 Hy	781
	SF	4½	90 Hy	90 Hy	794
	FF	Various	90	90	795
INTERNATIONAL					
708	FF		140	90	798
732H	FF		140	90	798
HDR60	FF	4½	140	90	796
R56H	SF	4	140	90	799
R1000	SF	4	140	90	799
R1001	SF	4	140	90	799
R1100	FF	4½	140	90	796
R1101	FF	4½	140	90	796

Make and Model	Type of Axle	Oil Capacity, Pints ①	Lubricant Recommended, SAE Number		Page Number
			Above 32° F.	Below 32° F.	
MACK					
RA17	SB		②	②	800
RA22	SB		②	②	800
RA36	SB		②	②	800
RA45	SB		②	②	800
PAK-AGE-CAR		5	90 EP	90 EP	801
SPICER	SF	3	90	90	802
	FF		140	90	803
TIMKEN					
51520	SB	3	140	90	804
52200	SB	8	140	90	804
53200	SB	8	140	90	804
53300	SB	8	140	90	804
53300③	SB	15	140	90	804
53500	SB	6	140	90	804
53600	SB	7	140	90	804
54200	SB	10	140	90	804
54400	SB	8	140	90	804
54400③	SB	15	140	90	804
55400	SB	9	140	90	804
56200	SB	11	140	90	804
56400	SB	12	140	90	804
56400③	SB	20	140	90	804
58200	SB	12	140	90	804
58300	SB	12	140	90	804
58415	SB	16	140	90	804
59000	SB	16	140	90	804
63000	WD	8	140	90	806
64800	WD	9	140	90	806
65200	WD	10	140	90	806
65700	WD	12	140	90	806
66700	WD	20	140	90	806
67000	WD	20	140	90	806
68700	WD	20	140	90	806
72200	DR	15	140	90	808
73300	DR	8	140	90	808
74400	DR	9	140	90	808
75200	DR	11	140	90	808
75400	DR	20	140	90	808
75700	DR	12	140	90	808
75700③	DR	16	140	90	808
76400	DR	18	140	90	808
76700	DR	20	140	90	808
76700③	DR	26	140	90	808
78000	DR	20	140	90	808
79000	DR	20	140	90	808
93300	2S DR	14	140	90	811
93530	2S DR	12	140	90	811
94000	2S DR	18	140	90	811
96000	2S DR	20	140	90	811
98415	2S DR	24	140	90	811
TIMKEN FOUR WHEEL UNITS (Inter-Axle Differential)					
100	FR	8–8	140	90	813
151	FR	9–9	140	90	813
200	FR	10–10	140	90	813
210	FR	10–10	140	90	813
251	FR	10–10	140	90	813
310	FR	12–12	140	90	813
320	FR	12–12	140	90	813
350	FR	12–12	140	90	813
410	FR	20–20	140	90	813
420	FR	20–20	140	90	813
450	FR	20–20	140	90	813

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①, ②, ③—See bottom of next page.

DRIVING AXLES

NOTE:—Front Driving Axles have same adjustments as corresponding rear driving axles. Universals, page 771. Transfer cases, page 767.

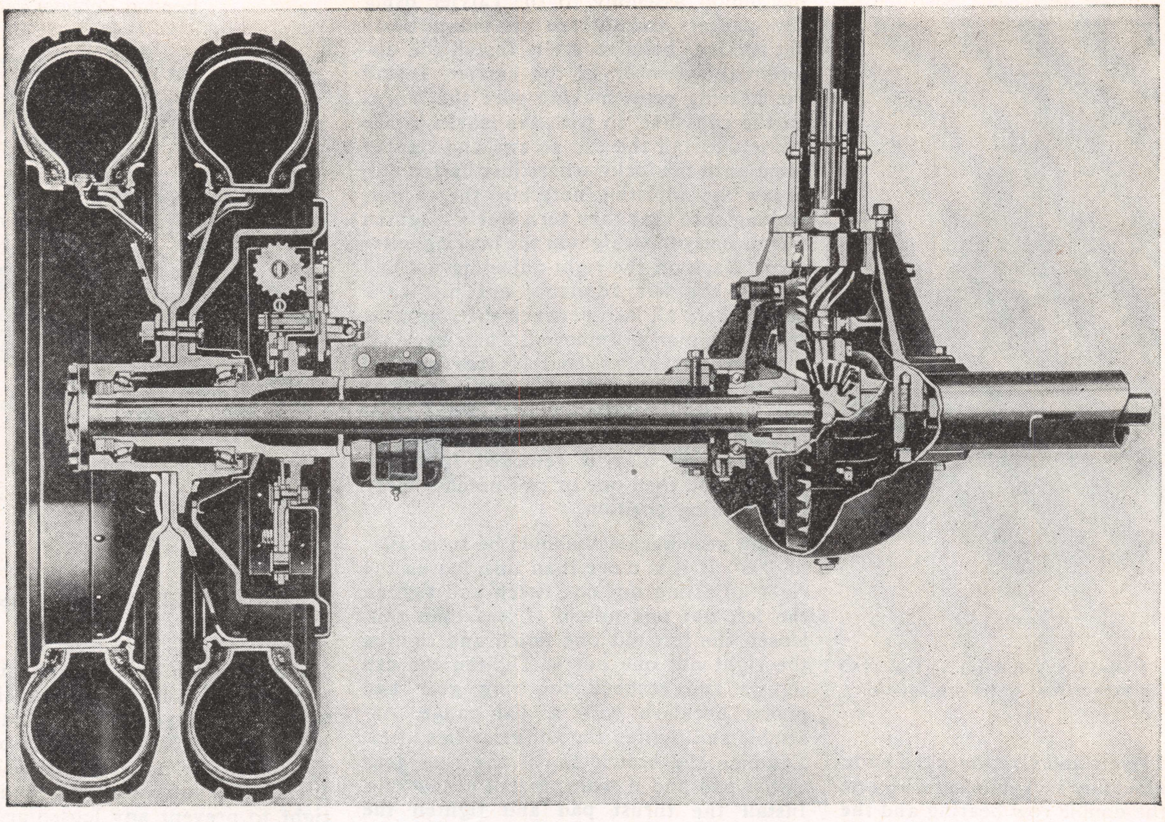
INDEX

Make and Model	Type of Axle	Oil Capacity, Pints ①	Lubricant Recommended, SAE Number Above 32° F.	Lubricant Recommended, SAE Number Below 32° F.	Page Number
TIMKEN (cont.)					
460	FR	20–20	140	90	813
520	FR	20–20	140	90	813
700	FR	7– 7	140	90	814
1000	FR	8– 8	140	90	814
1500	FR	12–12	140	90	814
3000	FR	14–14	140	90	814
WHITE					
20C	SB	14	140	90	815
25C	SB	11	140	90	814
33C	SB	11	140	90	814
34C	SB	10	140	90	814
38C	2 Speed		140	90	811
42C	2 Speed		140	90	811
43C	DR	22	140	90	808
44C	DR	22	140	90	808
45C	DR	22	140	90	808
48C Tim	SB	8	140	90	804
54C	DR		140	90	808
55C (Wh. Horse)	SB	6	140	90	815
65C	DR		140	90	808
72C (Wh. Horse)	SB	6	140	90	815
100C	SB	18	140	90	814
101C	SB	18	140	90	814
102C	SB	22	140	90	814
201C	DR		140	90	808
202C	DR		140	90	808
300C	2 Speed		140	90	811
301C	2 Speed		140	90	811
302C	2 Speed		140	90	811
304C	2 Speed		140	90	811
SBD1000	FR	8– 8	140	90	815
SBD1500	FR	12–12	140	90	815
WISCONSIN					
Front Dr. Axles					
F30-B10	SB	6	140	90	804
F30-B25	SB	6	140	90	804
WISCONSIN (cont.)					
F35	SB	7	140	90	804
F46	DR	10	140	90	808
F50	SB	10	140	90	804
F53	SB	12	140	90	804
F54	SB	11	140	90	804
F56	SB	14	140	90	804
F58	SB	15	140	90	804
F75	DR	9	140	90	808
F200	DR	12	140	90	808
F300	DR	16	140	90	808
F400	DR	16	140	90	808
F500	DR	18	140	90	808
F501	DR	10	140	90	808
F544	SB	8	140	90	804
F551	DR	10	140	90	808
F564	SB	14	140	90	804
F580	SB	15	140	90	804
WISCONSIN					
Rear Axles					
46R	DR	10	140	90	808
1200	DR	16	140	90	808
1300	DR	16	140	90	808
1400	DR	12	140	90	808
1500	DR	12	140	90	808
1700	DR	16	140	90	808
1757	DR	16	140	90	808
1900	DR	16	140	90	808
4600	DR	8	140	90	808
4900	DR	9	140	90	808
5000	DR	10	140	90	808
6600	DR	11	140	90	808
19000	DR	17	140	90	808
66000	DR	11	140	90	808
69000	DR	11	140	90	808
70000	DR	11	140	90	808
72300	DR	11	140	90	808

①—Capacities may vary from those shown due to changes in the axle housing which do not affect service instructions.

②—The Mack Company attaches a metal tag to the rear axle housing specifying the type of lubricant to be used. Use the following SAE number lubricant against the builder's recommendations on the metal tag: Mack No. 1, use 140EP. Mack No. 2, use 140. Mack No. 3, use 90EP. Mack No. 4, use 90.

③—High level.
DR—Double reduction.
¾ F—¾ floating.
FF—Full floating.
FR—Tandem unit.
2S DR—2 speed, double reduction
SB—Spiral bevel.
SF—Semi floating.
WD—Worm drive.



CHEVROLET. Full Floating Axle.

CHEVROLET

1936-40, 1½ TON

Full Floating Axle with Four Pinion Differential, Riveted Ring Gear and Straddle Mounted Drive Pinion for Torque Tube Drive.

CHEVROLET 1936-40, 1½ TON

Disassemble: To remove the axle shaft, bend the lugs of the lock plate away from the bolt heads with a cold chisel and hammer. Remove the cap screws and lock plate, after which the axle shaft and gasket can be removed.

To remove the wheel bearing remove the wheel and raise the lip of the lock from the notch in the lock nut. Remove the lock nut and then remove the lock, inner adjusting nut and thrust washer. Remove the hub and drum assembly. Install clamp on brake wheel cylinder. Remove inner bearing and oil seal with a puller. To remove the outer bearing, tap the outer race to relieve the tension at the snap ring. Then remove the snap ring on the inside of the hub. Remove the bearing by driving on the outer race of the bearing with a long ⅛" punch through the cap screw holes in the end of the hub. This will also bring out the inner race and roller assembly. Use care to engage the edge of the race with the punch and not damage the bearing seat in the housing. Also make sure to drive the race out evenly. The oil slinger is a drive fit in the housing and if it is removed it must be replaced with a new one.

To remove the differential carrier, remove the bolts from the universal ball retainer back of the transmission and slide the retainer and ball back on the front propeller shaft housing. Remove the trunnion bearing lock rings and drive the trunnion bearings out of the rear yoke of the universal joint and slide the yoke back on the shaft. Remove the two bolts which mount the front propeller shaft assembly to the frame cross member, then lower the assembly and pull it forward to remove it from the rear axle propeller shaft and torque tube. Remove the bolts and lockwashers which retain the differential assembly to the housing and remove the differential carrier.

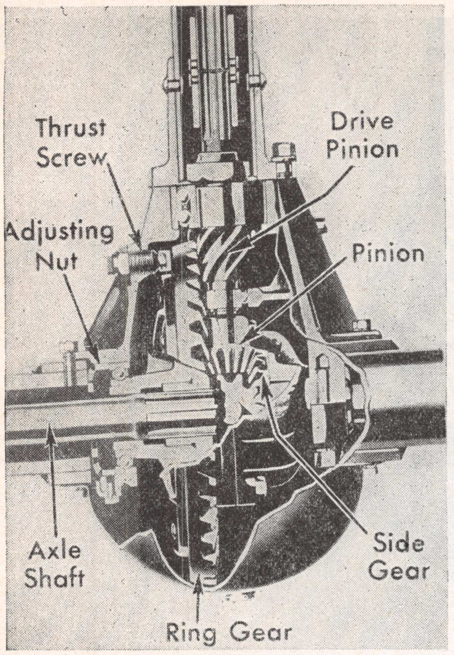
Mount the assembly in a vise and remove the ring gear thrust pad. Remove the differential adjusting nut locks. Remove the bearing cap bolts and lockwashers. The bearing caps may now be removed. Then remove the differential case and ring gear assembly from the carrier. Remove the torque tube to differential carrier bolts and remove the torque tube. Remove the propeller shaft assembly from the differential carrier. It may be neecssary to use a soft drift and hammer to drive out the propeller shaft and pinion if the bearings are tight in the carrier.

Clamp the propeller shaft assembly in a vise, cut off the rivet heads which hold the pinion shaft to the coupling and drive out the rivets. With a suitable tool, force the pinion with coupling assembled to it from the propeller shaft.

Press the coupling from the pinion in an arbor press. Remove the lock ring from the front bearing and press the pinion and shaft out of the bearing. Pressure must be exerted against the inner race. Remove the pinion bearing retaining nut. Then press the double row ball bearing off the shaft. Remove the differential bearings from the case with a bearing puller which pulls against the inner race of the bearings.

To disassemble the differential make sure that the case halves are marked so that they can be assembled in their original position. Remove the bolts from the case. Lift off the case cover and remove the differential gears and pinions. The ring gear may be removed from the right side of the case by tapping it with a soft-faced hammer.

Assemble: To assemble the pinion, press the double row ball bearing on the pinion shaft and install a new retaining nut and pull it down tight. Then using a cold chisel, cut through the sleeve on the nut in line with the edge of the keyway in the pinion shaft. Lock the nut by driving the edge of the nut sleeve into the keyway with a punch. Press the roller bearing on the pinion shaft with the chamfered side of the inner race toward the pinion. Install the lock ring. Press the coupling on the pinion shaft so that the hole in the pinion shaft and the hole in the coupling line up. Press the pinion and coupling on the propeller shaft, making sure that the rivet hole in the coupling lines up with the rivet hole in the propeller shaft. Insert



CHEVROLET. 1936-39 1½ ton truck. The 1940 axle is similar except that gears are hypoid.

the flat head rivets and rivet over the ends. Mount the assembly in V-blocks, with one V-block at the double row bearing and the other in the ground diameter which is back of the spline at the front end of the propeller shaft. The maximum indicator run-out to which this assembly should be straightened is .003" at the roller bearing, .010" at the finished part of the propeller shaft just ahead of the coupling, .015" in the rough section at the middle of the propeller shaft and .005" at the extreme front end of the propeller shaft.

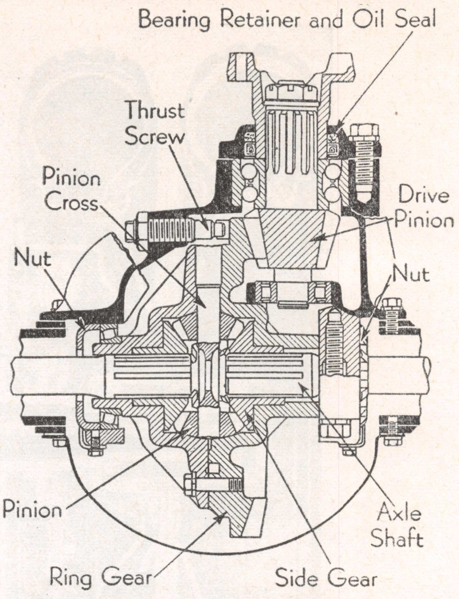
When assembling the differential, the flanges of the case, ring gear pilot and the back of the ring gear must be clean and free from burrs. When replacing the ring gear, use two guide pins made from the differential and ring gear screw. Their ends should be slightly tapered and screwdriver slots cut in them so that they can be easily removed. Lubricate the differential side gears and pinions and install them in the left half of the differential case. Assemble the right side of the case to the left side, being sure to line up the marks on the case halves. Install the two guide pins. Slip the ring gear over the pilot diameter of the right half of the differential case. Install the differential to ring gear cap screws and lockwashers, leaving the pilots in place and tighten the screws evenly one turn at a time until the ring gear face is flush with the case flange. Remove the guide pins and install the two remaining bolts and lockwashers. Then pull all bolts up tight.

Assemble the differential bearings to the case with a suitable driver. The wide side of the inner race must be toward the case. Place the differential carrier in a vise and install the bearing cap dowels in the carrier or in the bearing caps. Assemble the pinion assembly to the carrier using new gaskets and tighten the pinion bearing retainer bolts securely. Install the differential assembly in the carrier. Install the bearing caps, making sure the marks on the caps line up with the marks in the carrier. Install the cap screws and tighten them until the lockwashers just flatten out. Screw the adjusting nuts into the carrier, making sure that they turn freely. Tighten them snugly to straighten the bearing outer races. Back off the right adjusting nut and tighten the left adjusting nut just to a point where all lash between the ring gear and the pinion is removed. Then back off the left nut approximately two notches and to a locking position. Tighten the right nut to a solid position. Back off the right nut free of the bearing, then tighten the nut until all play is removed from the bearing and then one or two notches more to a locking position.

Ring gear backlash should be from .005" to .008". If it is more than this, loosen the right adjusting nut one notch and tighten the left nut one notch. If less than this, loosen the left nut one notch and tighten the right nut one notch. Tighten the cap screws and recheck the ring gear and pinion backlash with a dial gauge. Assemble and tighten the adjusting nut locks. Examine the bronze tip of the ring gear thrust pad and if worn, install a new one. Install the thrust pad and tighten the screw until the bronze tip lightly engages the back of the ring gear while rotating the gear. Back off the screw 1/12 turn and then tighten the lock nut, making sure the screw does not turn during the locking process.

Install the differential carrier in the housing with a new gasket between the carrier and the housing. Install the cap screws and tighten them securely. To replace the wheel bearings, place the inner race and roller assembly and the outer race in the wheel hub with the thin edge of the outer race downward. With a suitable wheel bearing replacer, press the bearing in the hub. Press the race only far enough to install the snap ring in an arbor press. Install the snap ring in the groove on the inside of the hub. Use a driver through the cap screw holes in the end of the hub to force the outer race back in positive contact with the snap ring. To replace the inner bearing, place the outer race on the bearing in the wheel hub with the wide side of the face down. Use a driver to press the race against its seat. Install the inner race and roller assembly. Install the oil seal with a suitable tool and an arbor press. Lock the seal in place by prick punching at three equally spaced places. Install the wheel hub and drum assembly, turning the hub to properly line up the bearings. Install the thrust washer and adjusting nut.

To adjust the wheel bearings, tighten the adjusting nut and then back it off 45 degrees. Turn the wheel hub by hand to make sure the hub turns freely. Install the adjusting nut lock and check the alignment of the tangs with the slots in the nut.



CHEVROLET. 1941-46 1½ ton truck

Rotate the hub by hand, grasping the hub at the wheel bolts, to see that the bearings are properly seated and that the hub turns freely. Bend the tang on the lock down into the notch of the adjusting nut. Install the outer lock nut and pull it up tight to prevent any loosening of the adjusting nut. Bend the tang of the lock into the notch of the lock nut. Install a new axle shaft flange gasket on the axle shaft and push the shaft into the housing. Use a new lock plate at the axle shaft cap screws and insert the cap screws in the axle shaft flange, tightening them alternately and make sure that they are pulled tight. Then bend the tangs of the lock plate against the heads of the cap screws.

Assemble the rear universal joint on the front propeller shaft assembly to the propeller shaft and torque tube. Bolt the front propeller shaft assembly to the frame crossmember. Assemble the front universal joint by installing the chamfered side, which is on the inside diameter, of the trunnion bearing toward the inside of the yoke. Drive the trunnions into place until the grooves line up with the slots in the yoke. Drive the lock ring into place, using new lock rings. Slide the retainer and universal ball over the front propeller shaft housing. Bolt the retainer to the back of the transmission case.

1941-1946, 1½ TON

Full Floating Axle with Four Pinion Differential, Riveted Ring Gear and Straddle Mounted Drive Pinion for Hotchkiss Drive.

Disassemble: To remove the axle shaft, bend the lugs of the lock plate away from the bolt heads with a cold chisel and hammer. Remove the cap screws and lock plate, after which the axle shaft and gasket can be removed.

To remove the wheel bearing, remove the wheel and raise the lip of the lock from the notch in the lock nut. Remove the lock nut and then remove the lock, inner adjusting nut and thrust washer. Remove the hub and drum assembly. Install clamp on brake wheel cylinder. Remove inner bearing and oil seal with a puller. To remove the outer bearing, tap the outer race to relieve the tension at the snap ring. Then remove the snap ring on the inside of the hub. Remove the bearing by driving on the outer race of the bearing with a long ⅛" punch through the cap screw holes in the end of the hub. This will also bring out the inner race and roller assembly. Use care to engage the edge of the race with the punch and not damage the bearing seat in the housing. Also make sure to drive the race out evenly.

NOTE—The oil slinger is a drive fit in the housing and if it is removed it must be replaced with a new one.

To remove the differential carrier from the axle, drain the lubricant, remove the differential cover and the axle shafts. Split the rear universal joint and drop the universal joint. Remove the bolts and lock washers which hold the differential carrier assembly to the axle housing and remove the differential carrier. Mount the assembly in a bench vise and remove the ring gear thrust pad from the side of the carrier. Remove the differential adjusting nut locks. Remove the bearing cap bolts and lockwashers. Remove the bearing caps. Then remove the differential case and ring gear assembly from the carrier. Remove the bolts from the pinion bearing retainer and oil seal and remove the pinion and shaft assembly from the carrier.

To disassemble the pinion, clamp the universal joint rear yoke in a vise and remove the cotter pin, nut and washer from the end of the pinion shaft. The universal joint flange, bearing retainer and oil seal may then be removed. To remove the rear pinion bearing, take off the lock ring and then press the pinion and shaft out of the bearing. Pressure must be exerted against the inner race, otherwise the bearing will be damaged. To remove the front bearing, install a bearing remover over the pinion teeth and against the inner race of the double row bearing. Then press the bearing off the pinion shaft.

Remove the differential bearings from the case with a bearing puller which pulls against the inner race of the bearings. To disassemble the differential make sure that the case halves are marked so that they can be assembled in their original position. Remove the bolts from the case. Lift off the case cover and remove the differential gears and pinions. The ring gear may be removed from the right side of the case by tapping it with a soft-faced hammer.

Assemble: To assemble the pinion, press the front double row bearing onto the pinion shaft with the extended portion of the bearing inner race toward the back of the gear teeth. Press the rear bearing on the end of the shaft with the chamfered side of the inner race towards the pinion. Install the lock ring. Slide the pinion bearing retainer and oil seal over the universal joint yoke. If replacement of the oil seal is necessary, install the felt packing toward the bottom of the recess and then the oil seal with the open end of the leather toward the pinion bearing. The oil seal should be pressed down against the felt packing. Soak a new leather oil seal in light engine oil at least one hour before installing it. Install the pinion bearing retainer gasket and then slide the universal joint yoke over the splines of the pinion shaft until it contacts the inner race of the bearing. Place the flat washer on the end of the pinion shaft and tighten the nut to a torque load of 160 to 280 ft. lbs. Lock the nut with a cotter pin.

When assembling the differential, the flanges of the case, ring gear pilot and the back of the ring gear must be clean and free from burrs. When replacing the ring gear, use two guide pins made from the differential and ring gear screw. Their ends should be slightly tapered and screwdriver slots cut in them so that they can be easily removed. Lubricate the differential side gears and pinions. Slip the side gears and pinions on the spider and install them in the left half of the differential case. Assemble the right side of the case to the left side, being sure to line up the marks on the case halves. Install the two guide pins. Slip the ring gear over the pilot diameter of the right half of the differential case. Install the differential to ring gear cap screws and lockwashers, leaving the pilots in place and tighten the screws evenly one turn at a time until the ring gear face is flush with the case flange. Remove the guide pins and install the two remaning bolts and lockwashers. Then pull up all bolts tight. Assemble the differential bearings to the case with a suitable driver. The wide side of the inner race must be towards the case.

Place the differential carrier in a vise and install the bearing cap dowels in the carrier or in the bearing caps. Assemble the pinion assembly to the carrier using new gaskets and tighten the pinion bearing retainer bolts securely. Install the differential assembly in the carrier. Install the bearing caps, making sure the marks on the caps line up with the marks in the carrier. Install the cap screws and tighten them until the lockwashers just flatten out. Screw the adjusting nuts into the carrier, making sure that they turn freely. Tighten them snugly to straighten the bearing outer races. Back off the right adjusting nut and tighten the left adjusting nut just to a point where all lash between the ring gear and the pinion is removed. Then back off the left nut approximately two notches and to a locking position. Tighten the right nut to a solid position. Back off the right nut free of the bearing, then tighten the nut until all play is removed from the bearing and then one or two notches more to a locking position.

Ring gear backlash should be from .005" to .008". If it is more than this, loosen the right adjusting nut one notch and tighten the left nut one notch. If less than this, loosen the left nut one notch and tighten the right nut one notch. Tighten the cap screws and recheck the ring gear and pinion backlash with a dial gauge. Assemble and tighten the adjusting nut locks. Examine the bronze tip of the ring gear thrust pad and if worn, install a new one. Install the thrust pad and tighten the screw until the bronze tip lightly engages the back of the ring gear while rotating the gear. Back off the screw 1/12 turn and then tighten the lock nut, making sure the screw does not turn during the locking process.

Install the differential carrier in the housing with a new gasket between the carrier and the housing. Install the cap screws and tighten them securely.

To replace the wheel bearings, place the inner race and roller assembly and the outer race in the wheel hub with the thin edge of the outer race downward.

With a suitable wheel bearing replacer, press the bearing in the hub. Press the race only far enough to install the snap ring in an arbor press. Install the snap ring in the groove on the inside of the hub. Use a driver through the cap screw holes in the end of the hub to force the outer race back in positive contact with the snap ring. To replace the inner bearing, place the outer race on the bearing in the wheel hub with the wide side of the face down. Use a driver to press the race against its seat. Install the inner race and roller assembly. Install the oil seal with a suitable tool and an arbor press. Lock the seal in place by prick punching at three equally spaced places. Install th wheel hub and drum assembly, turning th hub to properly line up the bearings. Insta the thrust washer and adjusting nut.

To adjust the wheel bearings, tighten th adjusting nut and then back it off 45 degrees. Turn the wheel hub by hand to mak sure the hub turns freely. Install the adjusting nut lock and check the alignment of the tangs with the slots in the nut. Rotate the hub by hand, grasping the hub at the wheel bolts, to see that the bearings are properly seated, and that the hub turns freely. Bend the tang on the lock down into the notch of the adjusting nut. Install the outer lock nut and pull it up tight to prevent any loosening of the adjusting nut. Bend the tang of the lock into the notch of the lock nut.

Install a new axle shaft flange gasket on the axle shaft and push the shaft into the housing. Use a new lock plate at the axle shaft cap screws and insert the cap screws in the axle shaft flange, tightening them alternately and make sure that they are pulled tight. Then bend the tangs of the lock plate against the heads of the cap screws. Assemble the rear universal joint. Replace the axle housing cover and gasket. Refill the rear axle with the proper lubricant to the level of the filler plug.

CHEVROLET AND GMC

Semi-Floating, with Two Pinion Differential, Riveted Ring Gear, for Torque Tube Drive.

Disassemble: To remove the axle shaft, remove the rear wheel. Remove the brake

drum from the axle shaft flange. Drain the lubricant and remove the differential cover. Remove the differential shaft lock screw. Pull out the differential shaft and the spacer block around it. Rotate the ring gear and remove the pinions. Push the axle shaft in toward the differential and remove the C washer from the recess at the inner end of the shaft. Using a suitable puller, remove the shaft from the housing. To remove the rear wheel bearing, insert a bearing puller into the housing and pull the bearing and oil seal out as assembly.

To remove the differential carrier, remove the nuts and lockwashers which hold the differential carrier to the axle housing and remove the differential carrier housing and torque tube from the rear axle housing. Place the unit in the vise. Before removing any parts, mark both differential bearing adjusting nuts and caps to indicate on which side each is mounted and also its location in the carrier so that they can be assembled with approximately the same drive gear adjustment. Remove the differential bearing cap screw locks and screws and lift out the differential assembly.

To disassemble the differential, remove the differential bearings from the differential case with a bearing puller. Clean, oil and check the bearings for roughness. The bearings are built with as high as .018″ end play, but after they are properly installed and adjusted there is no looseness. If it is just necessary to replace the bearings, use a suitable driver to replace the bearings. Check the ring gear for looseness. If it is necessary to remove the ring gear, use a ⅛″ drill to remove the rivet heads. Drill from the flange side of the case. Do not cut off the heads of the rivets with a cold chisel as the differential case may be disturbed. Tap off the ring gear with a soft hammer. After the ring gear has been removed from the differential case, the case must be checked on V-blocks and with a dial indicator. First check the ring gear pilot for run-out. This should not exceed .004″. Then check the face on which the ring gear is riveted for run-out. This should not exceed .004″. If either of these faces exceed this amount, replacement is the only remedy. The differential pinion shaft was removed to take out the axle shaft. All differential parts can be removed by hand.

To remove the drive pinion and propeller shaft, remove the three cap screws with lock nuts on the side of the differential carrier housing. Remove the propeller shaft and pinion from the housing. If it will not come out readily, bump its splined end on a wooden block to loosen it. Remove the shims and spacers from the inside of the propeller shaft housing at the front bearing seat. Keep the shims together so that the original assembly may be maintained. Inspect the splines for wear or looseness in the universal joint and examine the propeller shaft. Clean and oil the bearings and check for roughness. Check the double row ball bearings for end play. If there is end play in this bearing it should be replaced, as end play will allow the pinion to move in and out of mesh with the ring gear. Examine the pinion for cracked, chipped or scored teeth.

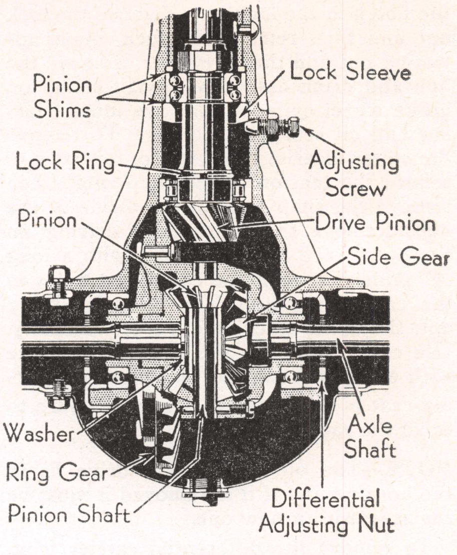
To disassemble the pinion from the propeller shaft it should be clamped in a vise at the pinion coupling so as not to compress the tube and damage it. Then raise the lip on the pinion thrust bearing retaining nut and loosen this nut. Cut off the rivet head which holds the pinion shaft to the coupling and drive out this rivet. Remove the pinion assembly by driving on the end of the gear with a brass drift or other soft tool to prevent damage to the gear. Clamp the spline end of the pinion in a vise with soft jaws and remove the pinion bearing lock nut. Press the double row bearing from the pinion shaft and remove the lock sleeve. Remove the single row rear bearing by removing the lock ring in front of the bearing and then pressing it off on an arbor press and with press plates.

After the bearings have been removed from the pinion, they should be cleaned and dried. After the bearings have been cleaned, they should be oiled and rotated by hand. The single row bearing should have an end play of .004″ to .006″.

Assemble: To assemble, press the single bearing on the pinion shaft. Install the lock sleeve with the tapered side toward the pinion. Press on the double row bearing. Install a new lock nut loosely. Press the pinion shaft into the propeller shaft so that the rivet holes in both parts are in alignment. Install a pin in the hole and rivet both ends. Tighten the bearing lock nut and lock it in the keyway of the pinion shaft. When this operation is done, the complete assembly should be mounted in V blocks, one block at the rear bearing and the other block at the ground diameter, which is back of the spline on the front end of the propeller shaft. The maximum indicator runout to which this assembly should be straightened is .002″ at the front double row bearing; .010″ at the part of the propeller shaft in front of rear splines; .015″ in the section at the center of the propeller shaft and .005″ at the extreme front end of the propeller shaft. Insert the shims in the torque tube. Install the pinion and propeller shaft in the differential housing. Insert the three pointed lock screws in the side of the housing and draw them down evenly and securely. Then tighten the lock nuts.

Bolt the gear to the case, using four bolts, and draw them up securely, leaving a hole open between each to bolt holes for riveting. Use only new rivets that fill the hole completely and that leave approximately 5/16″ of shank for heading. The rivet heads should be formed on the ring gear flange and not on the back of the differential case flange. Place the gear and case in a riveting fixture and, using the proper rivet set, head up opposite rivets. Do not work around the gear in riveting, as the gear is liable to be drawn to one side and run eccentric. Remove the bolts and finish riveting as already described. The runout should not exceed .007″ when checked at the back of the gear.

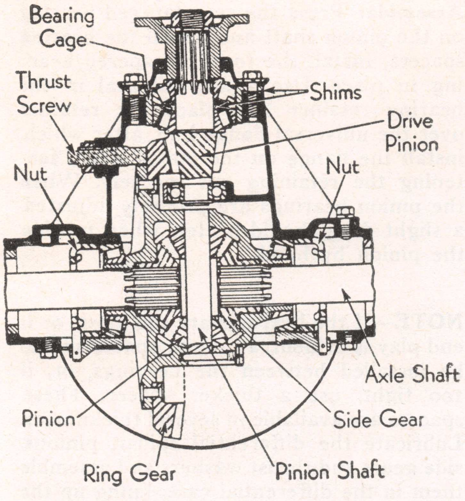
Before assembling the differential, examine the side gear bearing surfaces in the differential case and the thrust surfaces on the side and pinion gears. See that the hubs and splines of these gears are in good condition and that the side gear splines are a good fit on the axle shafts. Also check the fit of the pinion gears on the pinion shaft. If any of the parts are worn, they should be replaced. Press the differential bearing in place with the side marked "thrust here" toward the case. Locate the differential case in the carrier. Install the differential bearing caps and adjusting nuts. Draw up on the adjusting nuts until the marks indicate that the bearings are in their original position. Tighten the cap screws until the lockwashers are flat. Back off the right adjusting nut. Tighten the left adjusting nut until all lash is removed on the high spot and the nut is in its locking position, then back off the left nut one notch. Tighten the right nut snug and then tighten it from 1 to 1½ notches more to a locking position.



CHEVROLET. Semi-floating axle with riveted ring gear. Similar axle used on GMC.

Check for backlash. This should be .004″ to .006″. If it is more than this, loosen the right nut one notch and tighten the left nut one notch. If it is less than this, loosen the left nut one notch and tighten the right nut one notch. Tighten the cap screws and recheck the ring gear and pinion backlash. Assemble the adjusting nut locks. If it is necessary to move the pinion to secure proper tooth contact, it will be necessary to disassemble the rear axle and change the shims at the pinion front bearing. Now tighten the bearing cap lock screws securely and recheck the backlash. When correct, install the adjusting nut locks and lock the adjustment. After this is correct, assemble the carrier in the rear axle housing. A new gasket and lock washers should be used whenever the carrier is removed from the housing. Pull up the cap screws evenly and securely.

Lubricate the hubs of the differential side gears with rear axle lubricant and install them in the differential case. Then install the axle shafts in the reverse order from which they were removed, using a suitable



CLARK. Model B373.

driver to replace the bearing on the shaft. Spread the ends of the axle shafts to make sure that the shafts, locks and differential side gears are in positive contact. Roll the two differential pinions into place and install the axle shaft spacer, pinion gear shaft and lock screw. Check the end play. The maximum total side clearance of the spacer block is .008". Spacer blocks of several sizes are available for service to take up this play. If the block does not take up the clearance, new thrust washers should be installed in back of the differential side gears. If both axle shafts are removed, and they are not the same length, the longer shaft must be installed on the right side.

Install the housing cover, using a new gasket and fill the housing to its proper level with the correct lubricant.

CLARK

MODEL B373

Full Floating Axle with Two Pinion Differential, Riveted Ring Gear and Straddle Mounted Drive Pinion.

Disassemble: Disconnect the propeller shaft from the pinion shaft flange. Remove the axle shaft flange nuts and pull out the axle shafts. Straighten the tabs on the wheel bearing lock washers and remove the lock nuts, washers and adjusting nuts, after which the hubs may be removed. Remove the cap screws which fasten the differential carrier to the axle housing and remove the carrier assembly. Before removing any parts, mark both differential bearing adjusting nuts and caps so that they can be assembled with approximately the same drive gear adjustment. Remove the differential bearing cap screws and lift off the caps. Loosen the thrust block lock screw on the side of the differential carrier. Lift out the differential and ring gear. If it is necessary to remove the ring gear, remove the rivets which hold the ring gear to the differential case. Press the ring gear off the differential case. If the differential bearings are to be replaced, they can be removed from the differential case with a suitable bearing puller. Remove the differential pinion shaft lock screw and push out the differential pinion shaft. All the differential parts can then be removed by hand. Remove the cotter pin, nut and lock washer from the front of the pinion shaft and with a puller remove the universal joint flange. Remove the pinion bearing cap screws and remove the cap and oil seal. The drive pinion and bearings can now be removed from the carrier. If the pinion or bearings are to be replaced, the pinion can be pressed out of the bearings. Collect the shims between the bearing sleeve flange and the end of the carrier and note the thickness so that the original thickness of shims will be used when the parts are reassembled. The rear ball bearing may now be removed from the pinion shaft.

Assemble: Press the rear bearing cone on the pinion shaft. If the bearing cups were removed from the bearing sleeve, press them into their seats. Assemble the pinion and rear bearing cone to the sleeve and then install the spacer and rear bearing cone on the pinion shaft. No end play should be allowed at these bearings.

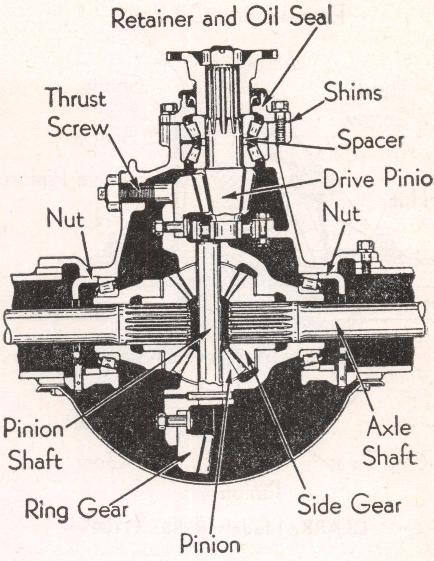
Play can be adjusted by shims between the bearing cones. Reducing the thickness of the shims reduces the end play.

The differential can be assembled in the reverse order from which it was disassembled. Push the differential pinion shaft into the case, making sure that the hole for the lock screw lines up with the hole in the case. Tighten the lock screw in place. Lubricate the differential bearings and press them on the differential case.

Assemble the drive pinion and bearings to the carrier housing, using the original shims between the bed of the carrier and the bearing sleeve flange. Replace the bearing cap and oil seal and tighten the companion flange in place, using a cotter pin in the nut to hold it in position. Assemble the differential assembly and bearings in the carrier in the housing. Replace the bearing adjusting nuts and the bearing caps, and tighten the caps in position. Turn the adjusting nuts until the marks on them indicate that they are in their original position. Then tighten the bearing cap screws and adjusting screw locks.

There should be no play in the differential bearings. If an adjustment is necessary, tighten the bearing adjusting nuts with sufficient force to seat the bearing cups solidly against the rollers. Back off the adjusting nuts to relieve strain and tighten them again slightly, against the bearing cups. Loosen the right adjusting nut and tighten the left nut, at the same time turning the ring gear, until all lash is removed. Then back off the left nut one turn. Tighten the right nut until it is snug and continue for one or two more notches, until a locking position is reached.

Check the tooth contact and if it is necessary to move the ring gear away from the pinion, tighten the right nut and loosen the left nut an equal number of notches until the contact is correct. If the ring gear must be moved toward the pinion, tighten the left nut and loosen the right nut an equal number of notches. By turning both nuts the same amount, the bearing play will not be changed. The pinion can be moved toward or away from the ring gear by changing the thickness of the shims between the pinion bearing sleeve flange and the end of the carrier. Adding shims moves the pinion away from the ring gear and reducing the thickness of the shims moves the pinion toward the ring gear.



CLARK. Models R650, R750.

When this adjustment is completed, turn the thrust block screw in until it contacts the ring gear and then back it off just slightly. The clearance between the ring gear and the thrust block should be .010" to .012".

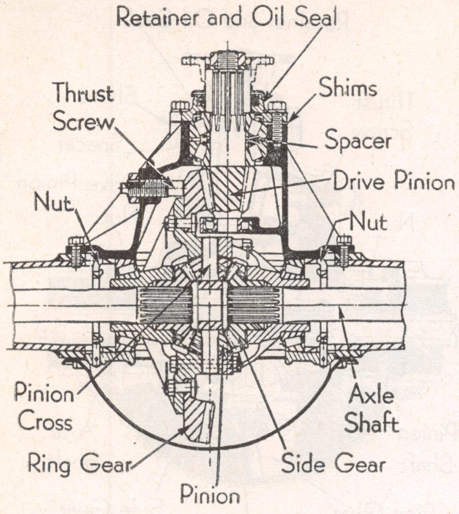
Assemble the carrier to the housing, using a new gasket and tighten the cap screws securely, using new lock washers under the screws. Lubricate the wheel bearings and assemble the hubs, bearings and adjusting nuts, using new oil seals. Adjust the bearings by tightening the bearing adjusting nuts until the wheel binds and then back them off just enough to permit the wheel to turn freely without end play. Install the axle shafts and tighten the flange nuts securely. Complete the assembly by attaching the universal joint flanges.

MODELS R650, R750

Full Floating Axle with Two Pinion Differential, Bolted Ring Gear and Straddle Mounted Drive Pinion.

Disassemble: Disconnect the propeller shaft from the pinion shaft flange. Unscrew the axle shaft bolts and pull out the shafts. Straighten the tabs on the wheel bearing lock washers and remove the nuts and washers, after which the hubs may be removed. Take off the differential inspection cover. Remove the cap screws which fasten the differential carrier to the axle housing and remove the carrier assembly.

NOTE—For axles equipped with a thrust screw, back out the screw to allow the ring



CLARK. Models R950, R1100

gear to clear when removing the differential assembly.

Mark the relationship of the differential bearing caps and adjusting nuts and then remove the bearing caps. Remove the differential lock pin and pull out the shaft; the differential parts are now loose and can be removed by hand. If the ring gear is riveted to the flange, use a drill which is smaller than the diameter of the rivet head and drill the rivets from the differential case side, after which, punch out the rivets. Remove the cap screws which fasten the drive pinion bearing retainer to the carrier housing and pull out the drive pinion assembly. Clamp the universal flange in a vise and remove the flange retaining nut, then the flange, retainer and bearings may be removed from the pinion shaft.

Assemble: Press the rear tapered bearing on the pinion shaft and install the bearing spacer. Install the forward tapered bearing in place. Use a new oil seal in the bearing retainer and place the retainer over the universal flange hub, after which, install the flange on the pinion shaft, fastening the retaining nut securely. When the pinion bearings are properly adjusted, a slight drag should be felt when turning the pinion by hand.

NOTE— If the bearings are too loose, or if end play is evident, a thinner spacer should be installed between the bearings. If the adjustment is too tight, use a thicker spacer. These spacers are available in several thicknesses.

Lubricate the differential pinions, side gears and thrust washers and install them into the differential case, then push in the pinion shaft, lining up the hole in the shaft with the hole in the case, after which, install the lock pin. Locate the differential case in the carrier and install the bearing caps and adjusting nuts, tightening the cap screws until the lock washers just flatten out.

NOTE—If new parts were installed or an adjustment is necessary, the adjusting nuts should be tightened with sufficient force to drive the bearing cups solidly against the rollers. Then back off the adjusting nuts to relieve the strain and tighten them again slightly against the bearing cup.

Now, while turning the ring gear, loosen the right adjusting nut and tighten the left adjusting nut until all lash is removed and then back off the left nut one turn. Tighten the right adjusting nut until it is snug and continue for one or two notches more, or until a locking position is reached. Mount a dial indicator on the carrier and check the backlash between the ring gear and pinion, which should be from .007" to .010". If the backlash exceeds this amount, loosen the right adjusting nut one notch and tighten the left nut one notch. If the backlash is less than specified, loosen the left nut one notch and tighten the right nut one notch. Now tighten the bearing cap lock screws securely and recheck the lash. When correct, install the adjusting nut locks and lock the adjustment.

On axles equipped with a thrust screw, install the screw into the carrier and turn it in until it contacts the ring gear, then back off about ¼ turn. Assemble the carrier in the axle housing, using a new gasket and lock washers under the cap screws, being sure to draw up the cap screws evenly and securely. Lubricate the wheel bearings and assemble the hubs, bearings and adjusting nuts, using new oil seals. Adjust the bearings by tightening the adjusting nut until the wheel binds, then back off just enough to permit the wheel to turn freely, yet without end play. Install the axle shafts and tighten the stud nuts securely. Complete the assembly by connecting propeller shaft.

MODELS R950, R1100

Full Floating Axle with Four Pinion Differential, Bolted Ring Gear and Straddle Mounted Drive Pinion.

Disassemble: Disconnect the propeller shaft from the pinion shaft flange. Unscrew the axle shaft flange bolts and pull out the shafts. Straighten the tabs on the wheel bearing lock washers and remove the nuts and washers, after which, the hubs may be removed. Take off the differential inspection cover. Remove the cap screws which fasten the differential carrier to the axle housing and remove the carrier assembly. Back out the thrust screw to allow the ring gear to clear when removing the differential assembly. Mark the relationship of the differential bearing caps and adjusting nuts and then remove the bearing caps. Mark both halves of the differential case so that when assembled, the original position is maintained, then remove the cap screws or bolts which attach both halves of the case, after which, the case may be separated and all the differential parts removed. Remove the cap screws which fasten the drive pinion bearing retainer to the carrier housing and pull out the drive pinion assembly. Clamp the universal flange in a vise and remove the flange retaining nut, after which the flange, retainer and bearings may be removed from the pinion shaft.

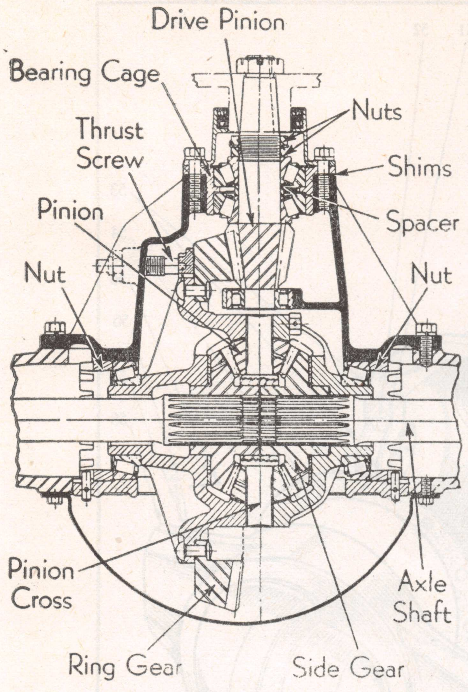
Assemble: Press the rear tapered bearing on the pinion shaft and install the bearing spacers. Install the forward tapered bearing in place. Use a new oil seal in the bearing retainer and place the retainer over the universal flange hub, after which, install the flange on the pinion shaft, fastening the retaining nut securely. When the pinion bearings are properly adjusted, a slight drag should be felt when turning the pinion by hand.

NOTE—If the bearings are too loose, or if end play is evident, a thinner spacer should be installed between the bearings, or, if too tight, use a thicker spacer. These spacers are available in several thicknesses. Lubricate the differential spider, pinions, side gears and thrust washers and assemble them in the differential case, lining up the marks on both halves of the case before installing the cap screws; after tightening the cap screw securely, thread locking wire through all the screw heads. Locate the differential case in the carrier and install the bearing caps and adjusting nuts, tightening the cap screws until the lock washers just flatten out.

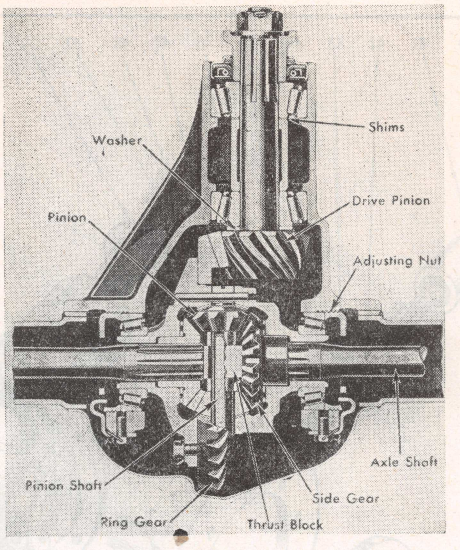
NOTE—If new parts were installed or an adjustment is necessary, the adjusting nuts should be tightened with sufficient force to drive the bearing cups solidly against the rollers.

Then back off the adjusting nuts to relieve the strain and tighten them again slightly against the bearing cup. Now while turning the ring gear, loosen the right adjusting nut and tighten the left adjusting nut until all lash is removed and then back off the left nut one turn. Tighten the right adjusting nut until it is snug and continue for one or two notches more, or until a locking position is reached. Mount a dial indicator on the carrier and check the backlash between the ring gear and pinion, which should be from .007" to .010". If the backlash exceeds this amount, loosen the right adjusting nut one notch and tighten the left nut one notch. If the backlash is less than specified, loosen the left nut one notch and tighten the right nut one notch

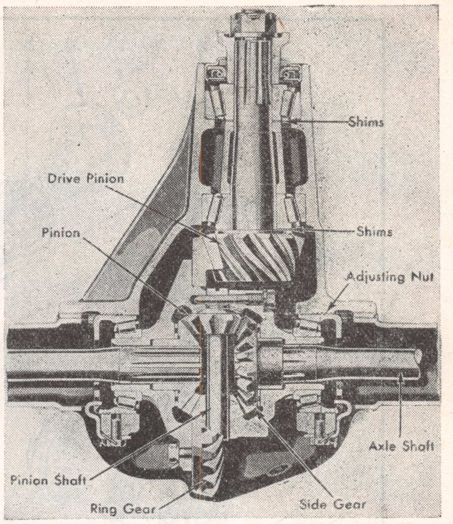
Now tighten the bearing cap lock screws securely and recheck the lash. When correct, install the adjusting nut locks and lock the adjustment. Screw the thrust screw into the carrier and turn it in until it contacts the ring gear, then back it off from 1/6 to ¼ turn and tighten the lock nut. Assemble the carrier in the axle housing, using a new gasket and lock washers under the cap screws, being sure to draw up the cap screws evenly and securely. Lubricate the wheel bearings and assemble the hubs, bearings and adjusting nuts, using new oil seals. Adjust the bearings by tightening the adjusting nut until the wheel binds, then back off just enough to permit the wheel to turn freely, yet without end play. Install the axle shafts and tighten the stud nuts securely. Complete the assembly by installing the propeller shaft.



CLARK. Model R1300



DODGE. Semi-floating with pin locking differential pinion shaft.



DODGE. Semi-floating with screw locking differential pinion shaft.

MODEL R1300

Full Floating Axle with Four Pinion Differential, Riveted Ring Gear and Straddle Mounted Drive Pinion.

Disassemble: Disconnect the propeller shaft flange from the pinion shaft flange. Unscrew the axle shaft flange nuts and pull out the shafts. Straighten the tabs on the wheel bearing lock washers and remove the lock nuts, washers and adjusting nuts, after which, the hubs may be removed. Take off the differential inspection cover. Remove the cap screws which fasten the differential carrier to the axle housing and remove the carrier assembly. Back out the thrust block adjusting screw to allow the ring gear to clear the thrust block when removing the differential assembly. Mark the relationship of the differential bearing caps and adjusting nuts and then remove the bearing caps and lift out the differential assembly. Mark both halves of the differential case so that when assembled, the original position is maintained, then unfasten the both halves of the case, after which, the case may be separated and all the differential parts removed. If the ring gear is to be replaced, use a drill which is smaller than the diameter of the rivet head and drill the rivet from the differential case side, after which, punch out the rivets. Pull the drive pinion and bearing cage assembly out of the carrier. Clamp the pinion or universal flange in a vise and remove the flange retaining nut, then the flange, oil seal cover, adjusting nuts, front roller bearing, spacer and bearing cage may be removed.

NOTE—Collect the shims under the bearing cage, noting the quantity and thickness in order to facilitate adjustment when assembling. The rear bearing roller may now be removed from the pinion shaft.

Assemble: Assemble the rear tapered bearing on the pinion shaft and install the bearing spacer. Place the bearing cage in position and assemble the front tapered bearing. Screw the bearing adjusting nut all the way up to be sure the bearings are seated, then back off the nut just enough to permit the cage to turn, yet not enough to allow it to spin. Install a new lock washer on the shaft and run the lock nut up tight, being careful not to change the adjustment. If necessary, back off the adjusting nut slightly. After the bearings are satisfactorily adjusted, bend one of the tabs of the lock washer over the adjusting nut and another over the lock nut to hold them securely in place.

Install the drive pinion assembly in the carrier, replacing the original quantity of shims under the bearing cage. Install a new oil seal in the cover and replace the bolts which fasten the pinion cage assembly to the carrier. Lubricate the differential spider, pinions, side gears and thrust washers and assemble them in the differential case, lining up the marks on both halves of the case before installing the cap screws; after tightening the cap screws securely, thread locking wire through all the screw heads. Locate the differential case in the carrier and install the bearing caps and adjusting nuts, tightening the cap screws until the lock washers just flatten out.

NOTE—If new parts were installed or an adjustment is necessary, the adjusting nuts should be tightened with sufficient force to drive the bearing cups solidly against the rollers. Then back off the adjusting nuts to relieve the strain and tighten them again slightly against the bearing cup.

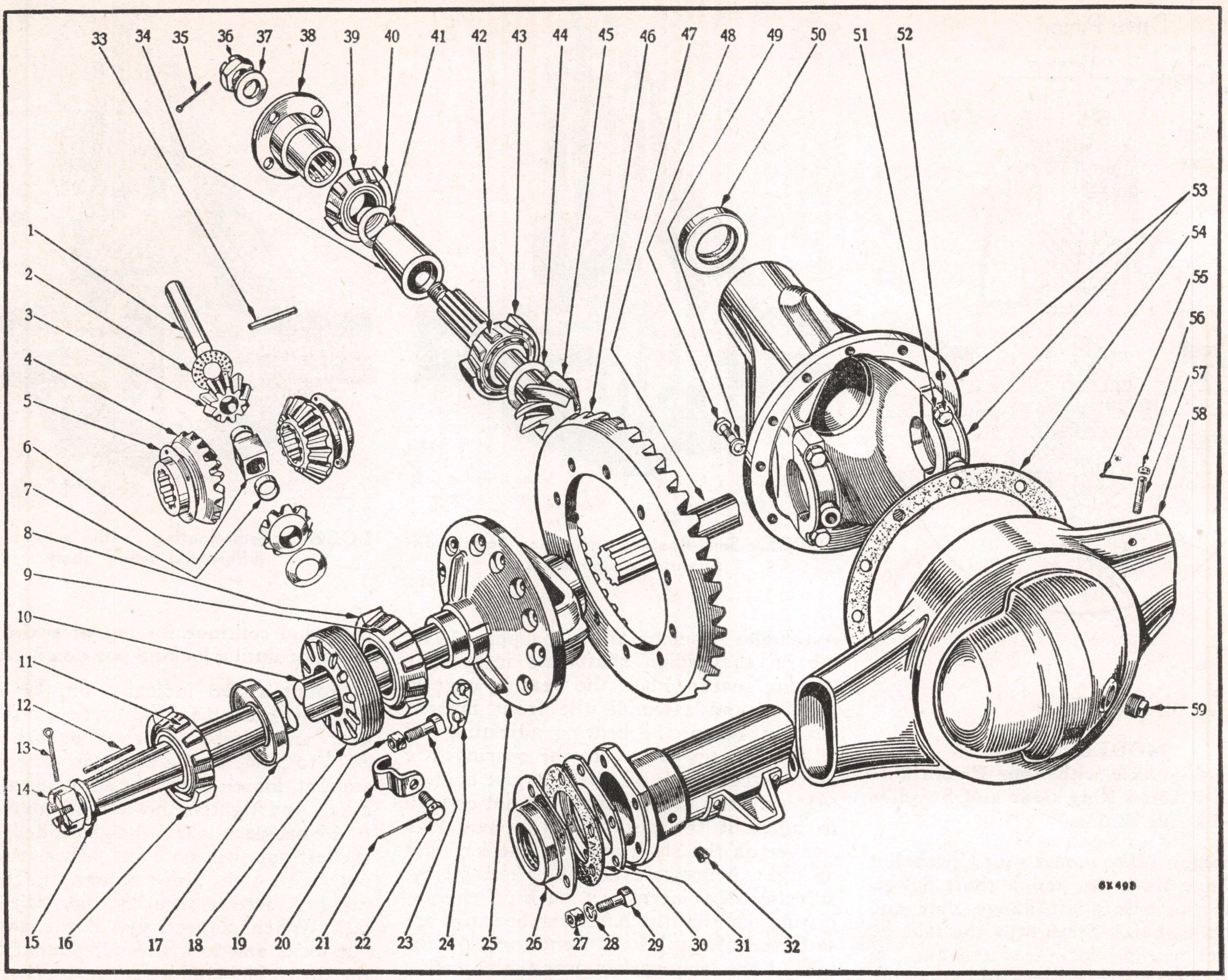
Now while turning the ring gear, loosen the right adjusting nut and tighten the left adjusting nut until all lash is removed and then back off the left nut one turn. Tighten the right adjusting nut until it is snug and continue for one or two notches more, or until a locking position is reached.

Mount a dial indicator on the carrier and check the backlash between the ring gear and pinion, which should be from .007" to .010". If the backlash exceeds this amount, loosen the right adjusting nut one notch and tighten the left nut one notch. If the backlash is less than specified, loosen the left nut one notch and tighten the right nut one notch. Now tighten the bearing cap lock screws securely and recheck the lash. When correct, install the adjusting nut locks and lock the adjustment. Screw the thrust block adjusting screw partly into the carrier. Lubricate the thrust block and hold it in place on the ring gear. Turn the adjusting screw up tight to permit the block to seat on the end of the screw. Continue turning the screw until the block contacts the ring gear, then back off the screw from 1/6 to ¼ turn and tighten the lock nut. Assemble the carrier in the axle housing, using a new gasket and lock washers under the cap screws, being sure to draw up the cap screws evenly and securely. Lubricate the wheel bearings and assemble the hubs, bearings and adjusting nuts, using new oil seals. Adjust the bearings by tightening the adjusting nut until the wheel binds, then back off just enough to permit the wheel to turn freely, yet without end play. Install the axle shafts, then tighten the nuts securely. Complete the assembly by installing the universal flange and propeller shaft.

DODGE

Semi-Floating Axle with Two Pinion Differential, Riveted Ring Gear and Drive Pinion Mounted on Two Taper Roller Bearings.

Disassemble: To remove the axle shafts, remove the rear wheel. Remove the cotter pin, nut and washer from the outer end of the axle shaft. Remove the hub and brake



DODGE. Semi-floating axle with thrust block at inner end of shafts

1—Differential pinion shaft
2—Differential pinion thrust washer
3—Differential pinion
4—Differential gear
5—Differential gear thrust washer
6—Axle drive shaft thrust block
7—Axle drive shaft thrust block spacer
8—Differential bearing cup
9—Differential bearing cone and rollers
10—Axle drive shaft
11—Axle drive shaft bearing cone and rollers
12—Axle drive shaft key
13—Axle drive shaft nut cotter pin
14—Axle drive shaft nut
15—Axle drive shaft nut washer
16—Axle drive shaft bearing cup
17—Axle drive shaft oil washer
18—Differential bearing adjuster
19—Axle drive gear bolt nut
20—Differential bearing adjuster lock
21—Differential bearing adjuster lock screw lock wire
22—Differential bearing adjuster lock screw
23—Axle drive gear bolt
24—Axle drive gear bolt nut lock
25—Differential case
26—Axle drive shaft bearing oil seal
27—Rear wheel brake support to axle housing bolt nut
28—Rear wheel brake support to axle housing bolt nut lockwasher
29—Rear wheel brake support to axle housing bolt
30—Axle drive shaft bearing oil seal retainer gasket
31—Axle drive shaft bearing shim
32—Axle drive shaft bearing oil hole plug
33—Differential pinion shaft lock pin
34—Axle drive pinion bearing spacer
35—Axle drive pinion flange nut cotter pin
36—Axle drive pinion flange nut
37—Axle drive pinion flange nut washer
38—Axle drive pinion flange
39—Axle drive pinion front bearing cone and rollers
40—Axle drive pinion front bearing cup
41—Axle drive pinion front bearing adusting shims
42—Axle drive pinion rear bearing cone and rollers
43—Axle drive pinion rear bearing cup
44—Axle drive pinion rear bearing washe
45—Axle drive pinion
46—Axle drive gear
47—Axle drive shaft
48—Axle drive pinion carrier screw
49—Axle drive pinion carrier screw lockwasher
50—Axle drive pinion bearing oil seal
51—Differential bearing cap screw lockwashe
52—Differential bearing cap screw
53—Axle drive pinion carrier and cap
54—Axle drive pinion carrier gasket
55—Housing vent nipple cap cotter pin
56—Housing vent nipple cap
57—Housing vent nipple
58—Housing
59—Housing cover plug

drum assembly with a suitable puller. Do not use a knock-off type of puller or strike the end of the axle shaft to loosen the hub because damage can be done to the differential parts by this method. Block the brake pedal to the floor board so that it cannot be depressed. Disconnect the hydraulic brake line from the wheel cylinder. Remove the stud nuts which hold the oil seal and brake support to the axle housing and remove the oil seals, brake support and shims. If both axle shafts are to be removed, keep the shims on each shaft separate and assembled to their respective ends of the axle housing to maintain the correct bearing adjustment. With a suitable puller, remove the axle shaft and bearing assembly. With a bearing puller, remove the bearing from the axle shaft. Use an oil seal puller to remove the seals from the housing.

NOTE—If an axle shaft is broken less than 8″ from the inner end of the shaft, the inner piece can be removed when the differential and carrier are removed. If the break is more than 8″ from the inner end of the shaft, it will be necessary to snare the inner end out through the housing with a wire loop or a similar tool, after removing the inner oil seal.

To remove the differential carrier, drain the oil from the differential by removing drain plug or two bottom cap screws which fasten the carrier to the rear axle housing. Remove the universal joint flange bolts at the rear universal joint and drop the propeller shaft. Remove the cap screws which hold the differential carrier to the axle housing and lift out the differential carrier. Mount the carrier on a bench or fasten it in a vise. Before removing any parts, mark both differential bearing adjusting nuts and caps to indicate on which side each is mounted and also its location in the carrier so that they can be assembled with approximately the same drive gear adjustment. Remove the differential bearing cap screws and lift off the caps. With a puller, remove the differential bearings. Lift out the differential and ring gear assembly.

To disassemble the differential and ring gear assembly, remove the bolts, or cap screws if they are used, which hold the ring gear to the differential case. Press the ring gear off the differential case. Remove the differential pinion shaft lock pin, or lock screw if it is used, and push out the differential pinion shaft. All differential parts will then be loose and can be removed by hand.

NOTE—The differential assembly must be removed before removing the drive pinion, but it is not necessary to remove the drive pinion or the differential assembly for removal of the drive pinion bearing oil seal.

Remove the cotter pin, drive pinion flange nut and washer from the front end of the pinion shaft. With a suitable tool, pull off the universal joint drive flange. If it is just necessary to remove the oil seal, remove it from the pinion shaft with a puller. If the pinion is to be removed, pull it out through the rear end of the carrier case. The bearing spacer, front bearing and shims may then be removed from the housing. With a bearing puller, remove the rear bearing cone from the pinion shaft. Unless the ring gear and pinion are to be replaced with new parts, use care not to get the front bearing shims and the rear bearing shims mixed.

Assemble: If the differential assembly was satisfactory from a standpoint of noise, before the unit was disassembled, then the drive pinion may be assembled with the original shims or washer behind the rear bearing. If new parts were installed or an adjustment was necessary, change these shims until the correct thickness is obtained to locate the pinion properly with relation to the ring gear.

Play in the pinion shaft bearings on 1936 models should be .004" to .008" and from .0015" to .0025" tight, pre-loaded, on 1937 to 1942 models. To obtain this play or preload, insert sufficient shims between the bearing spacer and the front bearing. If available, a dial indicator should be used to make this check. To make this adjustment, remove the drive pinion flange, oil seal, front bearing and then add or remove the required number of shims. Assemble the bearing, oil seal and flange, being sure to apply lubricant to the bearings before final assembly. Use a new cotter pin and lock washer when locking the flange in place.

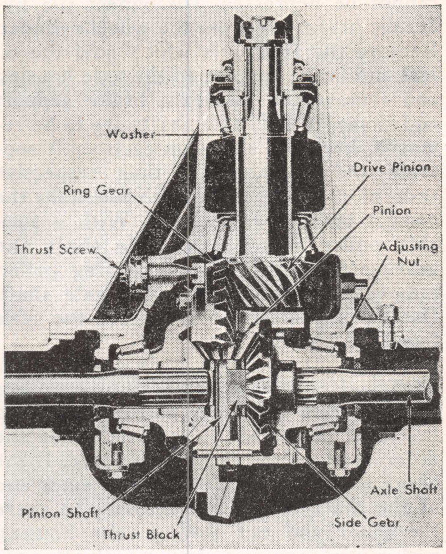
To assemble the differential, press the differential bearings in place. Install the side gear thrust washers and side gears in the case. Mesh the differential pinions with side gears, holding the thrust washers on the back of the gears. Rotate the side gears until the holes through the center of the pinions are in line with the hole for the pinion shaft, in the case. Push, do not drive, the pinion shaft in place so that the hole in the shaft for the lock screw or pin registers with the hole in the case. Then install the lock screw or pin. Locate the differential case in the carrier. Install the differential bearing caps and adjusting nuts. Draw up on the adjusting nuts until the marks which you made on the bearing adjusting nuts and caps indicate that the bearings are in their original position. Then tighten the cap screws in the bearing caps until the lock washers just flatten out.

Adjustment: If new parts were installed or an adjustment was necessary, the differential bearing adjusting nuts should be tightened with sufficient force to drive the bearing cups solidly against the rollers. Then back off the adjusting nuts to relieve strain and then tighten them again slightly against the bearing cup. Now while turning the ring gear, loosen the right adjusting nut and tighten the left adjusting nut until all lash is removed and then back off the left nut one turn. Tighten the right adjusting nut until it is snug and continue for one or two notches more, until a locking position is reached.

Mount a dial indicator on the carrier and check the backlash between the ring gear and the pinion. On 1936 models it should be .006" to .008", on 1937 to 1940 models it should be .006" to .010" and on 1941-42 models it should be .008" to .010". If the backlash exceeds this amount, loosen the right adjusting nut one notch and tighten the left nut one notch. If the backlash is less than specified, loosen the left nut one notch and tighten the right nut one notch. Now tighten the bearing cap lock screws securely and recheck the backlash. When correct, install the adjusting nut locks and lock the adjustment.

After this is correct, assemble the carrier in the rear axle housing. A new gasket and lock washers should be used whenever the carrier is removed from the housing. Pull up the cap screws evenly and securely.

To assemble the axle shafts, replace the shafts and bearings in the reverse order from which they were removed. Use a suitable drift to replace the oil seal. If a new leather oil seal is to be installed, soak the leather in oil for about 30 minutes and work it with a smooth steel bar until it is soft and pliable. If the old parts are replaced and the shims have not been disturbed, the end play should be correct when the parts have been assembled. If a new axle shaft, bearing, differential carrier or housing has been installed, it will be necessary to check the end play.



DODGE. Semi-floating with barrel type differential

End play can be checked when all the parts have been replaced except the wheel and hub. To make this check, rap each axle shaft, after the bolts are tight, to be sure the bearing cups are seated. Then place an indicator on the axle shaft and housing to determine the amount of end play of the shaft by pushing in and pulling out the shaft. If an adjustment is necessary, remove the axle shaft bearing oil seal and the brake support plate, after disconnecting the brake tube as already described. Add or remove shims to adjust the end play. Shims are located between the rear wheel brake support and the outer side of the axle housing flange.

When making this adjustment, an equal thickness of shims should be removed or added on each side of the axle housing to maintain a central position of the axle shaft thrust block. The hole in the thrust block is sufficiently larger than the diameter of the shaft to prevent axle shaft thrust from being thrown on the pinion shaft, providing the thrust block is held in its central position on the shaft.

Fill the housing to the level of the filler plug hole with the specified grade and type of lubricant. Attach the propeller shaft to the rear universal joint flange, using new cap screw locks.

Semi-Floating Axle with Two Pinion and Barrel Type Differential, Bolted Ring Gear and Drive Pinion Mounted on Two Taper Roller Bearings.

Disassemble: To remove the axle shaft, remove the rear wheel. Remove the cotter pin, nut and washer from the outer end of the axle shaft. Remove the hub and brake drum assembly with a suitable puller. Do not use a knock-off type of puller or strike the end of the axle shaft to loosen the hub because damage can be done to the differential parts by this method. Block the brake pedal to the floor board so that it cannot be depressed. Disconnect the hydraulic brake line from the wheel cylinder. Remove the stud nuts which hold the oil seal and brake support to the axle housing and remove the oil seals, brake support and shims. If both axle shafts are to be removed, keep the shims on each shaft separate and assembled to their respective ends of the axle housing to maintain the correct bearing adjustment. With a suitable puller, remove the axle shaft and bearing assembly. With a bearing puller, remove the bearing from the axle shaft. Use an oil seal puller to remove the seals from the housing.

NOTE—If an axle shaft is broken less than 8" from the inner end of the shaft, the inner piece can be removed when the differential and carrier are removed. If the break is more than 8" from the inner end of the shaft, it will be necessary to snare the inner end out through the housing with a wire loop or a similar tool, after removing the inner oil seal.

To remove the differential carrier, drain the oil from the differential by removing two bottom cap screws which fasten the carrier to the rear axle housing. Remove the universal joint flange bolts at the rear universal joint and drop the propeller shaft. Remove the cap screws which hold the differential carrier to the axle housing and lift out the differential carrier. Mount the carrier on a bench or fasten it in a vise. Before removing any parts, mark both differential bearing adjusting nuts and caps to indicate on which side each is mounted and also its location in the carrier so that they can be assembled with approximately the same drive gear adjustment. Remove the differential bearing cap screws and lift off the caps. Lift out the differential and ring gear assembly.

To disassemble the differential and ring gear assembly, remove the bolts, which hold the ring gear to the differential case. Press the ring gear off the differential case. Remove the differential case bearing on the cap side only with a suitable puller. Remove the differential case cap locking pin by driving it through the case. Place the differential case in a pan and fill the pan with water up to a level ½" below the cover. Remove the case and boil the water. Then submerge the case in the boiling water in order to heat the case without heating the cap. Do not heat the case with a flame. Remove the case from the water, attach it immediately to a fixture and remove the cap, using a spanner wrench. While a helper applies pressure on the spanner wrench, jar the cover loose with a hammer and soft drift with a smart rap on the web of the cover. Remove the differential pinion shaft locking pin by driving it out of the case with a hammer and punch. Push the differential pinion shaft out of the differential case. The gears, thrush washers and axle shaft thrust block will then all be loose and fall out of the case.

NOTE—The differential assembly must be removed before removing the drive pinion, but it is not necessary to remove the drive pinion or the differential assembly for removal of the drive pinion bearing oil seal.

Remove the cotter pin, drive pinion flange nut and washer from the front end of the pinion shaft. With a suitable tool, pull off the universal joint drive flange. If it is just necessary to remove the oil seal, remove it from the pinion shaft with a puller. If the pinion is to be removed, pull it out through the rear end of the carrier case. The bearing spacer, front bearing and shims may then be removed from the housing. With a bearing puller, remove the rear bearing cone from the pinion shaft. Unless the ring gear and pinion are to be replaced with new parts, use care not to get the front bearing shims and the rear bearing shims mixed.

Assemble: If the differential assembly was satisfactory from a standpoint of noise, before the unit was disassembled, then the drive pinion may be assembled with the original shims or washer behind the rear bearing. If new parts were installed or an adjustment was necessary, change these shims until the correct thickness is obtained to locate the pinion properly with relation to the ring gear. The pinion shaft bearings are from .0015" to .0025" tight, preloaded. To obtain this pre-load, insert sufficient shims between the shoulder of the pinion bearing shaft and the front bearing. If available, a dial indicator should be used to make this check.

To make this adjustment, remove the drive pinion flange, oil seal, front bearing and then add or remove the required number of shims. Assemble the bearing, oil seal, washer, oil slinger and flange, being sure to apply lubricant to the bearings before final assembly. The oil baffle in front of the rear pinion bearing should be assembled with its tab engaged in the lower notch of the carrier and the oil slinger in front of the front bearing should be installed between the flange and the washer with the beveled side toward the bearing. Use a new cotter pin and lock washer when locking the flange in place.

To assemble the differential, coat the parts with rear axle lubricant to facilitate holding them in place until the thrust block and differential pinion shaft are installed. Install the side gear thrust washers and side gears in the case. Mesh the differential pinions with the side gears, holding the thrust washers on the back of the gears. Rotate the side gears until the holes through the center of the pinions are in line with the hole for the pinion shaft in the case. Push, do not drive, the pinion shaft in place so that the hole for the lock pin registers with the hole in the case. Then install the lock pin. Peen over the outside edge of the hole to lock the pin in place. Heat the case as outlined in the disassembly instructions and install the case cap. Tighten it rigidly in place with a spanner wrench. Drill a new hole through the cap and the case of a size corresponding to the small end of the case cap locking pin. Then install a new locking pin.

Locate the differential case in the carrier. Install the differential bearing caps and adjusting nuts. Draw up on the adjusting nuts until the marks which you made on the bearing adjusting nuts and caps indicate that the bearings are in their original position. Then tighten the cap screws in the bearing caps until the lock washers just flatten out.

Adjustment: If new parts were installed or an adjustment was necessary, the differential bearing adjusting nuts should be tightened with sufficient force to drive the bearing cups solidly against the rollers. Then back off the adjusting nuts to relieve strain and then tighten them again slightly against the bearing cup. Now while turning the ring gear, loosen the right adjusting nut and tighten the left adjusting nut until all lash is removed and then back off the left nut one turn. Tighten the right adjusting nut until it is snug and continue for one or two notches more, until a locking position is reached.

Mount a dial indicator on the carrier and check the backlash between the ring gear and the pinion. It should be .006" to .010". If the backlash exceeds this amount, loosen the right adjusting nut one notch and tighten the left nut one notch. If the backlash is less than specified, loosen the left nut one notch and tighten the right nut one notch. Now tighten the bearing cap lock screws securely and recheck the backlash. When correct, install the adjusting nut locks and lock the adjustment. To adjust the drive gear thrust pad on the side of the differential carrier turn the screw in finger tight and then back it off ⅛ turn. Lock this adjustment with the lock nut.

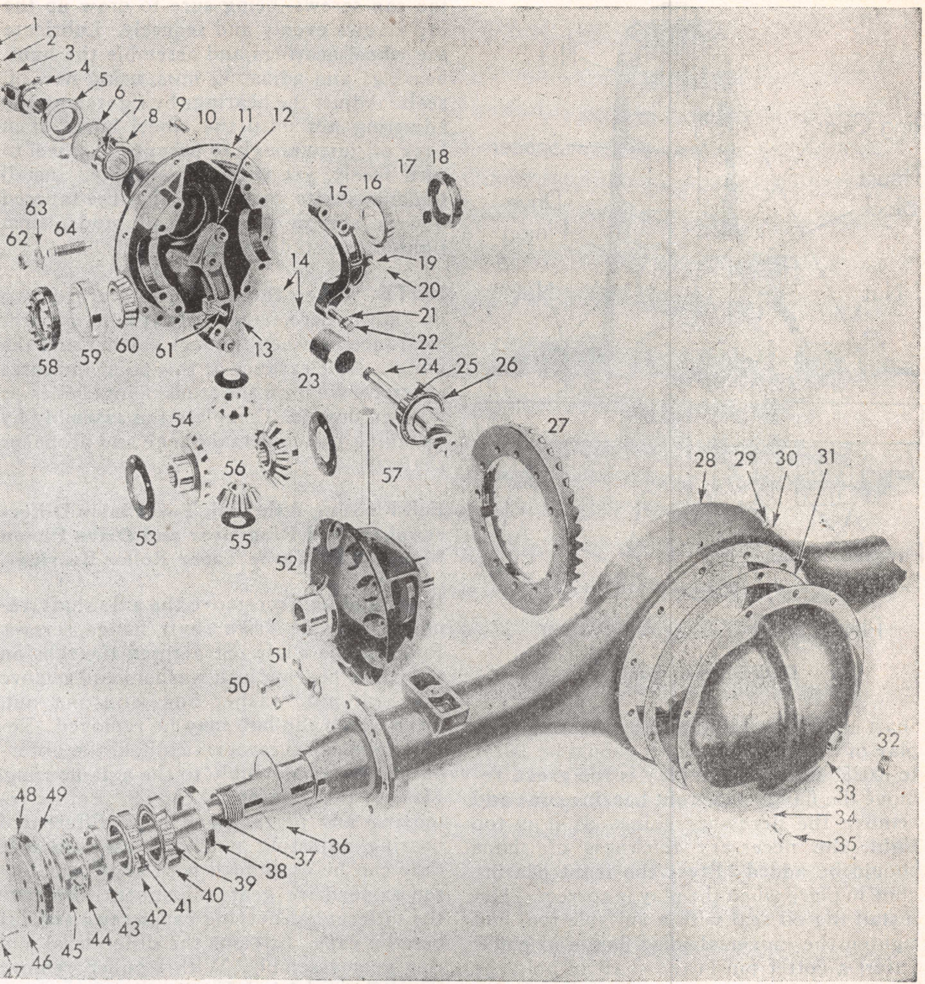
After this is correct, assemble the carrier in the rear axle housing. A new gasket and lock washers should be used whenever the carrier is removed from the housing. Pull up the cap screws evenly and securely.

To assemble the axle shafts, replace the shafts and bearings in the reverse order from which they were removed. Use a suitable drift to replace the oil seal. If a new leather oil seal is to be installed, soak the leather in oil for about 30 minutes and work it with a smooth steel bar until it is soft and pliable. If the old parts are replaced and the shims have not been disturbed, the end play should be correct when the parts have been assembled. If a new axle shaft, bearing, differential carrier or housing has been installed, it will be necessary to check the end play.

End play can be checked when all the parts have been replaced except the wheel and hub. To make this check, rap each axle shaft, after the bolts are tight, to be sure the bearing cups are seated. Then place an indicator on the axle shaft and housing to determine the amount of end play of the shaft by pushing in and pulling out the shaft. If an adjustment is necessary, remove the axle shaft bearing oil seal and the brake support plate, after disconnecting the brake tube as already described.

Add or remove shims to adjust the end play. Shims are located between the rear wheel brake support and the outer side of

1—Cotter pin
2—Rear axle drive pinion companion yoke nut
3—Rear axle drive pinion companion yoke washer
4—Rear axle drive pinion companion yoke
5—Rear axle drive pinion bearing oil seal
6—Rear axle drive pinion front bearing washer
7—Rear axle drive pinion bearing cone—front
8—Rear axle drive pinion bearing cup—front
9—Differental carrier screw
10—Lock washer
11—Differential carrier and cap assembly
12—Differential carrier bearing cap
13—Cotter pin
14—Rear axle drive pinion bearing shims
15—Differential carrier bearing cap
16—Differential bearing cone
17—Differential bearing cup
18—Differential bearing adjuster
19—Differential bearing adjuster lock
20—Cotter pin
21—Lock washer
22—Differential bearing cap screw
23—Rear axle drive pinion bearing spacer
24—Rear axle drive pinion
25—Rear axle drive pinion bearing cone—rear
26—Rear axle drive pinion bearing cup—rear
27—Rear axle drive gear
28—Rear axle housing assembly
29—Housing vent cap
30—Cotter pin
31—Housing cover gasket
32—Housing cover plug
33—Housing cover
34—Housing cover screw lock washer
35—Housing cover screw
36—Rear wheel bearing oil seal snap ring
37—Rear axle drive shaft
38—Rear wheel bearing oil seal
39—Rear wheel bearing cone
40—Rear wheel bearing cup
41—Rear wheel bearing cone
42—Rear wheel bearing cup
43—Rear wheel bearing adjusting nut—inner
44—Rear wheel bearing adjusting lock nut
45—Rear wheel bearing adjusting nut—outer
46—Rear axle drive shaft screw lockwasher
47—Rear axle drive shaft screw
48—Rear axle drive shaft
49—Rear axle drive shaft gasket
50—Rear axle drive gear screw
51—Rear axle drive gear screw lock



DODGE. Full floating

52—Differential case
53—Differential side gear thrust washer
54—Differential side gear
55—Differential pinion gear thrust washer
56—Differential pinion gear
57—Differential pinion gear shaft
58—Differential bearing adjuster
59—Differential bearing cup
60—Differential bearing cone
61—Differential bearing adjuster lock
62—Rear axle drive gear thrust screw lock nut
63—Rear axle drive gear thrust screw lock
64—Rear axle drive gear thrust screw

the axle housing flange. When making this adjustment, an equal thickness of shims should be removed or added on each side of the axle housing to maintain a central position of the axle shaft thrust block. The hole in the thrust block is sufficiently larger than the diameter of the shaft to prevent axle shaft thrust from being thrown on the pinion shaft, providing the thrust block is held in its central position on the shaft.

Fill the housing to the level of the filler plug hole with the specified grade and type of lubricant. Attach the propeller shaft to the rear universal joint flange, using new cap screw locks.

Full Floating Axle with Two Pinion Differential, Bolted Ring Gear and Drive Pinion Mounted on Two Taper Roller Bearings.

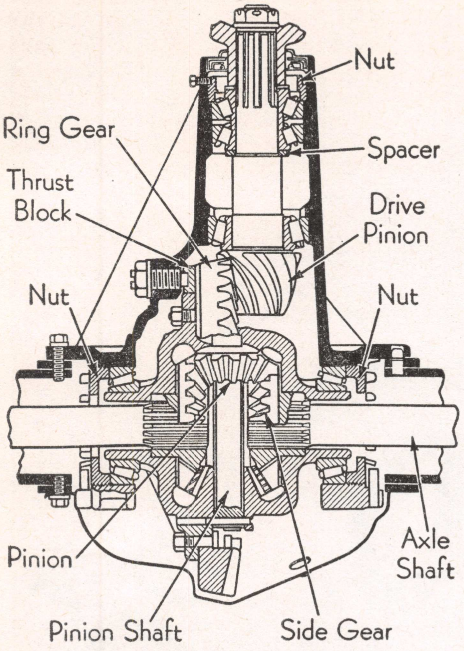
Disassemble: To remove the axle shaft, remove the axle drive shaft flange screws. Pull out the shaft. Straighten the tabs on the wheel bearing lock washers and remove the lock nuts, washers and adjusting nuts, after which the hub may be removed. Remove the cap screws which hold the differential carrier assembly to the axle housing. Lift out the differential carrier. Before removing any parts, mark both differential bearing adjusting nuts and caps so that they can be assembled with approximately the same drive gear adjustment. Remove the differential bearing cap screws and lift out the caps. Lift out the differential and ring gear assembly. With a puller remove the differential bearings.

To disassemble the ring gear from the case, remove the screws which hold the ring gear to the differential case. Push the ring gear off the differential case. Remove the differential pinion shaft. All differential parts will then be loose and can be lifted out of the case.

NOTE—The differential assembly must be removed before removing the drive pinion, but it is not necessary to remove the drive pinion or the differential assembly for removal of the drive pinion bearing oil seal.

To remove the drive pinion, remove the cotter pin, drive pinion flange nut and washer from the front end of the pinion shaft. With a suitable tool, pull off the universal joint drive flange. Pull or drive the drive pinion back through the carrier case. The bearing spacer, front bearing and shims can then be removed from the front of the housing. The rear bearing cup can be removed from the rear of the housing with a puller. With a bearing puller, remove the rear bearing cone from the pinion shaft. The thrust screw can be removed from the side of the carrier housing.

Assemble: If the rear bearing cone was removed or a new drive pinion is to be installed, press the rear bearing cone on the drive pinion. If the front or rear bearing cups were removed from the carrier housing, press them in place. Then replace drive pinion in the housing. Then slide the bearing spacer, original thickness of shims and the front bearing cone on the pinion shaft. Assemble the universal joint flange on the



DODGE. Full floating

shaft and tighten it in place. Check the end play of the pinion shaft. It should be .0015" to .0025" tight. If the play is too great, remove the flange and front bearing cone and remove the necessary shims. If it is too tight, the necessary thickness of shims should be added. Press the front bearing cone in place when the play is correct. Then install the oil seal with a suitable tool and tighten the universal joint flange in place. Insert a cotter pin in the shaft to hold the nut in position.

To assemble the differential, press the differential bearing in place. Install the side gear thrust washer and side gears in the case. Mesh the differential pinions with the side gears, holding the thrust washers on the back of the gears. Rotate the side gears until the holes through the center of the pinions are in line with the hole for the pinion shaft in the case. Press the pinion shaft in place. Locate the differential case in the carrier. Install the differential bearing caps and adjusting nuts. Draw up on the adjusting nuts until the marks show that the bearings are in their original position. Then tighten the screws in the bearing caps.

The backlash should be .006" to .010". If an adjustment is necessary, tighten the differential adjusting nuts with sufficient force to drive the bearing cups against the shoulders on the differential case. Back off the adjusting nuts to relieve strain and then tighten them again slightly against the bearing cup. The assembly should rotate with a slight drag when turning the ring gear by hand. The assembly must not spin. Insert the thrust screw in the side of the carrier housing and turn it in until it strikes the ring gear. Back it off 1/3 turn and lock it in position with the lock nut. This gives about .030" clearance.

Assemble the carrier in the axle housing, using a new gasket and lock washers under the cap screws, being sure to draw up the cap screws evenly and securely. Lubricate the wheel bearings and assemble the hubs, bearings and adjusting nuts, using new oil seals. Adjust the bearings by tightening the adjusting nut until the wheel binds, then back off just enough to permit the wheel to turn freely, yet without end play. Install the axle shafts, being sure that the tapered dowels are in place on all studs, then tighten the stud nuts securely.

NOTE—When the flange nuts are drawn up tight, there should always be a slight clearance between the lock washer and the flange. No clearance at this point indicates excessive wear on the studs, flange holes or tapered dowels. Complete the assembly by installing the universal flange and propeller shaft.

Full Floating Axle with Two Pinion Differential, Bolted Ring Gear and Drive Pinion Mounted on Three Taper Roller Bearings.

Disassemble: To remove the axle shaft, remove the axle drive shaft flange screws. Pull out the shaft. Straighten the tabs on the wheel bearing lock washers and remove the lock nut, washer and adjusting nut, after which the hub may be removed. Remove the cap screws which hold the differential carrier assembly to the axle housing. Lift out the differential carrier. Before removing any parts, mark both differential bearing adjusting nuts and caps so that they can be assembled with approximately the same drive gear adjustment. Remove the differential bearing cap screws and lift out the caps. Lift out the differential and ring gear assembly. With a puller, remove the differential bearings.

To disassemble the ring gear from the case, remove the screws which hold the ring gear to the differential case. Push the ring gear off the differential case. Remove the differential pinion shaft. All differential parts will then be loose and can be lifted out of the case.

NOTE—The differential assembly must be removed before removing the drive pinion, but it is not necessary to remove the drive pinion or the differential assembly for removal of the drive pinion bearing oil seal.

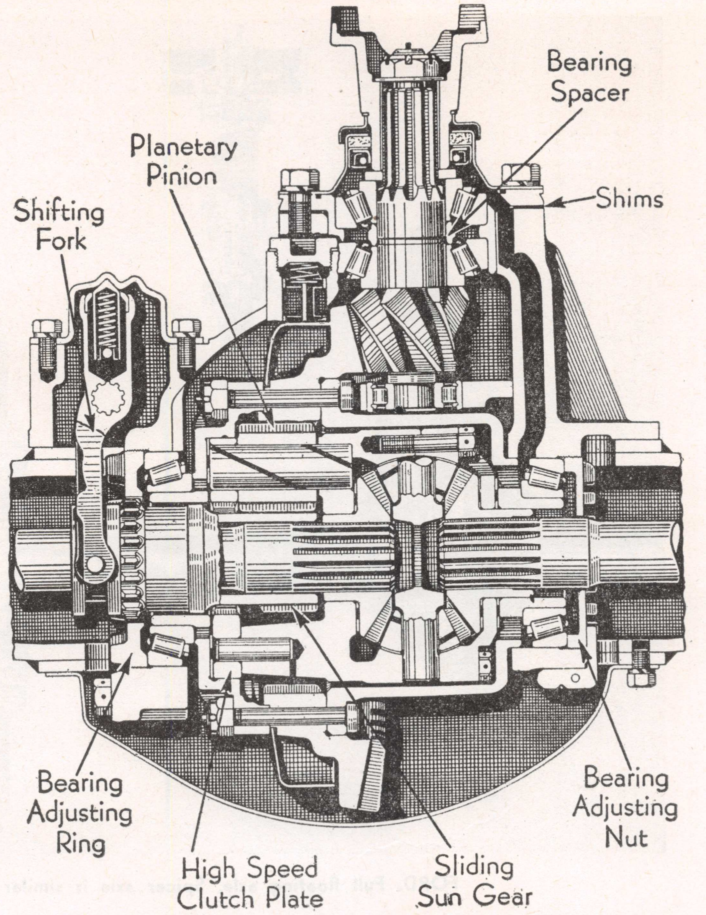
To remove the drive pinion, remove the cotter pin, drive pinion flange nut and washer from the front end of the pinion shaft. With a suitable tool, pull off the universal joint drive flange. With a puller, remove the oil seal from the front of the housing. Lift out the front bearing washer. Unscrew and remove the front bearing retainer lock screw and the bearing retainer nut. Pull the drive pinion out through the rear of the differential carrier. The washer just ahead of the front bearing does not fit the pinion shaft tightly and will drop into the carrier. Tap the center and front bearing cones from the pinion shaft with a drift and hammer. With a puller, remove the rear bearing cone from the pinion shaft. Drive the bearing cup for the front and center bearings out of the housing with a drift and hammer. The rear bearing cup can be removed from the housing with a puller. Remove the ring gear thrust screw from the side of the carrier.

Assemble: If the rear bearing cone was removed or a new drive pinion is being installed, press the rear bearing cone on the drive pinion. If the rear bearing cup was removed from the carrier, press it into its seat. The front bearing cup is marked with a letter Y and the marked end must always be assembled toward the front of the shaft. The cone marked Y should be mounted on the shaft so that it will be matched with the marked cup. Slip the drive pinion spacer on the pinion shaft against the shoulder of the shaft and press the rear center bearing cone in place against it. Then replace the pinion in the housing. Press the front bearing cone on the shaft. Place the washer on the shaft at the front of the bearing and tighten the companion flange on the end of the shaft. Then tighten the front bearing retainer nut against the front bearing cup.

With both the nut and the flange tight test each roller of the front bearing by pushing on the roller ends with the end of a file or an awl to determine if any of them are loose. If any looseness exists, use a thinner spacer at the rear of the center bearing cone. There should be no end play in the pinion shaft. The pinion bearings cannot be used to adjust the pinion gear. Tooth contact can only be adjusted at the differential bearings. When this is correct, remove the universal joint flange and replace the oil seal with a suitable tool. Then tighten the flange in place and insert a cotter pin in the nut to hold the nut in adjustment. Tighten the front bearing retainer nut lock screw at the front of the housing.

To assemble the differential, press the differential bearing in place. Install the side gear thrust washer and side gears in the case. Mesh the differential pinions with the side gears, holding the thrust washers on the back of the gears. Rotate the side gears until the holes through the center of the pinions are in line with the hole for the pinion shaft in the case. Press the pinion shaft in place. Locate the differential case in the carrier. Install the differential bearing caps and adjusting nuts. Draw up on the adjusting nuts until the marks show that the bearings are in their original position. Then tighten the screws in the bearing caps. The backlash should be .006" to .010". If an adjustment is necessary, tighten the differential adjusting nuts with sufficient force to drive the bearing cups against the shoulders on the differential case. Back off the adjusting nuts to relieve strain and then tighten them again slightly against the bearing cup. The assembly should rotate with a slight drag when turning the ring gear by hand. The assembly must not spin. Insert the thrust screw in the side of the carrier housing and turn it in until it strikes the ring gear. Back it off 1/3 turn and lock it in position with the lock nut. This gives about .030" clearance.

Assemble the carrier in the axle housing, using a new gasket and lock washers under the cap screws, being sure to draw up the cap screws evenly and securely. Lubricate



Eaton two-speed axle

the wheel bearings and assemble the hubs, bearings and adjusting nuts, using new oil seals. Adjust the bearings by tightening the adjusting nut until the wheel binds, then back off just enough to permit the wheel to turn freely, yet without end play. Install the axle shafts, being sure that the tapered dowels are in place on all studs, then tighten the stud nuts securely.

NOTE—When the flange nuts are drawn up tight, there should always be a slight clearance between the lock washer and the flange. No clearance at this point indicates excessive wear on the studs, flange holes or tapered dowels. Complete the assembly by installing the universal flange and propeller shaft.

EATON

TWO-SPEED AXLE

The pinion cage can be removed from the carrier after the bolts and washers which hold the cage to the front of the carrier have been removed. Then remove the nut holding the universal joint flange to the pinion shaft and press the shaft out of the cage. Shims between the end of the differential carrier and the pinion cage flange adjust the position of the pinion. Increasing the thickness of the shims moves the pinion away from the ring gear and decreasing the thickness of the shims moves the pinion toward the ring gear. There should be no end play in the pinion bearings but the bearings must be free to roll. The thickness of the spacer between the front and rear bearing cones adjusts bearing play and spacers of various thicknesses are available.

Differential: The differential is mounted on taper roller bearings with adjusting nuts at the outside of each bearing to adjust the ring gear and bearing play as described for the double reduction axles. Teeth are cut on the inside of the left adjusting nut which locks the sliding gear in position. The differential case is the two piece type which is bolted together. The left side of the differential case carries studs which act as shafts for the planet gears while the outer ends of these studs are supported by the high speed clutch plate which is bolted to the differential case. The ring gear is mounted between halves of the case which houses the planetary mechanism and differential case. The sliding clutch controlled by a shift lever is a long sleeve having a shifting collar at the outer end and a sun gear with long teeth at the inner end. Near the outer end is the low speed lock gear which locks with teeth in the left differential bearing adjusting nut.

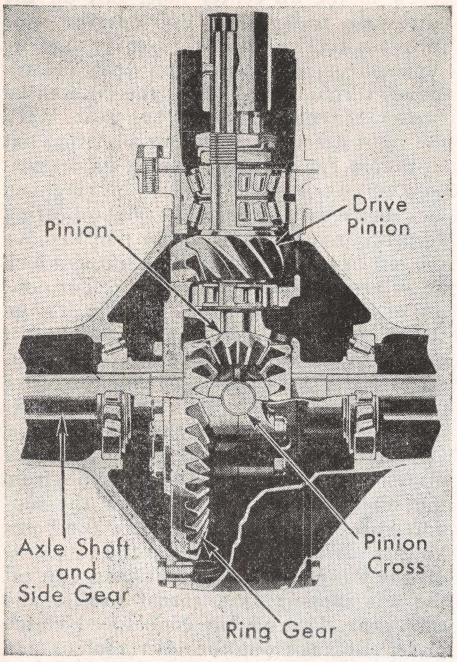
To disassemble the unit after it has been removed from the axle housing, remove the plug, washer, spring, capscrew, lockwasher and oil distributor from the side of the carrier housing. Remove the capscrews in the shift fork cover, noting the special screw in the off-center hole. Lift off the shift fork and gasket. Pull out the shift fork shaft. The shift fork may then be slipped from the sliding sun gear and removed through the back of the differential carrier. Slip out the sliding sun gear. Mark the right differential bearing adjusting nut so that it can be assembled in its original position. Loosen differential bearing cap lock bolts and remove the right bearing adjusting nut, lock and cotter pin. Remove the left bearing cap adjusting nut and lock as an assembly to assure correct positioning of the gear when reassembling. Tip up the left end of the planetary unit and lift it out. Remove the pinion bearing cage capscrews. Use a ball-peen hammer to drive out the pinion assembly, noting the thickness of the shims under the bearing cage. Check for end play in the bearings before disassembling. Remove the lockwire from the support case bolts. Unscrew the support case bolt nuts and remove the bolts. With a rawhide hammer, tap the ring gear off the flange of the support case. Lift off the left support case, thrust washer and ring gear. Pry off the high-speed clutch plate, and take out the idler pinions and pins. Lift off the differential assembly. Remove the support case thrust washer. Take out the differential case bolt lockwire and remove the bolts, noting the short bolts between the spider arms. Lift off the right differential case. Pick up the long hub side gear on the right side and slip off the thrust washer. Pull out the spider and differential side pinions, noting the thrust washers behind the pinions. Slip the washers and pinions off the spider arms. Take out the short-hub gear on the left side and remove the thrust washer. Remove the differential bearing cones by striking the inner race on alternate sides through holes provided in the support case.

Follow the steps described for disassembling the unit in the reverse order to assemble the unit. Lubricate both sides of all thrust washers well before replacing them. The chamfered sides of the differential thrust washers must be against the back face of the side gears. When assembling the planetary unit, cover the idler pins with lubricant. The chamfered teeth on the high speed clutch plate must face the pinions. Place the notches in the oil collector drum between the bolt holes in the bevel gear. When assembling the left differential bearing cap adjusting nut, hold the adjusting nut and bearing cap up away from the threads in the bore of the carrier until the cap bolts are started. Then drop the cap. The threads of the adjuster and the carrier will mesh freely.

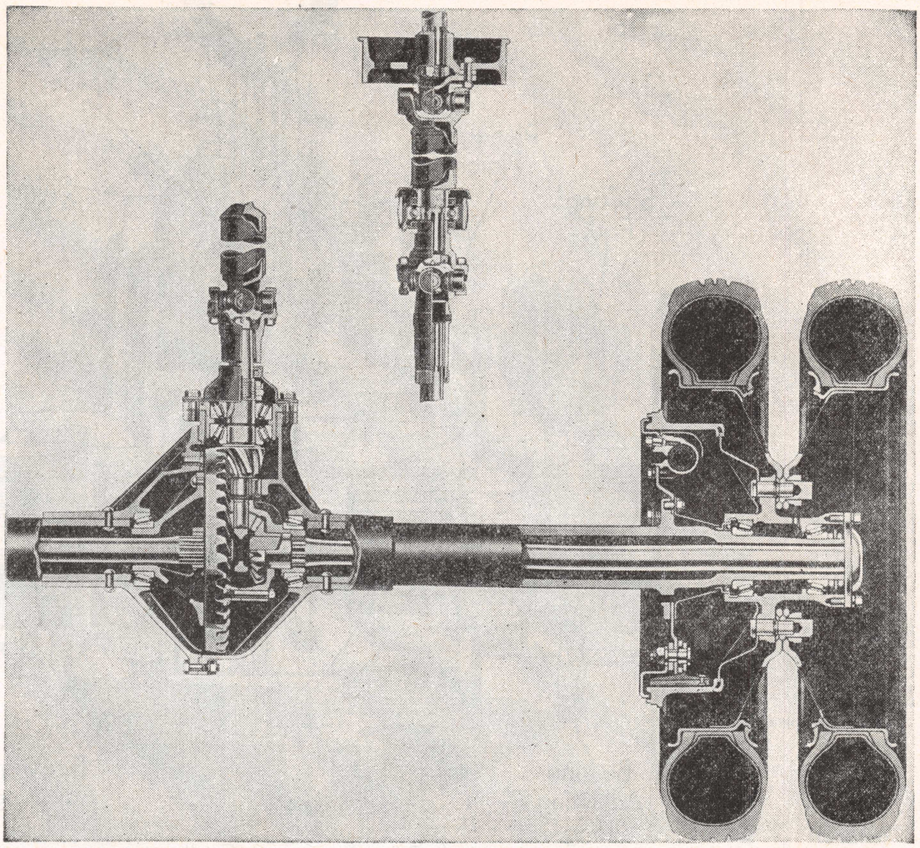
FORD

Three-Quarters Floating Axle with Four Pinion Differential, Bolted Ring Gear and Straddle Mounted Drive Pinion

Disassemble: Disconnect the rear spring from the axle housing. Unfasten the radius rods from the torque tube at the front. Remove the bolts which attach the torque tube



FORD. Three quarters floating



FORD. Full floating axle. Spicer axle is similar

to the differential housing and slide the torque tube from the propeller shaft. Drive out the rivet which fastens the propeller shaft to the drive pinion and remove the shaft. Remove the bolts which attach both axle housings to the differential housing and take off the housings. Mark the two halves of the differential case so they may be assembled in the same position, then remove the differential case attaching bolts and separate the case. Pick out the differential spider and pinions. Withdraw the axle shafts. Remove the drive pinion and bearings from the housing as a unit. Unscrew the drive pinion lock nut and adjusting nut and use a puller to remove the bearings and bearing cup.

Inspection: Examine the differential case for wear at the point where the back faces of the differential pinion and side gears contact the two halves of the case; if wear appears to be excessive, install a new case. Examine the axle shafts for wear on the taper, damaged keyways or threads, and see that the gear teeth are not worn excessively; if the back face of the gears are scored, or if any of the conditions mentioned are evident, replace the shaft.

If the bearing surface of the propeller shaft is worn to .005" undersize, replace the propeller shaft, the bearing and sleeve. Examine the axle housings to see if the wheel bearing surfaces are scored, pitted or worn more than .010" undersize or more than ¾" of its length; if so, replace the housing. The grease retainers in the axle housings and the torque tube should always be replaced when the axle is overhauled. Install the grease retainer in the torque tube with the sharp edge of the leather toward the universal joint; the grease retainers in the axle housings should be assembled with the sharp edge of the leather toward the differential. No attempt should be made to straighten badly bent radius rods as this practice usually elongates the rods, thereby changing the center line angle of the torque tube and the axle, placing a severe strain on the internal parts of the differential which results in rapid wear of these parts and misaligned rear wheels.

Assemble: Install the pinion bearings and bearing cup on the drive pinion, adjusting the bearing lock nuts so that the cup turns on the cones with a heavy drag and no end play. Before installing the pinion assembly in the housing, be sure the shoulder of the housing is clean and free from burrs. Use a blow torch to heat the neck of the differential housing and drive the outboard bearing in position. While the housing is still hot, install the drive pinion assembly, being sure that the bearing cup is against the shoulder of the housing.

NOTE—If a torch is not available, the housing may be heated by immersing it in boiling water or heated oil for about two minutes. A light film of grease applied to the outer surface of the bearing cup will facilitate the installation of the cup.

Assemble the differential bearing cups in the axle housings.

NOTE—A puller is recommended for this operation. Install the axle shaft in the right half of the differential case. Assemble the pinions on the spider and install in the right half of the differential case, meshing the pinions with the axle shaft gear.

NOTE—The pinions should be free-turning on the spider with about .005" clearance.

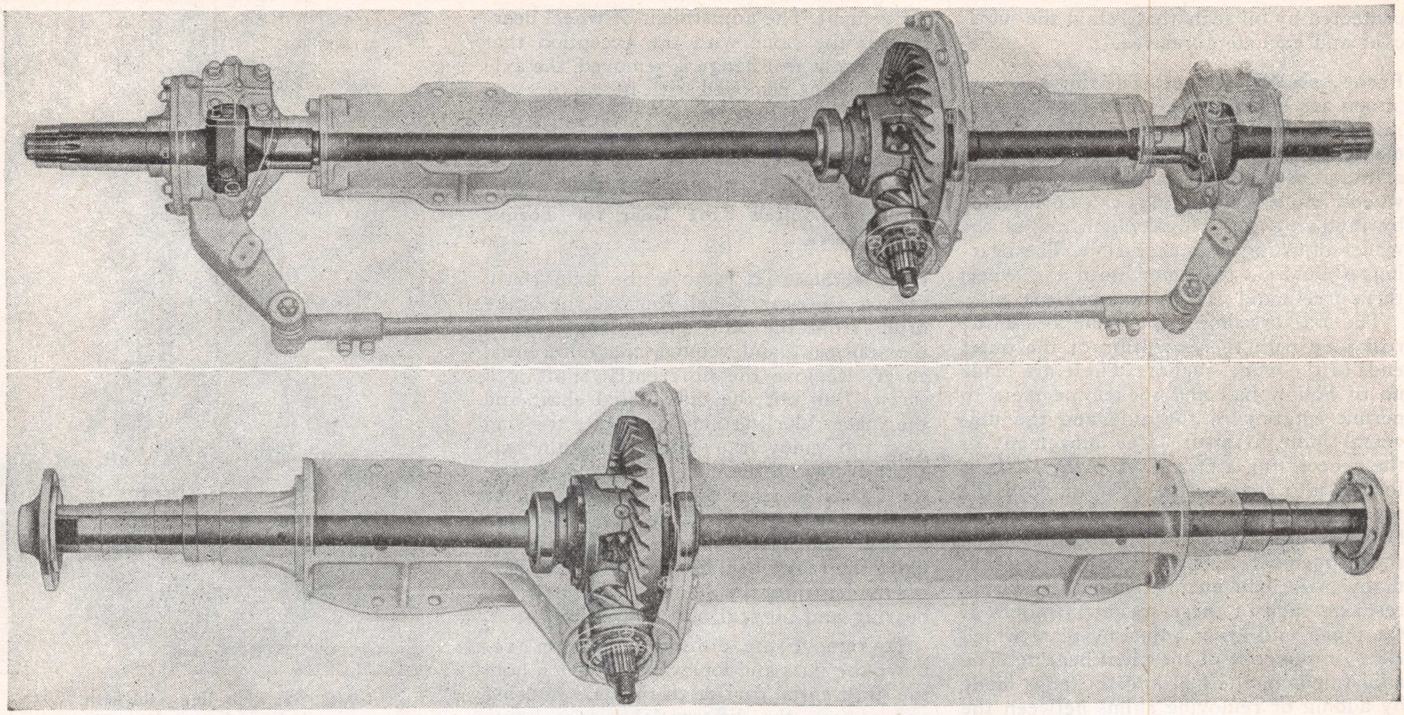
Slip the other axle shaft in the left half of the differential case and through the drive gear, bolting the assembly together securely, after which, install locking wire through all the bolts.

NOTE—Any burrs which may be present on the contacting surfaces of the differential case must be removed before assembling the differential.

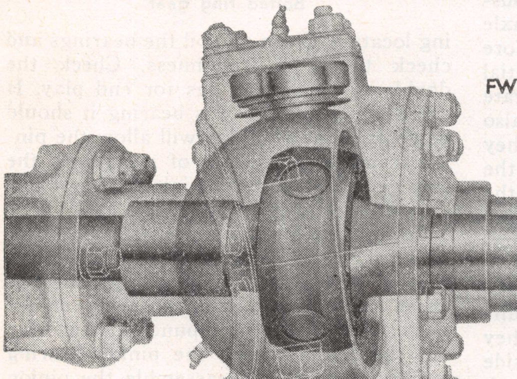
Check the backlash in the axle shaft gears by fastening one shaft in a vise. Then turn the other shaft by hand as far as possible in one direction and then in the opposite direction.

NOTE—The allowable travel, checked at the axle shaft keyway should not exceed .010"; if the backlash exceeds this amount, check the axle shaft end play, which should not be greater than .015" on either shaft. If the end play is in excess of .015", it indicates excessively worn parts or the two halves of the differential case are not seated properly. However, if the end play is not excessive, and the axle gear backlash is more than .010", it indicates that the teeth of some of the gears are badly worn.

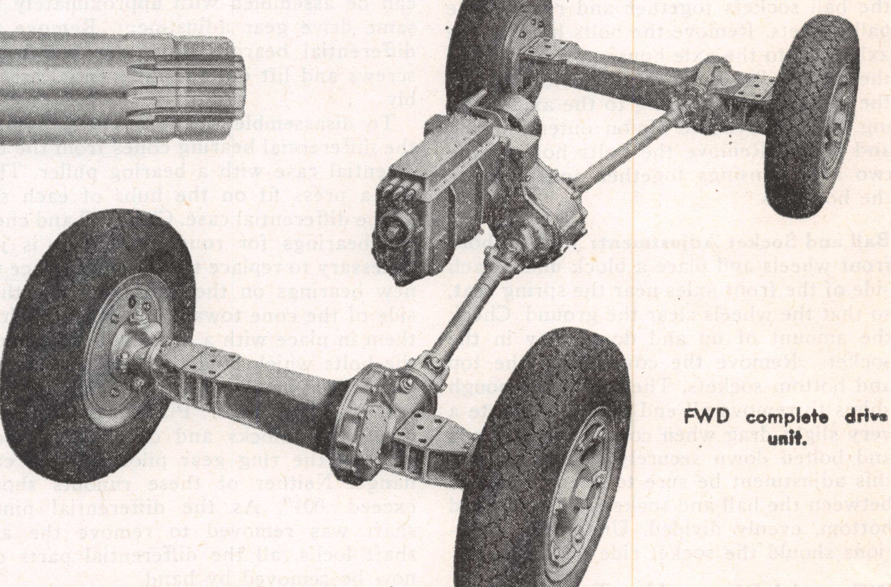
Fasten the right hand axle housing to the differential housing, using a new gasket, which is from .008" to .010" thick (part No. 18-4035-A). Install the differential assembly to the left hand housing. Assemble the left hand housing and differential assembly to the differential housing, pushing the right hand axle shaft



Top—FWD front axle. Bottom—FWD rear axle.



FWD universal joint.



FWD complete drive unit.

through its housing, after which, bolt the left axle housing to the differential housing, using a new gasket, which is from .008" to .010" thick (part No. 18-4035-A). The differential bearing clearance is then checked by turning both axle shafts in the same direction at the same time and at about the same speed (two persons are required for this operation). If the clearance is correct, a heavy drag will be evident when the differential is turned on its bearings.

NOTE—Turning only one shaft will not revolve the differential on its bearings.

If too much clearance is apparent, remove the right hand axle housing and install gasket number B-4035-BR which is from .004" to .005" thick, then check the clearance again. Now check the backlash between the drive pinion and the ring gear by using a dial indicator at the splines on the pinion shaft which should not be less than .003" nor more than .008". If the backlash is too great, install a thinner gasket between the left hand axle housing and the differential housing. Similarly, if there is not sufficient backlash, install a thicker gasket between the left hand housing and the differential housing.

CAUTION—To preserve the correct differential bearing clearance, whatever gasket thickness is added to the left hand housing must be removed from the right hand housing; whatever gasket thickness is removed from the left hand housing, must be added to the right hand housing.

Assemble the proper shaft to the drive pinion shaft, fastening them together with a rivet. Install the torque tube to the differential housing and complete the assembly in the reverse order of removal.

FWD

The front and rear axle differentials are interchangeable. The driving mechanism is fully enclosed and all moving parts are

protected by oil seals that retain the lubricant and exclude abrasives.

Front Axle Adjustment: The ring gear and pinion are fitted at the factory and no adjustment is necessary. The wheel stops are machined to the proper dimension when manufactured and are not adjustable. The wheels and wheel bearings can be adjusted by removing the flange which makes the wheel adjusting nuts accessible. The bearings should be tightened until the wheel turns freely and yet has no wobble or play.

The axle housing is the same as for the rear axle with the exception of the outer ends of the wheel support. These are made up of hollow ball and socket members to permit rotation of the axle and the universal joint to insure free movement of the wheels for steering. A pivot shaft is forged into the ball member at both the top and the bottom. A taper bearing is on both the upper and lower pivot shaft. The socket member consists of two halves that fit over the ball member and the bearing rests on each of these socket members of the upper and lower adjusting plate which rides on the cone of the pivot bearing. The adjustment of the ball and socket is made by adding or removing shims between the adjusting plate and the socket.

Disassemble: To disassemble the front axle, remove both front wheels. Then remove the skein bolts and skeins. Pull out the axle shafts. Remove the tie rod. Now remove the bolts holding the two halves of the ball sockets together and remove the ball sockets. Remove the bolts holding the axle balls to the axle housings and remove the axle balls. Remove the bolts holding the pinion outer housing to the axle housing and remove the pinion outer housing and shims. Remove the bolts holding the two axle housings together and separate the housings.

Ball and Socket Adjustment: Jack up both front wheels and place a block under each side of the front axles near the spring seat, so that the wheels clear the ground. Check the amount of up and down play in the sockets. Remove the cover from the top and bottom sockets. Then remove enough shims to remove all end play and create a very slight drag when covers are replaced and bolted down securely. When making this adjustment be sure to keep the space between the ball and sockets, both top and bottom, evenly divided. Under no conditions should the socket ride on the ball.

Differential Disassembly: To disassemble the differential, remove the differential bearings. Remove the cap screws holding the two halves of the differential case together. The spider, spider gears and side gears may now be removed. Remove the 16 rivets holding the ring gear to the flanged half of the differential case and remove the ring gear.

The parts are assembled in the reverse order.

Rear Axle: The rear axle assembly is the same as the front axle with the exception that it does not have a ball and socket arrangement. The adjustment of wheel bearings is the same with the exception that when the wheel flange is removed, the axle shaft will be removed with it.

GMC

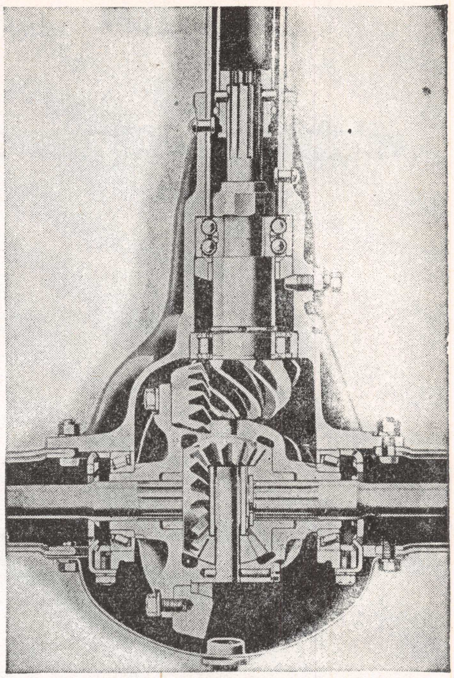
Semi-Floating Axle with Two Pinion Differential, Bolted Ring Gear for Torque Tube Drive.

Disassemble: To remove the axle shaft, remove the rear wheel. Remove the brake drum from the axle shaft flange. Drain the lubricant and remove the differential cover. Remove the differential shaft lock screw. Pull out the differential shaft and the spacer block around it. Rotate the ring gear and remove the pinions. Push the axle shaft in toward the differential and remove the C washer from the recess at the inner end of the shaft. Using a suitable puller, remove the shaft from the housing. To remove the rear wheel bearing, insert a bearing puller into the housing and pull the bearing and oil seal out as assembly.

To remove the differential carrier, remove the nuts and lockwashers which hold the differential carrier to the axle housing and remove the differential carrier housing and torque tube from the rear axle housing. Place the unit in a vise. Before removing any parts, mark both differential bearing adjusting nuts and caps to indicate on which side each is mounted and also its location in the carrier so that they can be assembled with approximately the same drive gear adjustment. Remove the differential bearing cap screw locks and screws and lift out the differential assembly.

To disassemble the differential, remove the differential bearing cones from the differential case with a bearing puller. They are a press fit on the hubs of each side of the differential case. Clean, oil and check the bearings for roughness. If it is just necessary to replace the bearings, place the new bearings on the hubs with the thick side of the cone toward the case and drive them in place with a suitable tool. Remove the bolts which hold the ring gear to the differential case and tap the ring gear off with a soft hammer. Place the differential case in V blocks and check the runout of both the ring gear pilot and the case flange. Neither of these runouts should exceed .001". As the differential pinion shaft was removed to remove the axle shaft locks, all the differential parts can now be removed by hand.

To remove the drive pinion and propeller shaft, remove the three cap screws with lock nuts on the side of the differential carrier housing. Let the assembly drop so that the spline end of the propeller shaft will strike on a wooden block or wooden floor and the pinion shaft will slide out. Remove the shims from the inside of the propeller shaft housing. Keep the shims together so that the original assembly may be maintained when the parts are assembled. Inspect the splines for wear or looseness in the universal joint and also inspect the shaft at the propeller shaft bushing location. Clean and oil the bearings and check them for roughness. Check the double row ball bearings for end play. If there is end play in this bearing it should be replaced as end play will allow the pinion to move in and out of mesh with the ring gear. Examine the pinion for cracked, chipped or scored teeth.

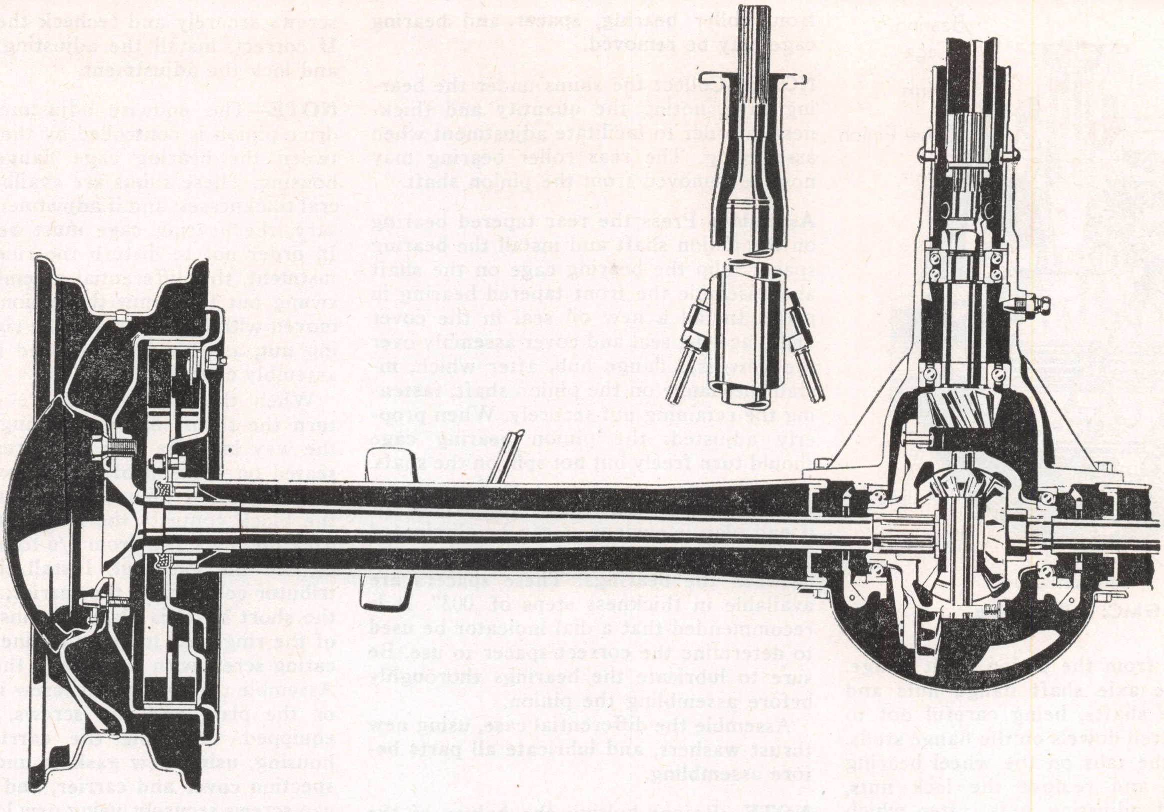


GMC. Semi-Floating axle with bolted ring gear

To disassemble the pinion from the propeller shaft, first drill the end of the rivet to clear the countersink into which it is upset, being careful to properly center the rivet with a center punch. Then drive out the rivet. Loosen the pinion bearing lock nut and then disassemble the pinion from the propeller shaft. Remove the front pinion bearing lock nut and press the pinion bearing from the pinion. Remove the rear pinion bearing lock ring and remove the rear bearing.

Assemble: To assemble, install the rear pinion bearing on the pinion shaft and install the lock ring in its groove in the shaft. Install the lock sleeve with its beveled side toward the pinion. Press the front double row bearing on the pinion shaft and install the bearing lock nut.

The pinion assembly may now be assembled to the propeller shaft by pressing the splined end into the coupling on the end of the propeller shaft so that the rivet hole in the pinion shaft lines up with the hole in the propeller shaft. Insert a new rivet in this hole and rivet over both ends. Tighten the bearing lock nut and lock it in the milled slot in the pinion shaft. Assemble the same thickness of shims in the counterbore of the propeller shaft housing that were removed from it, making sure that if the original ring gear and pinion are to be used, the shims are flat in the counterbore and not cocked. The total thickness of shims will be found to be from .030" to .036" and usually .033".



Semi-floating axle with wheel flange at outer end of axle

Whenever a new ring gear and pinion are installed, one .015" shim and one .018" shim should be used.

Assemble the propeller shaft assembly, driving it down until the bearings are seated in the housing. Drive it on by using a drift in the ⅞" hole in the pinion and not on the pinion teeth. Check through the bearing lock screw holes to make sure that the lock sleeve is in the correct position, up against the back of the front pinion bearing. Install the three tapered lock screws and draw them down evenly and tightly. Tighten the lock screw nuts.

To replace the ring gear on the differential case use five guide pins made by cutting the heads from ⅜"-24 cap screws about 1½" long. Slots should be cut in the heads of these guide pins so that they may be easily removed. Install these guide pins in alternate holes in the ring gear and slip the ring gear over the pilot diameter of the case, making sure that the back face of the ring gear and the face of the case are free from dirt and burrs. Install every other ring gear bolt and draw them up evenly and snugly so that the ring gear face is flush with the face of the case. Remove the guide pins and install the remaining bolts. Tighten all ring gear bolts. New lockwashers should be used under the head of each bolt. With the assembly mounted in V-blocks, check the runout of the back face of the ring gear with a dial indicator. This runout must not exceed .004".

Examine both differential side gear bearing surfaces in the differential case; also the backs or thrust surfaces of these gears and the differential pinion gears. Check both differential side bearings for roughness after they have been thoroughly cleaned and oiled. Inspect the differential side gears for scored hubs or thrust surfaces. Examine the internal splines and check their fit on an axle shaft. Inspect the thrust surfaces on the differential pinion gears and check their fit on the pinion shaft. To replace the differential bearings, place them on the hubs with the thick side of the inner race toward the case and drive them in place with a suitable tool. Locate the differential case in the carrier. Install the differential bearing caps and adjusting nuts. Draw up on the adjusting nuts until the marks indicate that the bearings are in their original position. Tighten the cap screws until the lockwashers just flatten out.

To check the adjustment, loosen the right adjusting nut and tighten the left nut, while at the same time turning the ring gear. Continue tightening the left nut until all lash is removed, then back off the left nut one notch. Tighten the right adjusting nut snugly, when the nut comes to a definite stop. Then tighten the right nut from a minimum of 1 to a maximum of 2 notches more, to a locking position. Mount a dial gauge on the carrier and check the backlash between the ring gear and pinion. This should be from .005" to .007". If the backlash is more than the above, loosen the right adjusting nut 1 notch and tighten the left nut 1 notch. If the backlash is less than specified, loosen the left adjusting nut 1 notch and tighten the right nut 1 notch. Tighten the bearing cap bolts securely. Then recheck the backlash. Install both adjusting nut locks.

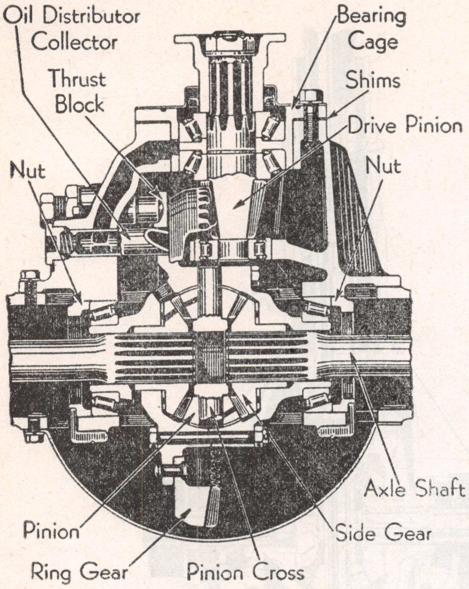
If it is necessary to remove the pinion to secure proper tooth contact, it will be necessary to disassemble the rear axle and change the number of shims at the pinion front bearing. When the adjustments are correct, assemble the carrier in the rear axle housing. A new gasket and lockwashers should be used whenever the carrier is removed from the housing. Pull up the cap screws evenly and securely. Lubricate the hubs of the differential side gears with hypoid gear lubricant and install them in the differential case.

Then install the axle shafts in the reverse order from which they were removed, using a suitable driver to replace the bearings on the shaft. Spread the ends of the axle shafts to make sure that the shafts, locks and differential side gears are in positive contact. Roll the two differential pinions into place and install the axle shaft spacer, pinion gear shaft and lock screw. Check the end play. The maximum total side clearance of the spacer block is .008". Spacer blocks of several sizes are available for service to take up this play. If the block does not take up the clearance, new thrust washers should be installed in back of the differential side gears. If both axle shafts are removed, and they are not the same length, the longer shaft must be installed on the right side.

Install the housing cover, using a new cork gasket and fill the housing to its proper level with the correct grade of lubricant.

Full Floating Axle with Four Pinion Differential. Riveted Ring Gear and Straddle Mounted Drive Pinion.

Disassemble: Disconnect the propeller



GMC. Full Floating

shaft flange from the pinion shaft flange. Unscrew the axle shaft flange nuts and pull out the shafts, being careful not to lose the tapered dowels on the flange studs. Straighten the tabs on the wheel bearing lockwashers and remove the lock nuts, washers and adjusting nuts, after which the hubs may be removed. Take off the differential inspection cover. Remove the cap screws which fasten the differential carrier to the axle housing and remove the carrier assembly. Take out the oil distributor collector from the carrier.

NOTE—The collector is held by a screw which extends through the carrier and into the collector and can be removed after first unscrewing the threaded plug on some units, or by removing the plate and cap screws on other units.

Back out the thrust block adjusting screw to allow the drive gear to clear the thrust block when removing the differential assembly. Mark the relationship of the differential bearing caps and adjusting nuts and then remove the bearing caps.

NOTE—If the original bearing adjustment is to be retained, remove the left hand bearing cap only, leaving the right one undisturbed. Then shift the differential case assembly over to the left side until it can clear the right hand cap and the pinion shaft rear bearing support.

Mark both halves of the differential case so that when assembled, the original position is maintained, then unscrew the nuts or cap screws which attach both halves of the case, after which the case may be separated and all the differential parts removed. If the ring gear is to be replaced, use a drill which is smaller than the diameter of the rivet head and drill the rivet from the differential case side, after which, punch out the rivets. Pull the drive pinion and bearing cage assembly out of the carrier. Clamp the pinion or universal flange in a vise and remove the flange retaining nuts, after which the flange, oil seal cover, front roller bearing, spacer and bearing cage may be removed.

NOTE—Collect the shims under the bearing cage, noting the quantity and thickness in order to facilitate adjustment when assembling. The rear roller bearing may now be removed from the pinion shaft.

Assemble: Press the rear tapered bearing on the pinion shaft and install the bearing spacer. Slip the bearing cage on the shaft and assemble the front tapered bearing in place. Install a new oil seal in the cover and place the seal and cover assembly over the universal flange hub, after which, install the flange on the pinion shaft, fastening the retaining nut securely. When properly adjusted, the pinion bearing cage should turn freely but not spin on the shaft.

NOTE—If the cage turns too freely, or if end play is evident, it can be eliminated by the use of a different thickness spacer between the bearings. These spacers are available in thickness steps of .003". It is recommended that a dial indicator be used to determine the correct spacer to use. Be sure to lubricate the bearings thoroughly before assembling the pinion.

Assemble the differential case, using new thrust washers, and lubricate all parts before assembling.

NOTE—Before bolting the halves of the differential case together, be sure to align the marks which were made before the case was taken apart. After the case is fastened securely, run locking wire through the screw or bolt heads.

Lubricate the differential bearings and place them in position on the hubs of the case. Assemble the drive pinion assembly in the carirer, replacing the original quantity of shims temporarily. Assemble the differential assembly in the carrier and install the bearing caps and adjusting nuts, drawing the nuts up until the marks which were made on the nuts and caps before disassembly are in the original position, then tighten the cap screws until the lockwashers just flatten out. If new parts were installed or an adjustment was necessary, tighten the differential bearing adjusting nuts with sufficient force to seat the bearing cups solidly against the rollers. Back off the adjusting nuts to relieve the strain and tighten them again slightly against the bearing cups. Loosen the right adjusting nut and tighten the left nut—at the same time turning the ring gear—until all lash is removed, then back off the left nut one turn. Tighten the right adjusting nut until it is snug and continue for one or two notches more, or until a locking position is reached.

Mount a dial indicator on the carrier and check the backlash between the ring gear and pinion, which should be from .005" to .010". If the backlash exceeds this amount, loosen the right adjusting nut one notch and tighten the left nut one notch. If less than specified, loosen the left nut one notch and tighten the right nut one notch. When the correct lash is established, tighten the bearing cap lock screws securely and recheck the backlash. If correct, install the adjusting nut locks and lock the adjustment.

NOTE—The endwise adjustment of the drive pinion is controlled by the shims between the bearing cage flange and the housing. These shims are availbale in several thicknesses, and if adjustment is necessary, the bearing cage must be removed. In order not to disturb the ring gear adjustment, the differential assembly can be swung out to permit the pinion to be removed without disturbing the right adjusting nut, as already mentioned in the disassembly chapter.

When the adjustments are completed, turn the thrust block adjusting screw all the way in to be sure the thrust block is seated on the end of the screw. Back off the screw and then tighten it again until the block contacts the ring gear. Finally, back off the screw from 1/6 to ¼ turn and tighten the lock nut. Install the oil distributor collector in the carrier, being sure the short bevel is placed against the back of the ring gear in order to line up the locating screw with the hole in the collector. Assemble the spring and screw in the plug, or the plate and cap screws, whichever equipped. Assemble the carrier to the housing, using new gaskets under the inspection cover and carrier, and fasten the cap screws securely, using new lockwashers under the cap screws.

NOTE—Be sure the breather on the inspection cover is not clogged.

Lubricate the wheel bearings and assemble the hubs, bearings and adjusting nuts, using new oil seals. Adjust the bearings by tightening the bearing adjusting nuts until the wheel binds, then back off just enough to permit the wheel to turn freely, yet without end play. Install the axle shafts, being sure that the tapered dowels are in place on all studs, then tighten the stud nuts securely.

NOTE—When the flange nuts are drawn up tight, there should always be a slight clearance between the lockwasher and the flange. No clearance at this point indicates excessive wear on the studs, flange holes or tapered dowels.

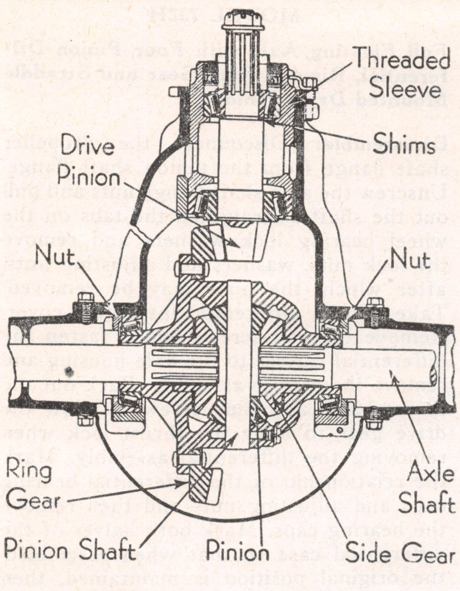
Complete the assembly by attaching the propeller shaft flange to the pinion shaft flange, lining up the marks which were made before disassembly.

INTERNATIONAL

MODELS HDR60, R1100, R1101

Full Floating Axle with Two Pinion Differential, Riveted Ring Gear and Drive Pinion Mounted on Two Taper Roller Bearings.

Disassemble: Disconnect the propeller shaft flange from the pinion shaft flange. Unscrew the axle shaft nuts and pull out the shafts. Straighten the tabs on the wheel bearing lockwashers and remove the nut and washers, after which the hubs may be removed. Take off the differential inspection cover Remove the cap screws



INTERNATIONAL. Model 708

which fasten the differential carrier assembly. Mark the relationship of the differential bearing caps and adjusting nuts and then remove the bearing caps. Remove the differential lock screw and pull out the shaft; the differential parts are now loose and can be removed by hand.

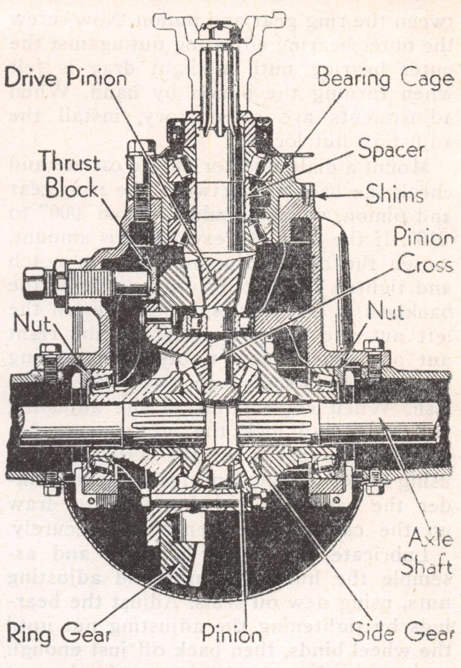
If the ring gear is riveted to the flange, use a drill which is smaller in diameter than the rivet head and drill the rivets from the differential case side, then punch them out. Remove the pinion flange retaining nut and pull off the flange. Remove the pinion adjusting nut lock and loosen the adjusting nuts. Press the pinion shaft through the inside of the carrier, bringing the inner bearing along with it. Remove the front bearing from the housing and, if the bearing cups are to be removed, use a suitable puller. The adjusting nuts can now be screwed out of the housing through the inside—the inner nut first.

Assemble: Screw the adjusting nuts into the carrier, the outer nut first. Press the bearing cups in place. Assemble the rear bearing on the pinion shaft and push the pinion into the carrier from the inside. Install the front bearing and assemble the pinion shaft flange, fastening it securely with the retaining nut.

NOTE—Pinion adjustments cannot be made until after the differential is installed.

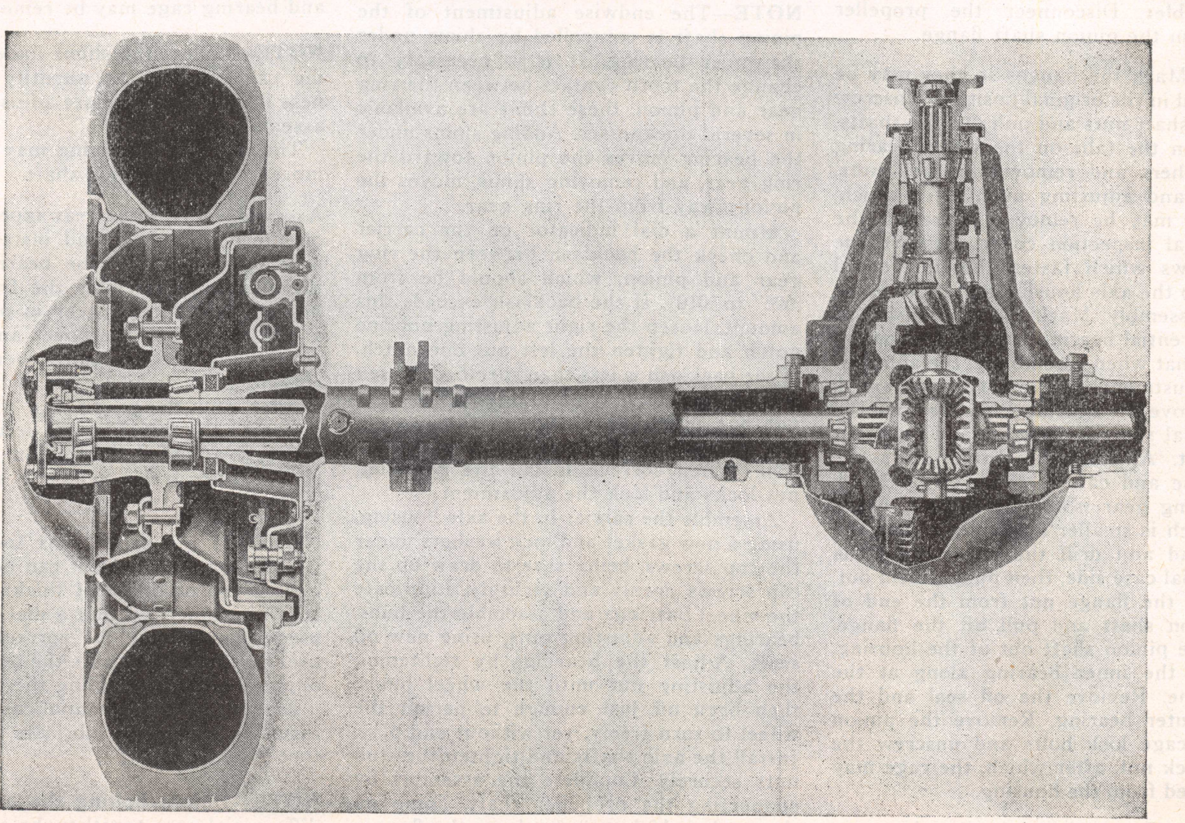
Lubricate the differential pinions, side gears and thrust washers and install them in the differential case, then push in the pinion shaft, lining up the hole in the shaft with the hole in the case, after which, install the lock pin. Locate the differential case in the carrier and install the bearing caps and adjusting nuts, tightening the cap screws until the lock washers just flatten out.

NOTE—If new parts were installed or an adjustment is necessary, the adjusting nuts should be tightened with sufficient force to drive the bearing cups solidly against the rollers. Then back off the adjusting nuts to relieve the strain and tighten them again slightly against the bearing cup.



INTERNATIONAL. Model 732H

Now while turning the ring gear, loosen the right adjusting nut and tighten the left adjusting nut until all lash is removed and then back off the left nut one turn. Tighten the right adjusting nut until it is snug and continue for one or two notches more, or until a locking position is reached Screw the pinion shaft inner bearing adjusting nut against the inner bearing until the proper tooth contact is established be



INTERNATIONAL. Full-Floating axle

tween the ring gear and pinion. Now screw the outer bearing adjusting nut against the outer bearing until a slight drag is felt when turning the pinion by hand. When adjustments are satisfactory, install the adjusting nut lock.

Mount a dial indicator on the carrier and check the backlash between the ring gear and pinion, which should be from .006" to 010". If the backlash exceeds this amount, loosen the right adjusting nut one notch and tighten the left nut one notch. If the backlash is less than specified, loosen the left nut one notch and tighten the right nut one notch. Now tighten the bearing cap lock screws securely and recheck the lash. When correct, install the adjusting nut locks and lock the adjustment. Assemble the carrier in the axle housing, using a new gasket and lock washers under the cap screws, being sure to draw up the cap screws evenly and securely.

Lubricate the wheel bearings and assemble the hubs, bearings and adjusting nuts, using new oil seals. Adjust the bearings by tightening the adjusting nut until the wheel binds, then back off just enough to permit the wheel to turn freely, yet without end play. Install the axle shafts and tighten the stud nuts securely. Complete the assembly by connecting the propeller shaft.

MODEL 708

Full Floating Axle with Two Pinion Differential, Riveted Ring Gear and Drive Pinion Taper Roller Bearings Mounted on Threaded Sleeves.

Disassemble: Disconnect the propeller shaft from the pinion shaft flange.

NOTE—Mark the flanges so they may be assembled in the original position. Unscrew the axle shaft nuts and pull out the shafts. Straighten the tabs on the wheel bearing lock washers and remove the lock nuts, washers and adjusting nuts, after which, the hubs may be removed. Take off the differential inspection cover. Remove the cap screws which fasten the differential carrier to the axle housing and remove the carrier assembly. Mark the relationship of the differential bearing caps and adjusting nuts so that when assembling, the approximate adjustment will be readily obtained, then remove the bearing caps. Remove the differential shaft lock screw and push out the shaft. All the differential parts are now loose and can be removed by hand. If the ring gear is to be replaced, use a drill which is smaller in diameter than the rivet head and drill the rivets from the differential case side, then punch them out. Unscrew the flange nut from the end of the pinion shaft and pull off the flange. Press the pinion shaft out of the housing, bringing the inner bearing along at the same time. Remove the oil seal and the pinion outer bearing. Remove the pinion bearing cage lock bolts and unscrew the cage check nut, after which, the cage may be screwed from the housing.

Assemble: Screw the pinion bearing cage into the housing. Press the inner bearing on the pinion shaft, replacing any shims which may have been under the bearing. Assemble the pinion shaft and inner bearing into the housing. Place the mud slinger and a new oil seal over the hub of the pinion flange and assemble the flange on the shaft, fastening the retaining nut securely. Screw the bearing cage in or out as required to obtain a slight drag on the bearing when the pinion is turned by hand. After the desired result is obtained, replace the bearing cage check nut, being sure the bearing adjustment has not been disturbed, then install the bearing cage cap screws and locks. Lubricate the differential side gears, pinions and thrust washers and assemble these parts in the differential case. Push in the differential shaft, lining up the hole in the shaft with the hole in the case, then install the lock screw. Locate the differential case in the carrier and install the bearing caps and adjusting nuts, tightening the cap screws until the lock washers just flatten out.

NOTE—If new parts were installed or an adjustment is necessary, the adjusting nuts should be tightened with sufficient force to drive the bearing cups solidly against the rollers. Then back off the adjusting nuts to relieve the strain and tighten them again slightly against the bearing cup.

Now while turning the ring gear, loosen the right adjusting nut and tighten the left adjusting nut until all lash is removed and then back off the left nut one turn. Tighten the right adjusting nut until it is snug and continue for one or two notches more, or until a locking position is reached.

NOTE—The endwise adjustment of the pinion shaft is controlled by shims under the inner bearing. If it is necessary to change the tooth contact between the ring gear and pinion, these shims are available in several thicknesses. Adding shims under the bearing moves the pinion toward the ring gear, and removing shims, moves the pinion away from the ring gear.

Mount a dial indicator on the carrier and check the backlash between the ring gear and pinion, which should be from .006" to .010". If the backlash exceeds this amount, loosen the right adjusting nut one notch and tighten the left nut one notch. If the backlash is less than specified, loosen the left nut one notch and tighten the right nut one notch. Now tighten the bearing cap lock screws securely and recheck the lash. When correct, install the adjusting nut locks and lock the adjustment.

Assemble the carrier in the axle housing, using a new gasket and lock washers under the cap screws, being sure to draw up the cap screws evenly and securely. Lubricate the wheel bearings and assemble the hubs, bearings and adjusting nuts, using new oil seals. Adjust the bearings by tightening the adjusting nut until the wheel binds, then back off just enough to permit the wheel to turn freely, yet without end play. Install the axle shafts and tighten the stud nuts securely. Complete the assembly by connecting the propeller shaft, lining up the marks which were made on the flanges before disassembly.

MODEL 732H

Full Floating Axle with Four Pinion Differential, Riveted Ring Gear and Straddle Mounted Drive Pinion.

Disassemble: Disconnect the propeller shaft flange from the pinion shaft flange. Unscrew the axle shaft flange nuts and pull out the shafts. Straighten the tabs on the wheel bearing lock washers and remove the lock nuts, washers and adjusting nuts, after which, the hubs may be removed. Take off the differential inspection cover. Remove the cap screws which fasten the differential carrier to the axle housing and remove the carrier assembly. Back out the thrust block adjusting screw to allow the drive gear to clear the thrust lock when removing the differential assembly. Mark the relationship of the differential bearing caps and adjusting nuts and then remove the bearing caps. Mark both halves of the differential case so that when assembled, the original position is maintained, then unscrew the nuts which attach both halves of the case, after which, the case may be separated and all the differential parts removed.

If the ring gear is to be replaced, use a drill which is smaller than the diameter of the rivet head and drill the rivet from the differential case side, after which, punch out the rivets. Remove the bearing cage cap screws and pull the drive pinion and bearing cage assembly out of the carrier. Clamp the pinion or universal flange in a vise and remove the flange retaining nut, after which, the flange, oil seal cover, outer spacer, front roller bearing, inner spacer and bearing cage may be removed.

NOTE—Collect the shims under the bearing cage, noting the quantity and thickness in order to facilitate adjustment when assembling.

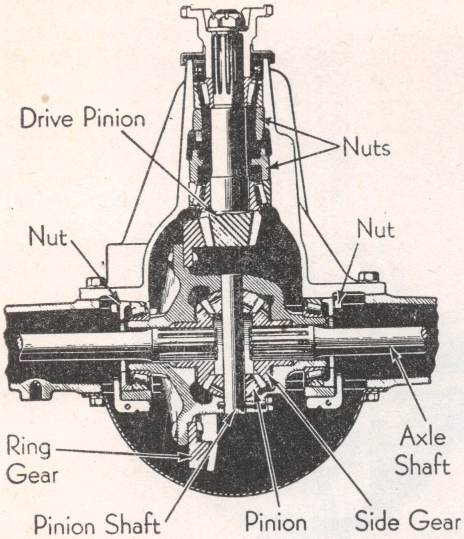
The rear roller bearing may now be removed from the pinion shaft.

Assemble: Press the rear tapered bearing on the pinion shaft and install the inner bearing spacer. Slip the bearing cage on the shaft and assemble the front tapered bearing and outer spacer in place. Install a new oil seal in the cover and place the seal and cover assembly over the outer spacer, after which, install the spacer washer and flange on the pinion shaft, fastening the retaining nut securely. When properly adjusted, the pinion bearing cap should turn freely but not spin on the shaft.

NOTE—If the cage turns too freely, or if end play is evident, it can be eliminated by the use of different thickness spacers. It is recommended that a dial indicator be used to determine the correct spacers to use. Be sure to lubricate the bearings thoroughly before assembling the pinion.

Assemble the differential case, using new thrust washers, and lubricate all parts before assembling.

NOTE—Before bolting the halves of the differential case together, be sure to align the marks which were made before the



INTERNATIONAL.
Models HDR60, R1100, R1101

case was taken apart. After the case is fastened securely, run locking wire through the bolt heads.

Lubricate the differential bearings and place them in position on the hubs of the case. Assemble the drive pinion assembly in the carrier, replacing the original quantity of shims temporarily. Assemble the differential assembly in the carrier and install the bearing caps and adjusting nuts, drawing the nuts up until the marks which were made on the nuts and caps before disassembly are in the original position, then tighten the cap screws until the lock washers just flatten out.

If new parts were installed or an adjustment was necessary, tighten the differential bearing adjusting nuts with sufficient force to seat the bearing cups solidly against the rollers. Back off the adjusting nuts to relieve the strain and tighten them again slightly against the bearing cups. Loosen the right adjusting nut and tighten the left nut—at the same time turning the ring gear—until all lash is removed, then back off the left nut one turn. Tighten the right adjusting nut until it is snug and continue for one or two notches more, or until a locking position is reached.

NOTE—The endwise adjustment of the drive pinion is controlled by shims under the bearing cage. If it is necessary to change the tooth contact between the ring gear and pinion, these shims are available in several thicknesses. Adding shims under the cage moves the pinion away from the ring gear while removing shims moves the pinion toward the ring gear.

Mount a dial indicator on the carrier and check the backlash between the ring gear and pinion, which should be from .006" to .010". If the backlash exceeds this amount, loosen the right adjusting nut one notch and tighten the left nut one notch. If less than specified, loosen the left nut one notch and tighten the right nut one notch. When the correct lash is established, tighten the bearing cap lock screws securely and recheck the backlash. If correct, install the adjusting nut locks and lock the adjustment. When the adjustments are completed, turn the thrust block adjusting screw all the way in to be sure the thrust block is seated on the end of the screw. Back off the screw and then tighten it again until the block contacts the ring gear. Finally, back off the screw from 1/6 to ¼ turn and tighten the lock nut.

Assemble the carrier to the housing, using new gaskets under the inspection cover and carrier, and fasten the cap screws securely, using new lock washers under the cap screws. Lubricate the wheel bearings and assemble the hubs, bearings and adjusting nuts, using new oil seals. Adjust the bearings by tightening the bearing adjusting nuts until the wheel binds, then back off just enough to permit the wheel to turn freely, yet without end play. Install the axle shafts and tighten the stud nuts securely. Complete the assembly by attaching the propeller shaft flange to the pinion shaft flange, lining up the marks which were made before disassembly.

MODELS R56H, R1000, R1001

Semi-Floating Axle with Two Pinion Differential, Riveted Ring Gear and Drive Pinion Mounted on Two Taper Roller Bearings.

Disassemble: Disconnect the propeller shaft flange from the pinion flange. To remove the axle shafts, take off the wheel and unscrew the nut from the end of the shaft. Remove the hub and brake drum assembly with a suitable puller.

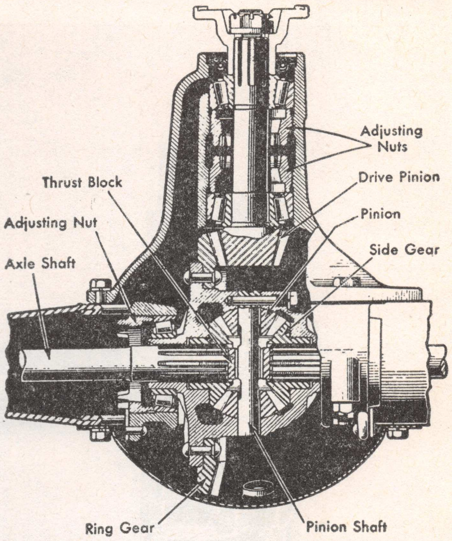
NOTE—Do not use a "knock-off" type puller, or strike the end of the shaft to loosen the hub, because damage to the differential parts will very likely result.

Remove the stud nuts which hold the oil seal and brake support to the axle housing, then remove the oil seals, brake support and shims.

NOTE—Keep the shims from each axle separate so the original adjustment will be maintained.

Use a puller to remove the axle shaft and bearing assembly. Press the bearing from the shaft. Use a suitable puller to remove the oil seals from the housing. Take off the differential inspection cover. Remove the cap screws which fasten the differential carrier to the axle housing and remove the carrier assembly. Mark the relationship of the differential bearing caps and adjusting nuts and then remove the bearing caps. Remove the differential lock screw and pull out the shaft—the differential parts are now loose and can be removed by hand.

If the ring gear is riveted to the flange, use a drill which is smaller in diameter than the rivet head and drill the rivets from the differential case side, then punch them out. Remove the pinion flange retaining nut and pull off the flange. Remove the pinion adjusting nut lock and loosen the adjusting nuts. Press the pinion shaft through the inside of the carrier, bringing the inner bearing out at the same time. Remove the front bearing from the housing and, if the bearing cups are to be removed, use a suitable puller. The adjusting nuts can now be screwed out of the housing through the inside—the inner nut first.



INTERNATIONAL.
Model R56H, R1000, R1001 Semi-floating

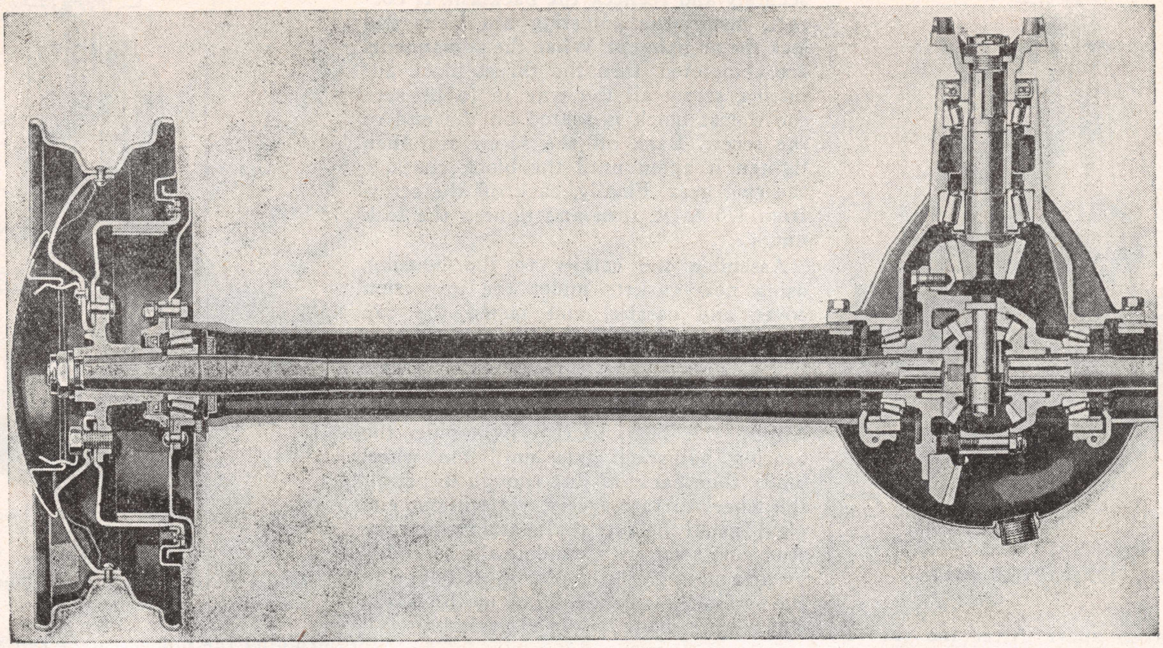
Assemble: Screw the adjusting nuts into the carrier—outer nut first. Press the bearing cups in place. Assemble the rear bearing on the pinion shaft and push the pinion into the carrier from the inside. Install the front bearing and assemble the pinion shaft flange, fastening it securely with the retaining nut.

NOTE—Pinion adjustments cannot be made until after the differential is installed.

Lubricate the differential pinions and side gears and install them in the differential case, then push in the shaft, lining up the hole in the shaft with the hole in the case, after which, install the lock screw. Locate the differential case in the carrier and install the bearing caps and adjusting nuts, tightening the cap screws until the lock washers just flatten out.

NOTE—If new parts were installed or an adjustment is necessary, the adjusting nuts should be tightened with sufficient force to drive the bearing cups solidly against the rollers. Then back off the adjusting nuts to relieve the strain and tighten them again slightly against the bearing cup.

Now while turning the ring gear, loosen the right adjusting nut and tighten the left adjusting nut until all lash is removed and then back off the left nut one turn. Tighten the right adjusting nut until it is snug and continue for one or two notches more, or until a locking position is reached. Screw the pinion shaft inner bearing and adjusting nut against the inner bearing until the proper tooth contact is established between the ring gear and pinion. Now screw the outer bearing adjusting nut against the outer bearing until a slight



Semi-Floating axle with contact button at inner end of shaft

drag is felt when turning the pinion by hand. When the adjustments are satisfactory, install the adjusting nut lock.

Mount a dial indicator on the carrier and check the backlash between the ring gear and pinion, which should be from .006" to .010". If the backlash exceeds this amount, loosen the right adjusting nut one notch and tighten the left nut one notch. If the backlash is less than specified, loosen the left nut one notch and tighten the right nut one notch. Now tighten the bearing cap lock screws securely and recheck the lash. When correct, install the adjusting nut locks and lock the adjustment. Assemble the carrier in the axle housing, using a new gasket and lock washers under the cap screws, being sure to draw up the cap screws evenly and securely. Install the axle shafts and bearings. Use a suitable drift to replace the oil seal.

NOTE—If the old parts are being used, and the shims have not been disturbed, the end play should be correct when the parts have been assembled. However, if a new axle shaft, bearing, differential carrier or axle housing has been installed, it will be necessary to check the end play.

Check the end play after all the parts have been replaced except the wheel and hub. To make this check, tap each axle shaft—after tightening the bolts—to be sure the bearing cups are seated. Then place an indicator on the axle shaft and housing to determine the amount of end play, by pulling and pushing the shaft. If an adjustment is necessary, remove the axle shaft oil seal and brake support, then add or remove the required number of shims—which are located between the brake support and the outer face of the axle shaft flange.

NOTE—When making this adjustment, an equal thickness of shims should be added or removed on each side of the axle housing to maintain a central position of the axle shaft thrust block.

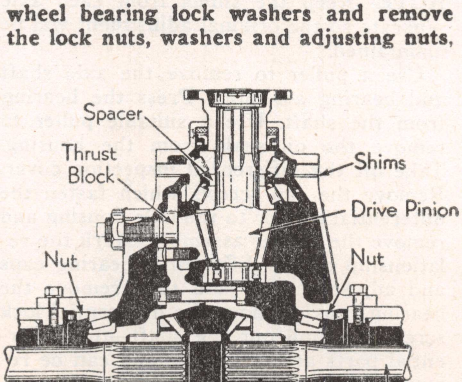
When the correct adjustment has been established, complete the assembly, and when connecting the propeller shaft, be sure the connection is made in line with the marks which were made before disassembly.

MACK

MODELS RA17, RA22, RA36, RA45

Full Floating Axle with Three Pinion Differential Bolted Ring Gear and Straddle Mounted Drive Pinion.

Disassemble: Disconnect the propeller shaft from the pinion shaft flange. Remove the axle shaft flange nuts and pull out the axle shafts. Straighten the tabs on the wheel bearing lock washers and remove the lock nuts, washers and adjusting nuts, after which the hubs may be removed. Remove the cap screws which fasten the differential carrier to the axle housing and remove the carrier assembly. Mark both differential bearing adjusting nuts and caps. Remove the differential bearing cap screws and lift off the caps. Loosen the thrust block lock screw on the side of the differential carrier. Lift out the differential and ring gear.



MACK. Models RA17, RA22, RA36, RA45

If it is necessary to remove the ring gear remove the bolts which hold the ring gear to the differential case. Press the ring gear off the differential case. If the differential bearings are to be replaced, they can be removed from the differential case with a suitable bearing puller. Mark both halves of the differential case so that they can be assembled in their original position and remove the nuts which hold the differential case bolts. Remove the bolts after which the differential parts can be removed by hand. Remove the cotter pin, nut and lock washer from the front of the pinion shaft and with a puller remove the universal joint flange. Remove the pinion bearing cap screws and remove the cap and oil seal. The drive pinion and bearings can now be removed from the carrier.

If the pinion or bearings are to be replaced, the pinion can be pressed out of the bearings. Collect the shims between the bearing cup flange and the end of the carrier and note the thickness so that the original thickness of shims will be used when the parts are reassembled. The rear roller bearing may now be removed from the pinion shaft.

Assemble: Press the rear bearing cone on the pinion shaft. Assemble the pinion to the bearing cup and then install the bearing spacer and the front bearing cone on the pinion shaft. Tighten the companion flange in place. This cone is a snug sliding fit to permit its movement when making adjustments. No end play should be allowed at these bearings. They should be from .000" to .002" tight, which can be felt as a slight drag when turned by hand. Play can be taken up by grinding down the spacer between the bearing cones or by installing a shorter spacer and shims. Assemble the differential case, using new thrust washers and lubricate all parts before assembling them. Before bolting the halves of the differential case together, be sure to align the marks which were made before the case was disassembled.

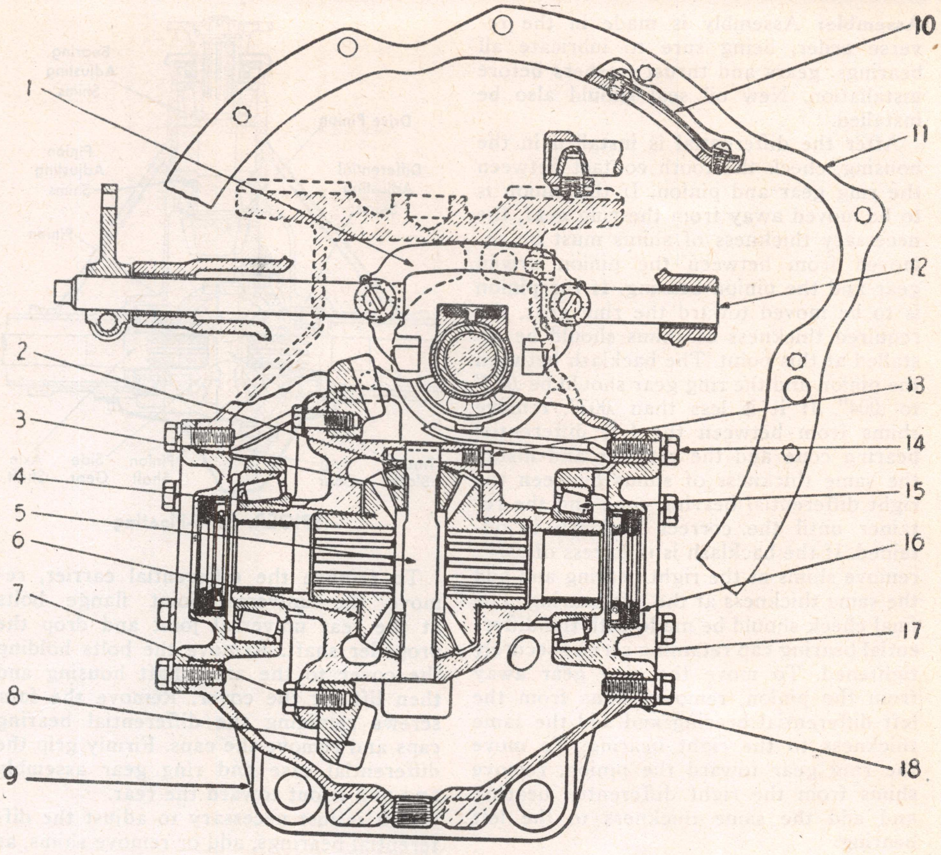
After the case is securely fastened, be sure to lock the nuts in place. Lubricate the differential bearings and press them on the differential case. Assemble the drive pinion and bearings to the carrier housing, using the original shims between the bed of the carrier and the bearing cup flange. Replace the bearing cup and oil seal and tighten the companion flange in place, using a cotter pin in the nut to hold it in position. Assemble the differential and bearings assembly in the carrier housing. Replace the bearing adjusting nuts and the bearing caps, and tighten the caps in position. Turn the adjusting nuts until the marks on them indicate that they are in their original position. Then tighten the bearing cap screws and adjusting screw locks.

There should be no play in the differential bearings. If an adjustment is necessary, tighten the bearing adjusting nuts with sufficient force to seat the bearing cups solidly against the rollers. Back off the adjusting nuts to relieve strain and tighten them again slightly against the bearing cups. Loosen the right adjusting nut and tighten the left nut, at the same time turning the ring gear, until all lash is removed. Then back off the left nut one turn. Tighten the right nut until it is snug and continue for one or two more notches, until a locking position is reached.

Check the tooth contact and if it is necessary to move the ring gear away from the pinion, tighten the right nut and loosen the left nut an equal number of notches until the contact is correct. If the ring gear must be moved toward the pinion, tighten the left nut and loosen the right nut an equal number of notches. By turning both nuts the same amount, the bearing play will not be changed. The pinion can be moved toward or away from the ring gear by changing the thickness of the shims between the pinion bearing cup flange and the end of the carrier. Adding shims moves the pinion away from the ring gear and reducing the thickness of the shims moves the pinion toward the ring gear.

When this adjustment is completed, turn the thrust block screw in until it contacts the ring gear and then back it off just slightly. The clearance between the ring gear and the thrust block should be .010" to .012".

Assemble the carrier to the housing, using a new gasket and tighten the cap screws securely, using new lock washers under the screws. Lubricate the wheel bearings and assemble the hubs, bearings and adjusting nuts, using new oil seals. Adjust the bearings by tightening the bearing adjusting nuts until the wheel binds and then back them off just enough to permit the wheel to turn freely without end play. Install the axle shafts and tighten the flange nuts securely. Complete the assembly by attaching the univerasl joint flanges.



PAK-AGE-CAR

1—Clutch throwout yoke
2—Thrust washer
3—Differential pinion gear
4—Differential side gear
5—Differential pinion pin
6—Thrust washer
7—Ring gear screw
8—Ring gear
9—Housing
10—Timing inspection hole cover
11—Clutch housing
12—Clutch throwout shaft
13—Lock screw
14—Bearing retainer cap screws
15—Differential bearing
16—Oil seal
17—Bearing cap
18—Differential bearing shim

PAK-AGE-CAR

Two Pinion Differential with Bolted Ring Gear Mounted in Same Housing as Transmission.

NOTE—If repairs are to be made to the transmission, see the **"Transmission"** chapter for instructions.

Disassemble: Remove the rear axle and power plant assembly from the chassis. Unscrew the wheel shaft nuts and pull off the hub and brake drum assemblies. Unfasten the spring from the transmission case and from the wheel supports. Disconnect the radius rods from the wheel supports. The wheel supports and wheel shafts may then be removed from the outer universal joints. Pull the drive shaft assemblies out of the differential. Disconnect the clutch housing from the engine and separate the transmission and differential assembly from the engine. Disconnect the clutch housing from the transmission housing. Remove the cap screws from the differential bearing caps and remove the caps, shims and bearings.

NOTE—Keep these shims separate so that when assembling, the approximate ring gear and pinion backlash adjustment will be readily obtained.

Remove the differential assembly from the housing. Take out the differential shaft lock screw and push out the shaft. All the differential parts will now be loose and can be removed by hand. If the ring gear is to be replaced, remove the cap screws and tap the gear from the differential case flange. Unscrew the nut from the end of the pinion shaft and remove the pinion shaft driven gear.

NOTE—Collect the shims which are located between the drive gear and bearing. These shims control the endwise adjustment of the pinion with relation to the ring gear.

Press the pinion shaft out of the housing and remove the bearing.

Assemble: Assembly is made in the reverse order, being sure to lubricate all bearings, gears and thrust washers before installation. New oil seal should also be installed.

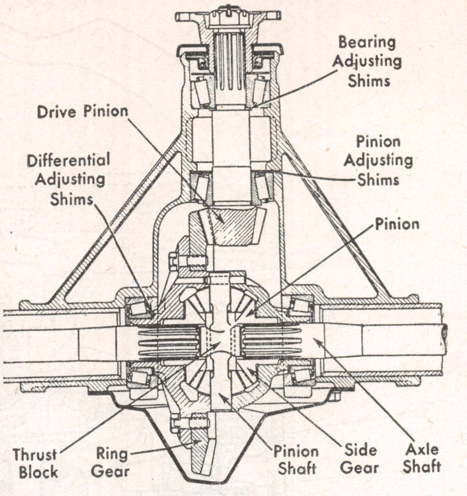
After the differential is installed in the housing, check the tooth contact between the ring gear and pinion. If the pinion is to be moved away from the ring gear, the necessary thickness of shims must be removed from between the pinion driven gear and the pinion bearing. If the pinion is to be moved toward the ring gear, the required thickness of shims should be installed at this point. The backlash between the pinion and the ring gear should be .002" to .004". If it is less than .002", remove shims from between the left differential bearing cone and the retainer and install the same thickness of shims between the right differential bearing cone and the retainer until the correct backlash is obtained. If the backlash is in excess of .004", remove shims at the right bearing and add the same thickness at the left bearing. The final check should be made with the differential bearing cap retaining screws securely tightened. To move the ring gear away from the pinion, remove shims from the left differential bearing and add the same thickness to the right bearing. To move the ring gear toward the pinion, remove shims from the right differential bearing and add the same thickness to the left bearing.

SPICER

Semi-Floating with Two Pinion Differential, Bolted Ring Gear and Drive Pinion Mounted on Two Taper Roller Bearings.

Disassemble: To remove the axle shaft, remove the rear wheel. Remove the cotter pin, nut and washer from the outer end of the axle shaft. Remove the hub and brake drum assembly with a suitable puller. Do not use a knock-off type of puller or strike the end of the axle shaft to loosen the hub because damage can be done to the differential parts by this method. Block the brake pedal to the floor board so that it cannot be depressed. Disconnect the hydraulic brake line from the wheel cylinder. Remove the stud nuts which hold the oil seal and brake support to the axle housing and remove the oil seals, brake support and shims. If both axle shafts are to be removed, keep the shims on each shaft separate and assembled to their respective ends of the axle housing to maintain the correct bearing adjustment. With a suitable puller, remove the axle shaft and bearing assembly. With a bearing puller, remove the bearing from the axle shaft. Use an oil seal puller to remove the seals from the housing.

If an axle shaft is broken less than 8" from the inner end of the shaft, the inner piece can be removed when the differential and carrier are removed. If the break is more than 8" from the inner end of the shaft, it will be necessary to snare the inner end out through the housing with a wire loop or a similar tool, after removing the inner oil seal.



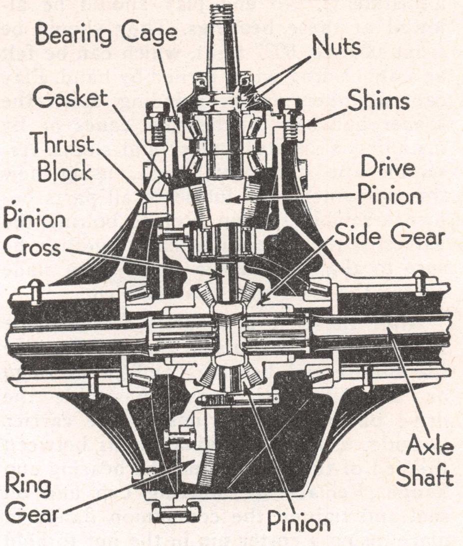
SPICER. Semi-Floating

To remove the differential carrier, remove the universal joint flange bolts at the rear universal joint and drop the propeller shaft. Remove the bolts holding the cover to the axle shaft housing and then lift off the cover. Remove the four screws retaining the differential bearing caps and remove the caps. Firmly grip the differential case and ring gear assembly and pull it out toward the rear.

If it is just necessary to adjust the differential bearings, add or remove shims, as required, between the differential case and either differential bearing cone until the differential bearing cups will just slide into the housing when installed on the differential case assembly and bearing cones assembly. Remove the differential case assembly and pull off one of the differential bearing cones. Add an additional .008" to .010" shim between the bearing cone and the differential case. Reinstall the differential assembly in the housing and tighten the bearing cups; if the bearings are properly adjusted, a considerable bearing drag will be noted when the ring gear is revolved by hand. After the differential bearings have been adjusted, it will be necessary to check the ring gear for backlash.

If it is necessary to disassemble the differential it will be necessary to remove the ring gear. To remove the ring gear, remove the bolts which hold the ring gear to the differential case. Press the ring gear off the differential case. Remove the differential lock screw and push out the differential pinion shaft, with a brass drift. The axle shaft thrust block can now be removed. By revolving the differential side gears by hand, the differential pinions and pinion thrust washers will come opposite the two holes in the case and can be withdrawn. The differential side gears and side gear thrust washers can now be removed through the holes in the case.

NOTE—The differential assembly must be removed from the axle housing before removing the drive pinion, but it is not necessary to remove the drive pinion or the differential assembly for removal of the drive pinion bearing oil seal.

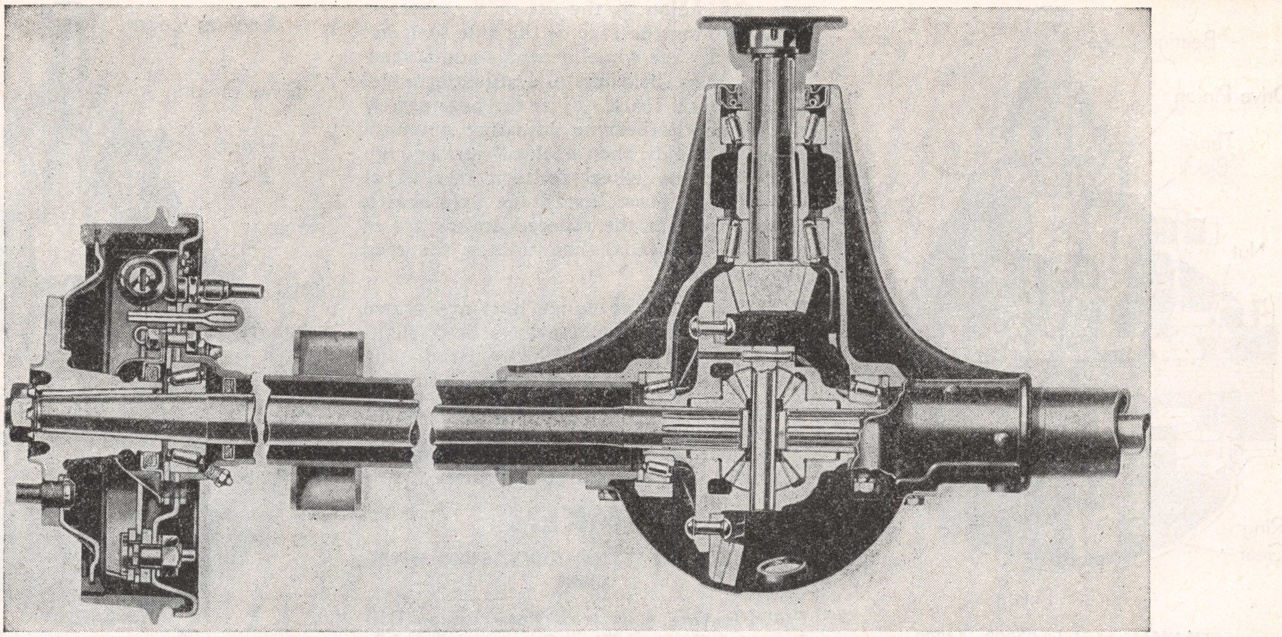


Spicer. Full-Floating

Remove the cotter pin, drive pinion flange nut and washer from the front end of the pinion shaft. With a suitable tool, pull off the universal joint drive flange, and dust shield assembly. The pinion should be pressed out of the front bearing toward the rear. It is important that the pinion is pressed and not driven out of the housing to prevent damage to the forward bearing. The oil retainer parts can then be pried out of the front of the housing. The pinion oil slinger and the front bearing can now be withdrawn from the housing.

Assemble: If the differential assembly was satisfactory from a standpoint of noise before the unit was disassembled it may be possible to assemble the drive pinion with the original shims. If new parts were installed or an adjustment was necessary the shims can be changed to locate the pinion with relation to the ring gear, otherwise it is not necessary to remove the rear bearing cup. If the bearing cup was removed, insert the original shims between the pinion rear bearing cup and the pinion housing. If a new pinion is installed, press the rear bearing cone on the pinion shaft. Install the pinion and rear pinion bearing cone in the housing. Place a heavy brass drift against the head of the pinion so that the rear pinion bearing cone tightly contacts the bearing cup. With the pinion held in this position, pass the forward bearing cone over the shaft and tap the cone onto the shaft until it contacts with the shoulder of the pinion shaft and the shims. Install the flange and plain washer and securely tighten the nut, omitting the oil slinger, oil retainer and the gasket until the pinion and bearing adjustment have been checked. Revolve the pinion flange to check the bearing drag. The bearings will give the most satisfactory service when adjusted so as to produce a slight drag to rotation when the pinion is revolved by hand.

If the bearing adjustment is not satisfactory, remove or add shims as required and recheck. When bearing play is correct, check the tooth contact of the ring gear and the pinion. To remove the pinion to-



Semi-floating axle with thrust block at inner end of shafts

ward the ring gear, add shims between the rear pinion bearing cup and pinion housing and add the same thickness of shims between the shoulder of the pinion shaft and the forward pinion bearing cone. To move the pinion away from the ring gear, remove an equal number of shims instead of adding them. This will not change the play in the bearings. When the bearing play and the position of the pinion are correct, remove the flange retaining nut, washer and flange. Place the pinion oil slinger over the pinion shaft and press the pinion oil retainer into the pinion housing. If extreme care was exercised in removing the oil retainer, it can be reinstalled; however, it is usually advisable to install a new retainer and retainer gasket. Install the flange, washer and flange retaining nut.

The differential can be reassembled in the reverse order from which it was disassembled, making sure that the lock pin or screw for the differential shaft is securely locked. Make sure that the ring gear screws are drawn up uniformly and as tight as possible, and that they are locked in place. Special care must be taken to see that the ring gear bolt holes are chamfered on the back side of the ring gear. If they are not chamfered, the bolt holes on the ring gear side of the differential case flange must be chamfered. This will prevent causing a burr around the holes when the ring gear cap screws are drawn down and thus permit the ring gear to be drawn firmly and evenly against the flange.

The backlash between the pinion and the ring gear should be .002" to .004". If it is less than .002", remove shims from between the left differential bearing cone and the case and install the same thickness of shims between the right differential bearing cone and the case until the correct backlash is obtained. If the backlash is in excess of .004", remove shims at the right bearing and add the same thickness at the left bearing. Shifting the ring gear .005" will change backlash approximately .0035". The final check should be made with the differential bearing cap retaining screws securely tightened.

To move the ring gear away from the pinion, remove shims from the left differential bearing and add the same thickness to the right bearing. To move the ring gear toward the pinion, remove shims from the right differential bearing and add the same thickness to the left bearing.

To assemble the axle shafts, replace the shafts and bearings in the reverse order from which they were removed.

Use a suitable drift to replace the oil seal. If a new leather oil seal is to be installed, soak the leather in oil for about 30 minutes and work it with a smooth steel bar until it is soft and pliable. If the old parts are replaced and the shims have not been disturbed, the end play should be correct when the parts have been assembled. If a new axle shaft, bearing, differential carrier or housing has been installed, it will be necessary to check the end play.

End play can be checked when all the parts have been replaced except the wheel and hub. To make this check, rap each axle shaft, after the bolts are tight, to be sure the bearing cups are seated. Then place an indicator on the axle shaft and housing to determine the amount of end play of the shaft by pushing in and pulling out the shaft. If an adjustment is necessary, remove the axle shaft bearing oil seal and the brake support plate, after disconnecting the brake tube as already described. Add or remove shims to adjust the end play. Shims are located between the rear wheel brake support and the outer side of the axle housing flange. When making this adjustment, an equal thickness of shims should be removed or added on each side of the axle housing to maintain a central position of the axle shaft thrust block. The hole in the thrust block is sufficiently larger than the diameter of the shaft to prevent axle shaft thrust from being thrown on the pinion shaft, providing the thrust block is held in its central position on the shaft.

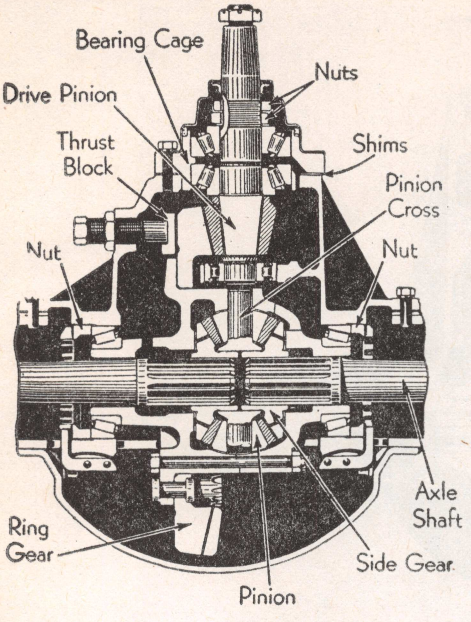
Replace the housing cover. Fill the housing to the level of the filler plug hole with the specified grade and type of lubricant. Attach the propeller shaft to rear universal joint flange, using new cap screw locks.

Full Floating Axle with Four Pinion Differential, Riveted Ring Gear and Straddle Mounted Drive Pinion.

Disassemble: Disconnect the propeller shaft at the pinion shaft end and use a suitable puller to remove the flange from the pinion shaft. Unscrew the axle shaft flange nuts and pull out the shafts, being careful not to lose the tapered dowels on the flange studs. Straighten the tabs on the wheel bearing lock washers and remove the lock nuts, washers and adjusting nuts, after which, the hubs may be removed. Remove the cap screws which retain the pinion bearing cage in the differential housing and withdraw the drive pinion assembly. Remove the oil seal and cover assembly. Straighten the tabs on the pinion bearing adjusting nut washer and remove the lock nut, washer, adjusting nut and spacer. Remove the pinion bearing cage from the pinion shaft, bringing the front bearing along with it. Use a suitable puller to remove the pinion bearing cups or drive them out with a brass drift.

NOTE—When installing the cups, be sure to drive them in straight, otherwise a sprung bearing cage will likely result; be sure also, that they are pressed down firmly against the shoulder in the pinion cage.

Remove the bolts which fasten the two halves of the axle housing together and separate the housing. Mark both halves of



TIMKEN. Models 53000, 54000

the differential case so that when assembled, the original position is maintained, then unscrew the bolts which attach the two halves of the case, after which, the case may be separated and all the differential parts removed.

Assemble: Fasten the drive pinion in a vise and assemble the bearings and pinion shaft to the cage, being sure to lubricate the bearings thoroughly before installing. Place the spacer on the shaft and run the adjusting nut up all the way to be sure the bearings are properly seated, then back off the nut just enough to permit the cage to be turned, yet not enough to allow it to spin. Install a new lock washer on the shaft with its inner prong seated in the pinion shaft slot, then run the lock nut up tight, being careful not to change the adjustment. If necessary, back off the adjusting nut slightly. After adjusting the bearings satisfactorily, bend one of the tabs of the lock washer over the adjusting nut and another over the lock nut to hold the nuts securely in place.

Lubricate the differential spider, pinions, side gears and bronze thrust washers (if used) and assemble them in the differential case, lining up the marks on both halves of the case before installing the cap screws; after tightening the cap screws securely, thread locking wire through all the screw heads. Lubricate the differential side bearings and install them in the housing. Install a new thrust block, being sure the locking pin is a tight fit in its hole. Install the differential assembly in the left hand housing. Lubricate the pinion shaft rear bearing and place it in position in the right hand housing. Install the drive pinion assembly in the housing, replace the oil seal and cover, fastening the assembly to the housing securely. Bolt the two halves of the rear axle housing securely together.

NOTE—No gasket is used between the housings and no attempt should be made to alter the backlash between the drive gear and pinion by the use of a gasket, or by machining the face of the axle housing.

Lubricate the wheel bearings and assemble the hubs, bearings and adjusting nuts, using new oil seals. Adjust the bearings by tightening the bearing adjusting nut until the wheel binds, then back off just enough to permit the wheel to turn freely, yet without end play. Install the axle shafts, being sure that the tapered dowels are in place on all studs, then tighten the stud nuts securely.

NOTE—When the flange nuts are drawn up tight, there should always be a slight clearance between the lock washer and the flange. No clearance at this point indicates excessive wear on the studs, flange holes or tapered dowels.

Complete the assembly by installing the universal flange and propeller shaft.

TIMKEN

SERIES 51520, 52200, 53000, 54000, 56000, 58000

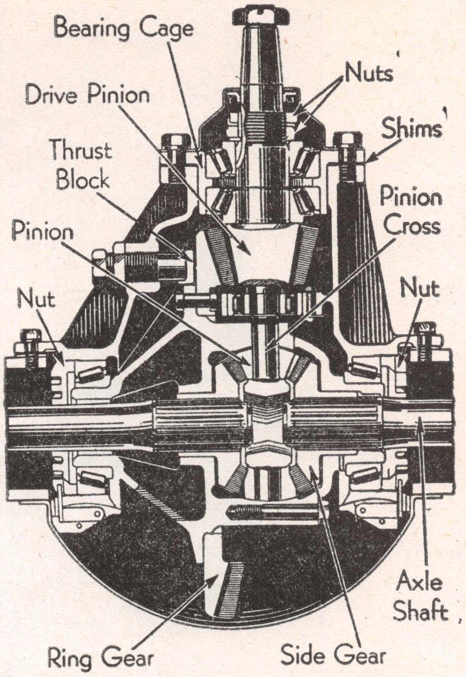
Full Floating Axle with Four Pinion Differential, Riveted Ring Gear, and Straddle Mounted Drive Pinion.

NOTE—The drive pinion assembly can be removed without disturbing the differential assembly on series 53000 and 54000. However, on the 56000 and 58000 series, the differential assembly will first have to be removed before the drive pinion can be removed.

Disassemble: Disconnect the propeller shaft flange from the pinion shaft flange. Unscrew the axle shaft flange nuts and pull out the shafts, being careful not to lose the tapered dowels on the flange studs. Straighten the tabs on the wheel bearing lock washers and remove the lock nuts, washers and adjusting nuts, after which, the hubs may be removed. Remove the cap screws which fasten the differential carrier and back inspection cover (if equipped) to the axle housing and remove the carrier assembly. Back out the thrust block adjusting screw to allow the ring gear to clear the thrust block when removing the differential assembly. Mark the relationship of the differential bearing caps and adjusting nuts and then remove the bearing caps.

NOTE—If the original bearing adjustment is to be retained, remove the left hand bearing cap only, leaving the right one undisturbed. Then shift the differential case over to the left side until it can clear the right hand bearing cap and pinion shaft rear bearing support.

Mark both halves of the differential case and then unscrew the nuts or cap screws which attach both halves of the case, after which, the case may be separated and all the differential parts removed. If the ring gear is to be replaced, use a drill which is smaller than the diameter of the rivet head and drill the rivets from the differential case side, after which, punch out the rivets. Remove the cap screws which retain the pinion bearing cage in the carrier and withdraw the drive pinion assembly. Remove the oil seal and cover assembly. Straighten the tabs on the pinion bearing adjusting nut washer and remove the lock nut, washer, adjusting nut and spacer washer. Remove the pinion bearing cage from the pinion shaft, bringing the front bearing along with it. Use a suitable puller to remove the pinion bearing cups or drive them out with a brass drift.

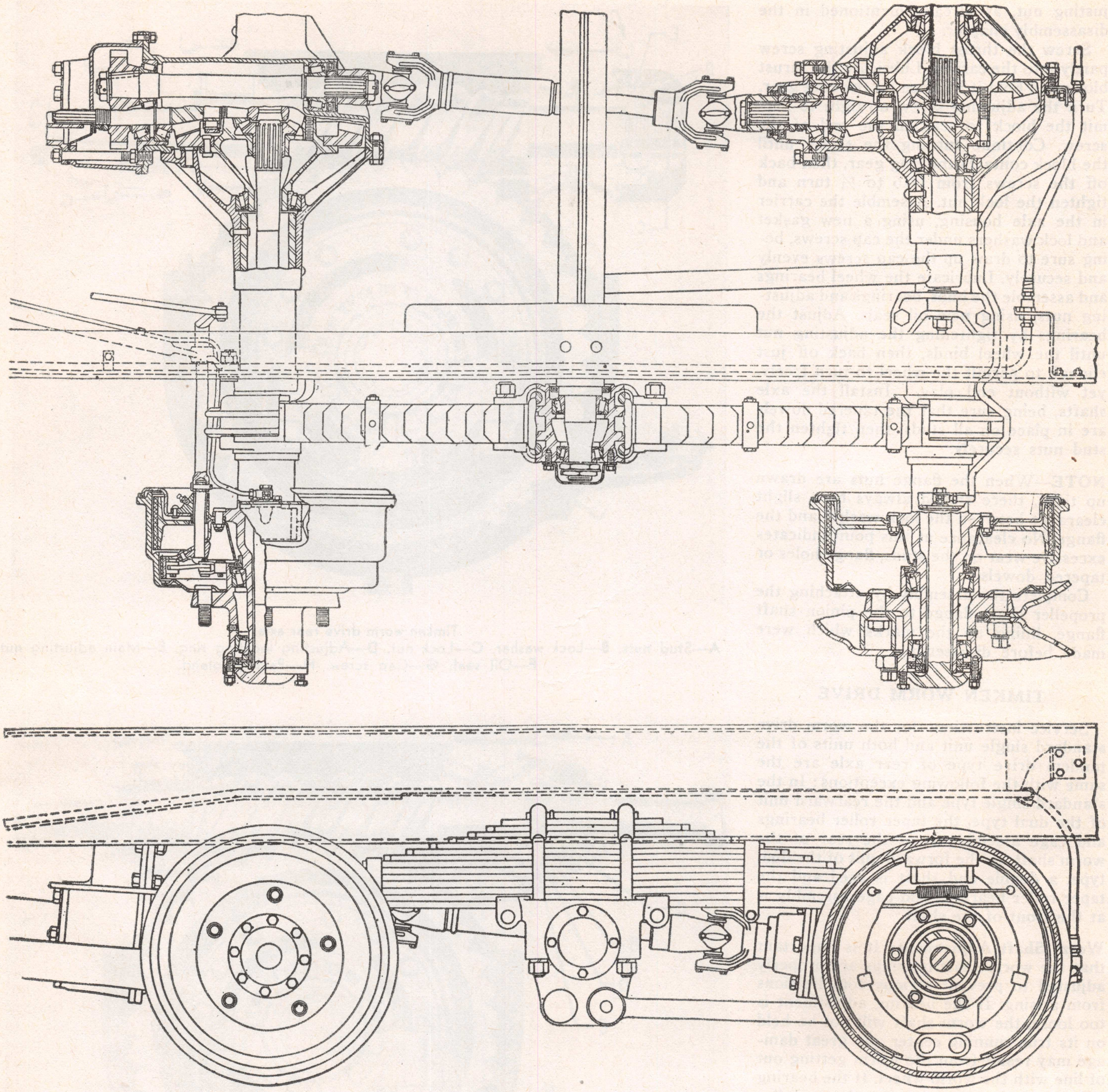


TIMKEN. Models 56000, 58000

NOTE—When installing the cups, be sure to drive them in straight, otherwise a sprung bearing cage will likely result; be sure also, that they are pressed down firmly against the shoulders in the pinion cage.

CAUTION—When the pinion assembly is removed from the carrier, be sure to collect any shims which may be assembled between the cage and the housing, noting the quantity and thickness in order to facilitate adjustment when assembling.

Assemble: Fasten the drive pinion in a vise and assemble the bearings and pinion shaft to the cage, being sure to lubricate the bearings thoroughly before installing. Place the spacer washer on the shaft and run the adjusting nut up all the way to be sure the bearings are properly seated, then back off the nut just enough to permit the cage to be turned, yet not enough to allow it to spin. Install a new lock washer on the shaft then run the lock nut up tight, being careful not to change the adjustment. If necessary, back off the adjusting nut slightly. After adjusting the bearings satisfactorily, bend one of the tabs of the lock washer over the adjusting nut and another over the lock nut to hold the nuts securely in place. Assemble the drive pinion assembly in the carrier, replacing the original quantity of shims. Lubricate the differential spider, pinions, side gears and thrust washers and assemble them in the differential case, lining up the marks on both halves of the case before installing the cap



Marmon-Herrington tandem rear axle.

screws; after tightening the cap screws securely, thread locking wire through all the screw or bolt heads. Locate the differential case in the carrier and install the bearing caps and adjusting nuts, tightening the cap screws until the lock washers just flatten out.

NOTE—If new parts were installed or an adjustment is necessary, the adjusting nuts should be tightened with sufficient force to drive the bearing cups solidly against the rollers. Then back off the adjusting nuts to relieve the strain and tighten them again slightly against the bearing cup.

Now, while turning the ring gear, loosen the right adjusting nut and tighten the left adjusting nut until all lash is removed and then back off the left nut one turn. Tighten the right adjusting nut until it is snug and continue for one or two notches more, or until a locking position is reached. Mount a dial indicator on the carrier and check the backlash between the ring gear and pinion, which should be from .005" to .010". If the backlash exceeds this amount loosen the right adjusting nut one notch and tighten the left nut one notch. If the backlash is less than specified, loosen the left nut one notch and tighten the right nut one notch. Now tighten the bearing cap lock screws securely and recheck the lash. When correct, install the adjusting nut locks and lock the adjustment.

NOTE—The endwise adjustment of the drive pinion is controlled by the shims between the bearing cage flange and the housing. These shims are available in several thicknesses, and if an adjustment is necessary, the bearing cage must be removed. In order not to disturb the ring gear adjustment, the differential assembly can be swung out to permit the pinion to be removed without disturbing the right adjusting nut, as already mentioned in the disassembly chapter.

Screw the thrust block adjusting screw partly into the carrier. Lubricate the thrust block and hold it in place on the ring gear. Turn the adjusting screw up tight to permit the block to seat on the end of the screw. Continue turning the screw until the block contacts the ring gear, then back off the screws from 1/16 to ¼ turn and tighten the lock nut. Assemble the carrier in the axle housing, using a new gasket and lock washers under the cap screws, being sure to draw up the cap screws evenly and securely. Lubricate the wheel bearings and assemble the hubs, bearings and adjusting nuts, using new oil seals. Adjust the bearings by tightening the adjusting nut until the wheel binds, then back off just enough to permit the wheel to turn freely, yet without end play. Install the axle shafts, being sure that the tapered dowels are in place on all studs, then tighten the stud nuts securely.

NOTE—When the flange nuts are drawn up tight, there should always be a slight clearance between the lock washer and the flange. No clearance at this point indicates excessive wear on the studs, flange holes or tapered dowels.

Complete the assembly by attaching the propeller shaft flange to the pinion shaft flange, lining up the marks which were made before disassembly.

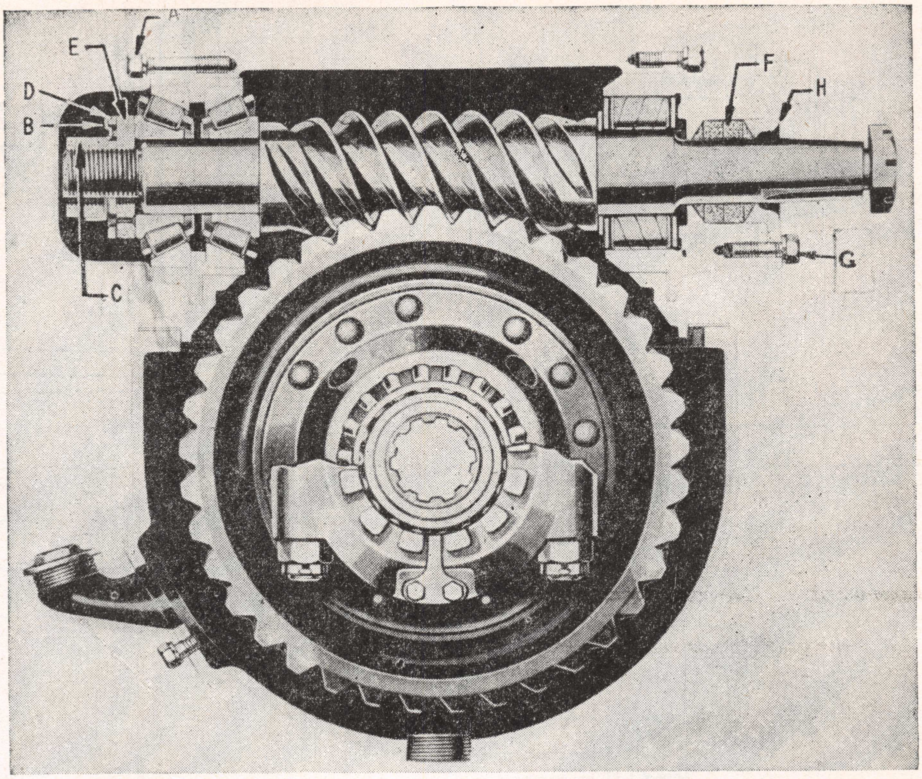
TIMKEN WORM DRIVE

Service instructions for the worm drive standard single unit and both units of the tandem drive type of rear axle are the same with the following exceptions: In the standard single type and the rearward unit of the dual type, the taper roller bearings and cage assembly is at the rear of the worm shaft. In the forward unit of the dual type, a double end shaft is used and the taper roller bearings and cage assembly is at the front of the shaft.

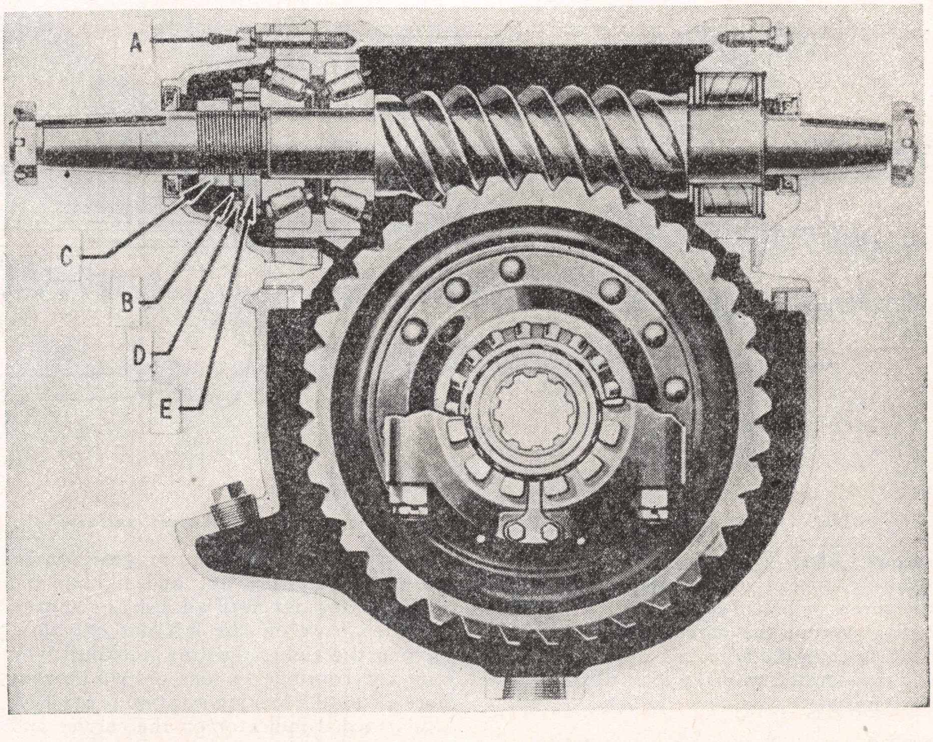
Worm Shaft Adjustment: It is important that the worm shaft bearings are properly adjusted to prevent serious complications from arising. If the bearing adjustment is too loose, the worm shaft will not be held on its true running center and great damage may result from the worm getting out of line with the worm wheel. If the bearing adjustment is too tight, the thrust collar on the bearing cone and the thrust end of the bearing rollers may break down and result in damage to the other moving parts. Bearing play should be checked with an indicator.

The worm shaft thrust in both directions is taken on two tapered roller bearings at the rear of the worm shaft, while the front end of the worm shaft is held in a true horizontal position, when under load, by a straight roller bearing.

To adjust the thrust bearing, remove the bearing cover by taking off the cover stud nuts. The bearing nut lock washer can then be removed. After unscrewing the bearing lock nut, the adjusting locating ring can be removed. Then tighten or loosen the main adjusting nut until the end play is from .000" to .002" tight. When reassembling, make sure that the bearing nut lock washer is bent over securely.



Timken worm drive rear axle.
A—Stud nuts. B—Lock washer. **C—**Lock nut. **D—**Adjusting locating ring. **E—**Main adjusting nut. **F—**Oil seal. **G—**Cap screw. **H—**Packing gland.



Timken worm drive rear axle for tandem rear axle.
A—Stud nuts. B—Lock washer. **C—**Lock nut. **D—**Adjusting locating ring. **E—**Main adjusting nut.

The oil seal at the front of the worm shaft is a self contained seal assembled between a beveled spacer at the inner end with a beveled packing next to the gland and requires no adjustment. Leaks can be stopped by tightening the gland cap screws. If the parts are worn to the extent that leaks cannot be stopped, the seals should be replaced.

Differential Bearings and Worm Gearing: Differential bearing adjustments should be made on the left bearing. Do not disturb the right bearing except when it is necessary to take down the entire differential assembly. By making the adjustment on the left side, the alignment of the worm and wheel will not be destroyed. To adjust the left bearing, the differential carrier must be removed from the axle housing. To do this, take out both drive shafts, remove the cap screws and stud nuts which hold the carrier to the housing. Disconnect the propeller shaft and lift out the entire carrier assembly. Then release the bearing nut lock by removing its cap screw on the left adjusting ring and tighten the bearings by turning the adjusting nut with a flat tool until all play in the differential assembly has been removed. After the adjustment is tight, loosen the adjusting ring one notch and lock it in position.

The carrier may now be replaced. Be sure to tighten the cap screws and stud nuts which hold the carrier to the axle housing.

Worm Gearing Tooth Contact: When adjusting the worm gearing tooth contact, the difference between the underslung type and the overhung type must be remembered. The direction of rotation is the same in both types, but the worm in the overhung type is cut with a right hand thread and the underslung type is cut with a left hand thread.

To check the contact position on the worm and wheel teeth, paint the wheel teeth with a thin coat of Prussian blue, and turn the worm with a wrench or temporary crank on the end of the worm shaft. As the worm and wheel revolve the blue will be wiped off the wheel teeth, showing the area of contact on the tooth surfaces. It must be remembered that each tooth consists of an entering and leaving side. The point where worm threads enter wheel teeth is the entering side and the opposite tooth side is the leaving side. The entering side of the tooth is the portion that has the flattest angle, the leaving side being almost straight or vertical. The proper tooth contact is approximately 80% full starting at the leaving side.

To obtain proper tooth contact, first set the wheel to its maximum amount of backlash. Then move the wheel to the right or left until contact is correct. Use the drive sides of the teeth when checking the adjustment as the coast side will automatically show a desirable tooth contact when the drive side is correct.

Always bear in mind that the design of worm gear teeth causes the drive and coast contact to reverse or appear as what is commonly known in other types of gearing as a cross contact. In worm gearing the entering portion on the drive side of the teeth, will be on the opposite portion of teeth on the coast side.

CAUTION—Always check bearing adjustments with an indicator, don't guess. Be sure the oilseal parts are correctly assembled and in good condition. Make sure that all bolts are assembled tightly in place and that all locks are securely fastened. Be careful when riveting, for too much pressure exerted on the rivets may distort the worm wheel, making it impossible to obtain correct tooth contact. Bear in mind when assembling worm wheels to the differential that cold riveting is preferable. When adjusting for correct tooth contact, only a slight movement, if any, of the wheel is necessary after maximum backlash is obtained. When a new worm wheel is assembled to the differential, check the side of the wheel for runout, rotating the wheel on the differential bearings. This should not exceed .004". Be sure to lubricate properly.

Disassemble: To disassemble the differential, remove the cap screws or nuts attaching the differential carrier assembly to the axle housing. Remove the nuts attaching the axle shaft drive flanges to wheel hubs and remove the axle shafts. The carrier can now be completely removed. Remove the cap screws and plates which lock the differential side bearings adjusting rings in place. Remove the cotter pins from the differential side bearing cap stud nuts and remove the nuts. Mark the bearing caps to insure correct position when the parts are assembled and then remove the caps. Back off one differential bearing adjusting nut and lift the entire differential from the carrier.

To further disassemble the differential, mark the case halves to insure correct position of the case halves at the time of assembly. With a center punch, mark the heads of the rivet in the exact center. With a drill, slightly smaller than the size of the rivet, drill the heads of the rivets to a depth just below the bottom of the rivet head. With a chisel, cut off the drilled heads of the rivets.

CAUTION—The differential case should be suitably supported during this operation to prevent the case from being distorted or damaged. No attempt should be made to remove or replace rivets unless the proper tools are available.

Use a punch smaller than the size of the rivets and drive the rivets out of the case. Separate the case halves and remove the driving rings, worm wheel, pinion gears, side gears and pinion spider. Thrust washers are used between the side gears and case and pinion gears and driving rings.

Worm Shaft: To disassemble the worm shaft, remove the nut (front and rear on dual drive) from the worm shaft and remove the propeller shaft driving yoke. Remove the nuts attaching the cover and oil seal assembly to the axle carrier and remove the cover. The same stud nuts attach the bearing cage to the axle carrier. Remove the nuts attaching the cage and oil seal assembly to the axle carrier and remove the cover. The worm shaft can now be removed from the axle carrier through the forward opening, taking the forward bearing cage and bearings with the shaft. The straight roller bearing is a slip fit on the shaft. The bearing can be removed at the same time the rear cage is removed.

Clamp the worm shaft in a bench vise between two wood blocks, making sure not to grip the shaft on the worm gear. Serious damage to the gear will result in improper handling of the worm shaft or worm wheel. Straighten the lip of the adjustment lock nut washer and remove the lock nut, lock washers, lock rings and adjusting nut. The cage can now be removed from the worm shaft, taking the forward bearing with the cage assembly.

Clean and inspect both roller bearings. Also clean the worm shaft bearing cage thoroughly and inspect the bearing cups. The cups can be removed with the puller or driven out carefully from the other end of the cage. Use a brass drift and tap on the opposite sides alternately so that the cup will come out straight. If the cup is cocked badly while removing or installing it, the cage may become distorted so that the hole for the bearing cup will be too large for proper fit. When installing cups, they should be pressed in squarely to prevent springing the cage out of shape. Be sure the cups are forced down against the shoulder in the cage.

Housing Inspection: See that the inside of the housing is properly cleaned as well as the outer ends. Temporarily install the wheel hubs. Draw the adjusting nuts up snugly so that the hub will just turn, but do not lock the adjustment at this time. Install the axle shafts, drawing the nuts up tight with the tapered dowels in place. Axle shafts which show evidence of twist or strains, or which have worn splines, should be discarded. Turn the hubs slowly, one at a time. Spline run-out should not exceed 1/32". When certain that the axle shafts are true, lay a straight edge along the splines. If the housing is not sprung, misalignment of the shafts indicated under the straight edge should not exceed 1/32". Remove the shafts and proceed with assembly.

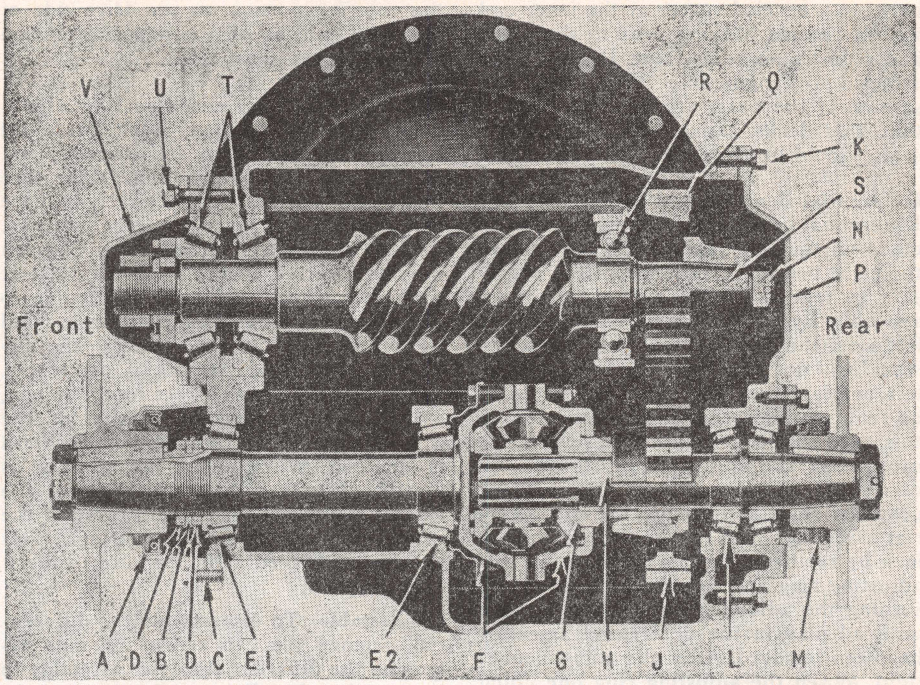
Assembly: Before assembling, all bearings, thrust washers and bushings should be lubricated with light gear oil to prevent scoring when the truck is first put into service.

Worm Shaft: Clamp the worm shaft in a vise between wood blocks, making sure not to grip on the worm gear. Assemble the taper roller bearings and the worm shaft to the cage. Install the bearing adjusting nut, drawing the nut up tight to be sure all bearing surfaces seat and that all clearance in the bearing is taken up. Back off the inner adjusting nut about 1/32 turn and install the lock ring. The lock ring contains 16 holes. These divisions can be doubled by turning the ring over thereby reducing axial movement of the nut to .0026". With proper bearing adjustment, the cage should not spin. Thrust clearance taken with a dial indicator should be .0005" to .002" tight. Install the bearing lock ring and lock nut. Tighten the lock nut and check the bearing adjustment. If the bearing adjustment is still satisfactory, bend the lip of the lock washer over the flat of the lock nut.

Before installing the worm shaft and cage assembly into the axle carrier make sure that the bearing inner washer, which is a press fit on the rear end of the worm shaft, is in its proper position. Install the worm shaft and cage assembly into the axle carrier from the front end. Install the cover and oil seal assembly to the carrier and tighten the cover nuts securely. The oil seal is a press fit in the cover. The seal must be in good condition to prevent loss of lubricant around the worm shaft. If the seal is worn or damaged it should be replaced. Replace the straight roller bearing assembly on the end of the worm shaft. Replace its bearing cage and cover assembly. The oil seal assembly which is a press fit in the cover must be in good condition to prevent loss of lubricant around the worm shaft. Replace the nuts attaching the bearing cage to the axle carrier and tighten the nuts securely.

Assembling Differential: Check mating surfaces of both differential case halves for burrs or other foreign material. Reassemble the differential spider, pinion gears and thrust washer between the two driving rings. Driving rings are fitted with four lugs which fit into mating notches in the worm wheel. Assemble the driving rings, differential spider, and pinion gears to the worm wheel. Assemble the differential spider, pinion gear and worm wheel assembly to case halves making sure two differential side gears are in proper position. Thrust washers are used between the side gears and the case halves. Use of new thrust washers is recommended when the axle is overhauled. The halves of the differential case must be assembled according to marks made at disassembly. The case must be riveted together with special rivets using a suitable fixture. After assembly is completed, an indicator reading should be taken on the worm wheel. If the runout at the flange sides exceeds .002", the cases should be replaced with new parts. Eccentricity of the worm wheel should not exceed .002". Install the differential and worm wheel assembly in the axle carrier and adjust the worm wheel for tooth contact and side bearing adjustment.

Worm and Wheel Adjustment: When installing the differential in the carrier it is necessary to adjust the differential side bearings to provide proper contact between the worm threads and wheel teeth. Side bearings must also be adjusted for side thrust clearance. Note that the worm threads enter the wheel teeth at the left side and leave at the right side. Therefore, with power applied, the worm tends to push the wheel toward the right side. By adjusting the wheel slightly off center to the left side, contact area shifts to the center of the teeth when full power is applied.



Timken Inter-axle differential.

Drive contact should start at the leaving side of the wheel teeth and extend ½ to ¾ across the face of the teeth. It is not necessary to check coast contact as it is always relative to drive contact.

To adjust the worm wheel for proper tooth contact and the differential side bearings for proper side thrust clearance proceed as follows: Check the worm shaft bearing adjustment. The worm shaft should be from .0005" to .002" tight. This reading can be taken on the worm shaft with the dial indicator. Adjust the differential side bearing adjusting rings until the worm wheel is approximately on center with the worm shaft. The differential side bearing adjusting rings should be taken up to remove all excessive clearance and then backed off 1 to 2 notches to provide .004" to .006" clearance. Paint the drive face of the wheel teeth with a very thin coat of Prussian blue. Rotate the worm shaft clockwise, looking from the front and at the same time hold slack out of the wheel. As the worm and wheel revolve, the blue will be wiped off the wheel teeth showing the area of tooth contact on the tooth surface. Correct contact should be obtained by shifting the differential one or two notches toward the left side. When adjusting the differential side bearing adjusting rings for tooth contact always remember that if the left ring is loosened one notch, the right ring must be tightened one notch. Loosening one ring and tightening the opposite ring will allow the differential assembly to be shifted without disturbing the bearing adjustment. After proper worm wheel and worm shaft tooth contact has been secured, replace the lock and cap screws to maintain the adjustment. Check the bearing cap stud nuts and lock the nut with a cotter pin the full size of the hole in the stud.

Installing Carrier: Always use a new gasket between the differential carrier flange and axle housing. Replace the carrier assembly to the axle housing, using a new lockwasher under the nuts or cap screw heads. Be sure that each nut and cap screw is drawn up tightly.

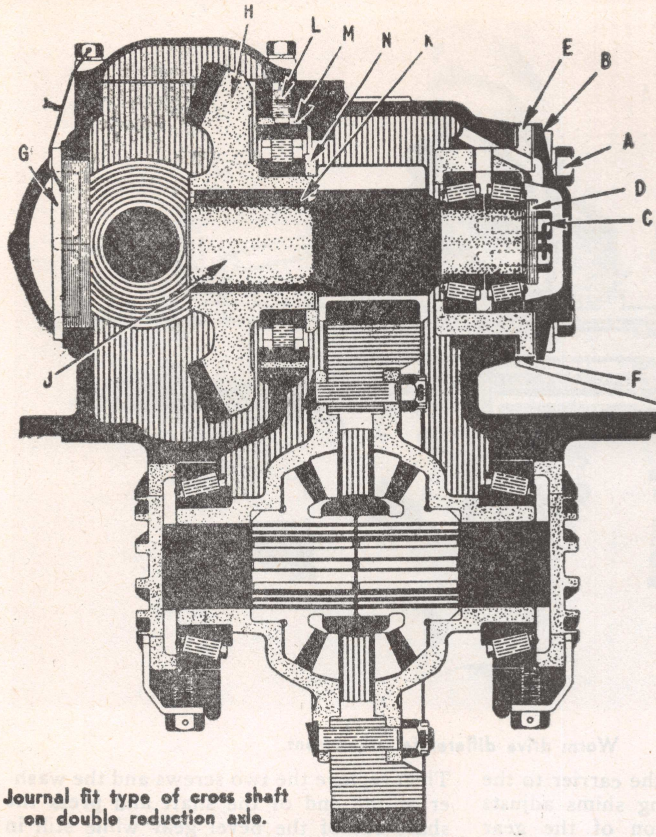
If the wheel and hubs have been removed, they must be replaced and adjusted. Install the axle shafts, using a new gasket under the driving flange and new lockwashers under the stud nuts. Be sure that the split tapered dowels are in place and the stud nuts drawn up tightly.

TIMKEN-WISCONSIN DOUBLE REDUCTION AXLE

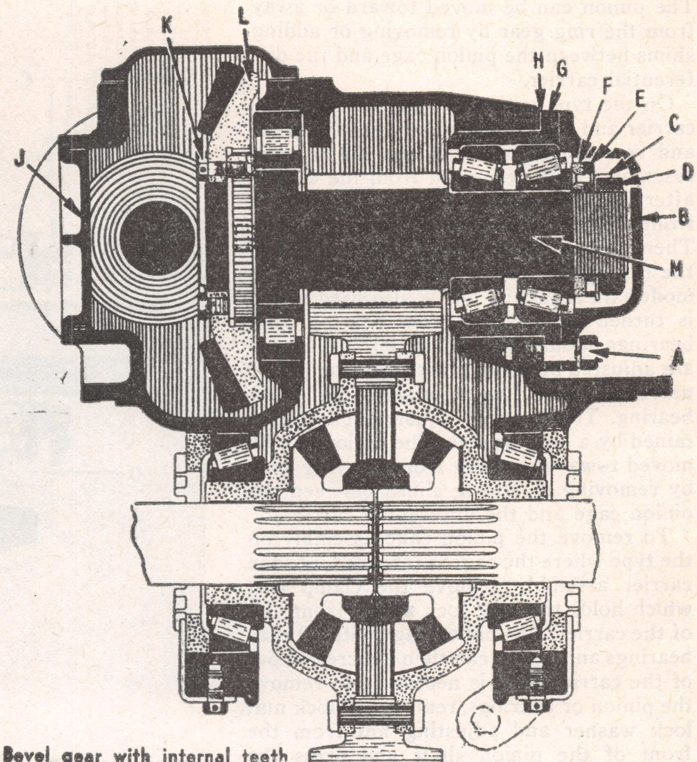
NOTE—Instructions also apply to Autocar axles.

Adjustments to these axles can be divided into three groups; the pinion, the cross shaft or ring gear and the differential. The illustrations show the various types of construction that may be found at these three points and some combination of those shown will cover the axle found on the truck fitted with this axle.

Pinion and Pinion Bearing: On the type with the cage bolted to the carrier and with no spacer between the front and rear pinion bearings, the pinion cage assembly can be removed from the carrier after the nuts which hold the cage to the front end of the carrier have been removed. Remove the cap at the front of the cage. Then remove the lock nut, lock washer and adjusting nut from the front of the pinion shaft and press the pinion shaft out of the cage. The rear bearing, nearest the pinion, should be a tight fit on the bearing surface while the front bearing should be

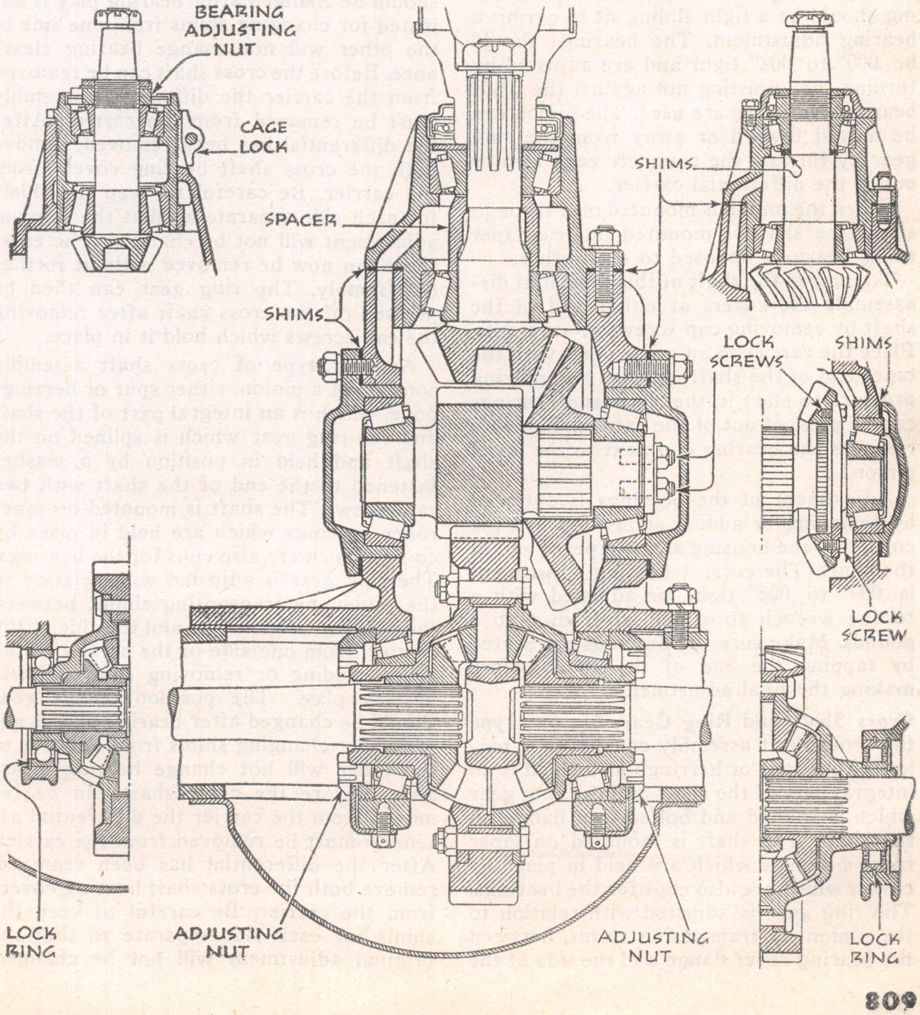


Journal fit type of cross shaft on double reduction axle.



Bevel gear with internal teeth to fit cross shaft on double reduction rear axle.

a tight sliding fit in the cage to permit a bearing adjustment. Shims or a spacer of various thicknesses between the pinion shaft shoulder and the front bearing cone adjust bearing play. The bearings should be .000" to .002" tight after the adjusting nut has been tightened against the front bearing. When the bearing adjustment is correct, place the lock washer against the adjusting nut and with a hammer and punch, indent the washer into one of the holes of the adjusting nut. Then lock the adjustment with the Allen set screw in the lock nut or by bending the edge of the lockwasher over two flat sides of the lock nut, depending upon which type is used.



Timken Double Reduction Axle. General construction shown in central illustration. Across the top are the three methods of mounting the pinion. Left—Pinion cage threaded into carrier with screw for bearing adjustment. Center—Cage bolted to carrier with shims for bearing play and pinion adjustment. Right—Cage bolted to carrier with nut for bearing play and shims for pinion adjustment. Across the center are the two methods for mounting the ring gear. Center—Ring gear held to cross shaft with bolts and washer in center of shaft. Right—Ring gear mounted on cross shaft flange and held in position with bolts. Across the bottom are the three types of mounting the differential. Left—Ball bearing with no adjustment. Center—Taper roller bearings with adjusting nuts. Right—Straight roller bearings with no adjustment.

The pinion can be moved toward or away from the ring gear by removing or adding shims between the pinion cage and the differential carrier.

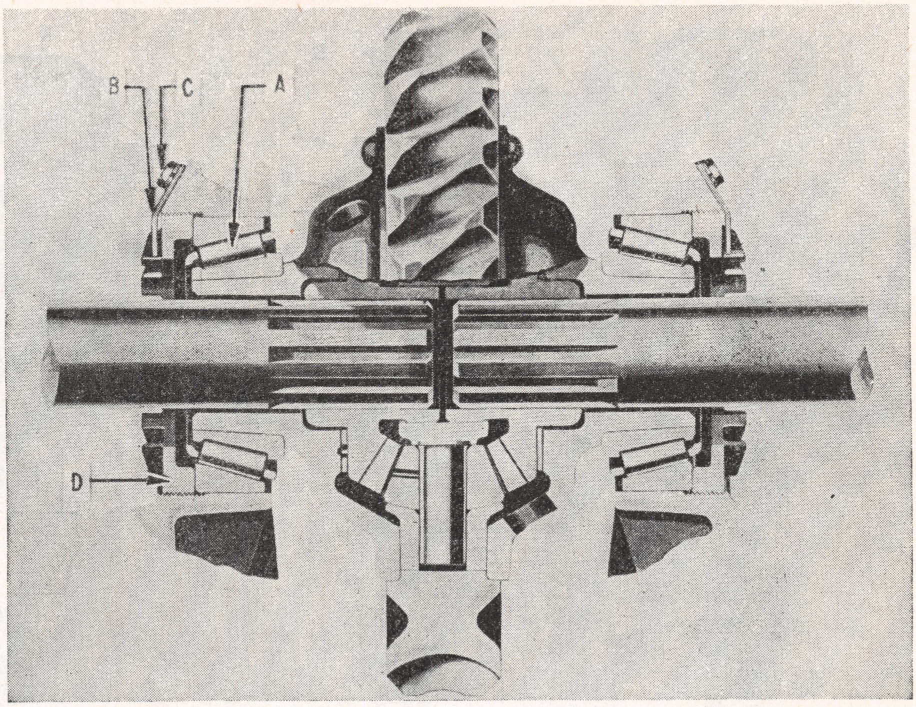
On the type with the cage bolted to the carrier and with a spacer between the front and rear pinion bearings, the pinion cage assembly can be removed from the carrier after the nuts which hold the cage to the front end of the carrier have been removed. Then remove the universal joint flange and the cap at the front of the cage. On some models an adjusting nut is also used which is turned against the front bearing. The bearings should be .000″ to .002″ tight and are adjusted by turning the adjusting nut or universal joint flange against the front bearing. The bearing adjustment is maintained by a lock washer. The pinion can be moved toward or away from the ring gear by removing or adding shims between the pinion cage and the differential carrier.

To remove the pinion cage assembly on the type where the cage is threaded into the carrier assembly remove the clamp bolt which holds the cage lock at the front end of the carrier. The pinion eage with oil seal, bearings and pinion can then be screwed out of the carrier. If it is necessary to remove the pinion or bearings, remove the lock nut, lock washer and adjusting nut from the front of the pinion shaft and press the pinion shaft out of the cage. The rear bearing, nearest the pinion, should be a tight fit on the bearing surface while the front bearing should be a tight sliding fit to permit a bearing adjustment. The bearings should be .000″ to .002″ tight and are adjusted by turning the adjusting nut against the front bearing. No shims are used. The pinion can be moved toward or away from the ring gear by turning the complete cage into or out of the differential carrier.

When the pinion is mounted on a through shaft, the shaft is mounted on two taper roller bearings opposed to each other.

To remove the shaft of this type, first disassemble the covers at either end of the shaft by removing cap screws or stud nuts. Place the carrier in an arbor press with the taper end of the shaft up, then by applying pressure to start it, the shaft and bearings can be pressed out of the carrier. This also removes the bearing cup next to the bevel pinion.

Adjustment of the bearings is obtained by removing or adding shims between the cover and the housing at the tapered end of the shaft. The correct bearing adjustment is .000″ to .002″ tight, or adjusted with a torque wrench to a pull of from 6 to 8 pounds. Make sure the bearings are seated by tapping the end of the shaft before making the final adjustments.



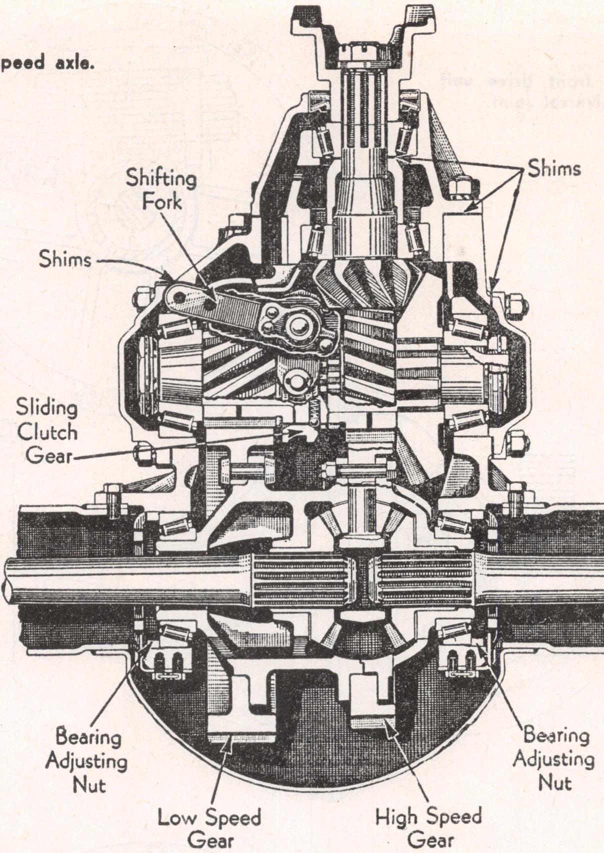
Worm drive differential adjustment.

Cross Shaft and Ring Gear: On one type the cross shaft assembly consists of a pinion, either spur or herringbone, which is an integral part of the shaft and the ring gear which is splined and bolted to a flange on the shaft. The shaft is mounted on taper roller bearings which are held in place by covers which are also cups for the bearings. The ring gear is adjusted with relation to the pinion by transposing shims, between the bearing cover flange and the side of the carrier, from one side of the carrier to the other. Adding or removing shims adjusts bearing play. The position of the gear should be changed after bearing play is adjusted for changing shims from one side to the other will not change bearing clearance. Before the cross shaft can be removed from the carrier the differential assembly must be removed from the carrier. After the differential has been removed, remove both the cross shaft bearing covers from the carrier. Be careful to keep the shims for each side separate so that the original adjustment will not be changed. The cross shaft can now be removed without further disassembly. The ring gear can then be pressed off the cross shaft after removing the cap screws which hold it in place.

Another type of cross shaft assembly consists of a pinion, either spur or herringbone, which is an integral part of the shaft and the ring gear which is splined on the shaft and held in position by a washer fastened to the end of the shaft with two cap screws. The shaft is mounted on taper roller bearings which are held in place by covers which are also cups for the bearings. The ring gear is adjusted with relation to the pinion by transposing shims, between the bearing cover flange and the side of the carrier, from one side of the carrier to the other. Adding or removing shims adjusts bearing play. The position of the gear should be changed after bearing play is adjusted for changing shims from one side to the other will not change bearing clearance. Before the cross shaft can be removed from the carrier the differential assembly must be removed from the carrier. After the differential has been removed, remove both the cross shaft bearing covers from the carrier. Be careful to keep the shims for each side separate so that the original adjustment will not be changed. Then remove the two screws and the washer at the end of the shaft and press the shaft out of the bevel gear while still in the carrier. The cross shaft and ring gear are then removed separately.

On a third type, the bevel gear is pressed on the cross shaft. To disassemble the cross shaft, first remove the differential and gear assembly. Now remove the nuts from the bearing cover, releasing the cover. Now remove the cap screws and lock washer from the end of the cross shaft. Then by inserting puller screws in the tapped holes of the shaft bearing cage and applying pressure, the cage with its bearings can be removed. Keep the bearing shim pack intact with the cage. Now remove the plug from the housing at the other end of the cross shaft. Place the carrier in an arbor press with the bevel gear up. Place a block between the back face of the gear and carrier casting. Then by applying pressure to the cross shaft, the bevel gear which is a journal fit and locked on the shaft with a key, can be pressed off the shaft, at the same time out of the carrier. A lock screw (L) retains the inner bearing sleeve in the carrier, and should not be disturbed unless it is necessary to replace the sleeve. To assemble, reverse this procedure making sure that the spacer (N) is in position and that the bevel gear is pressed up tight against the cross shaft shoulder. A bearing adjustment is obtained by tightening or loosening the cap screws and lock plate at the end of the cross shaft. The correct adjustment is .000″ to .002″ tight. If it is necessary to change the bevel gear tooth contact, add or remove shims between the housing and the eap.

To disassemble another internal gear type remove the stud nuts holding the cap to the housing and then lift off the cap. Now straighten the lock on the cross shaft and remove the nut and lock from the cross



Timken-Wisconsin two-speed axle.

shaft. Then remove the lock ring and jam nut from the shaft. Insert puller screws in the tapped holes of the bearing cage, then by applying pressure, the cage with its bearings will be released from the carrier. Keep the shim pack intact with the cage. Now remove the plug from the other side of the housing and the cap screws from the bevel gear. Place the carrier in an arbor press with the bevel gear up. Insert a block between the bevel gear and carrier casting. Then by applying pressure to the shaft, it can be pressed out of the bevel gear, at the same time out of the carrier. To assemble, reverse this procedure, making sure the internal teeth of the bevel gear are in alignment with the teeth on the cross shaft, and that the bevel gear is pressed up flush on its shoulder. The nut just outside the bearing, adjusts bearing play. It should be .000" to .002" tight. If it is necessary to change the bevel gear tooth contact, add or remove shims between the bearing cage and the carrier.

Differential: Two piece differential cases are used with a large gear, either spur or herringbone, mounted on the differential case. The gear is either bolted or riveted to the differential case with the same bolts or rivets which hold the two piece differential case together. After the bolts or rivets are removed, the large gear can be removed and the differential can be disassembled by hand. When assembling the bolted type, be sure that the heads of the bolts are on the ring gear side of the differential.

When the differential is mounted on taper roller bearings, the bearings are held in adjustment by a nut at the outside of each bearing. Turning both adjusting nuts the same number of turns in the same direction moves the differential to the side but does not affect bearing play. Turning both adjusting nuts the same number of turns but in opposite directions adjusts bearing play but does not move the differential.

When the differential is mounted on ball bearings the bearings are held in position by a lock ring at the outside of each bearing and no adjustment is possible.

When the differential is mounted on straight roller bearings, the bearings are held in position by a lock ring around the center of the bearing outer race and no adjustment is possible.

TIMKEN-WISCONSIN TWO-SPEED AXLE

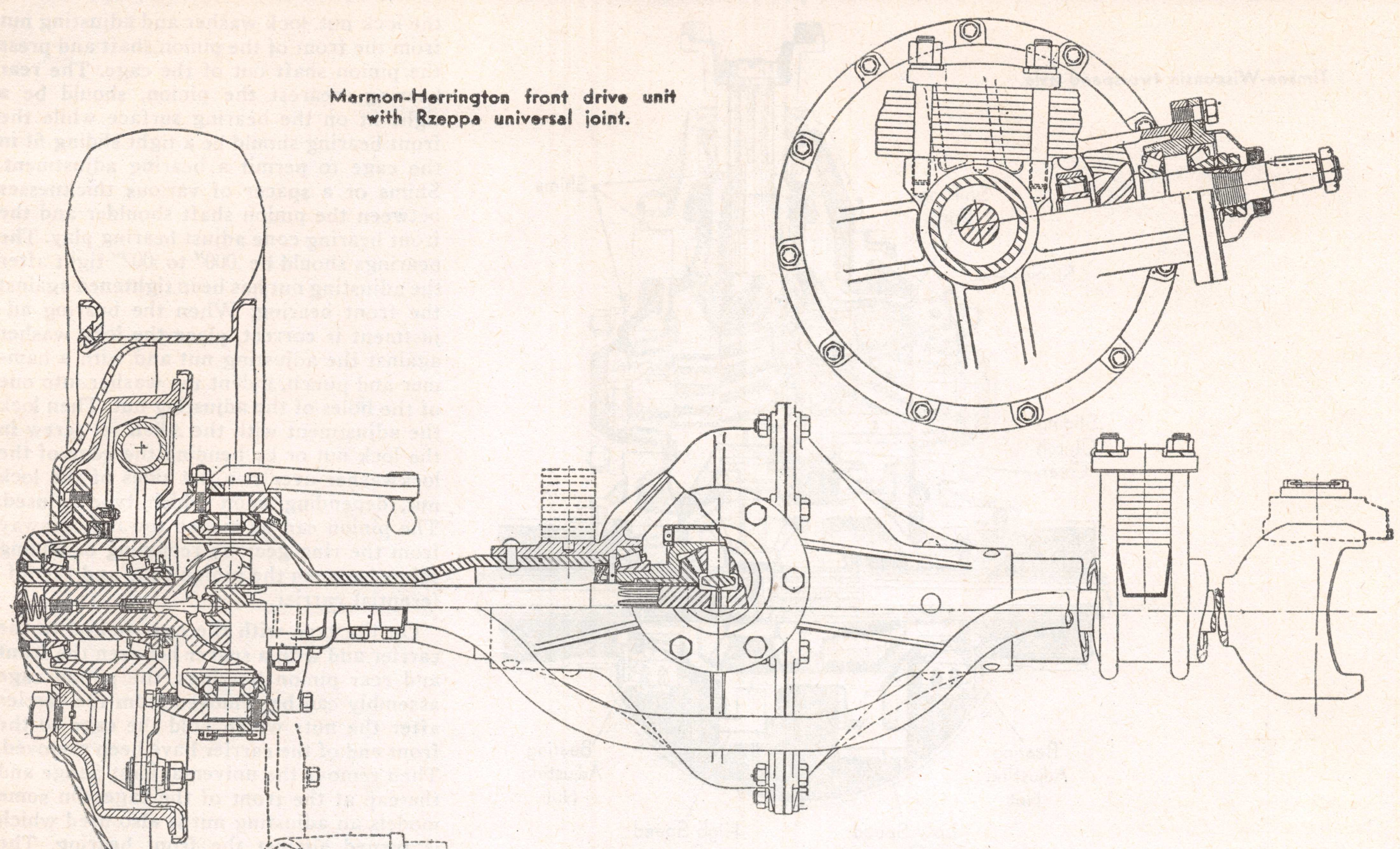
Adjustments to these axles can be divided into three groups; the pinion, the cross shaft or ring gear, and the differential. Various types of construction may be found at these three points but the most common is the one shown above. Those illustrated for the Timken-Wisconsin double reduction axle will cover any combination you might find.

Pinion and Pinion Bearing: On the type with the cage bolted to the carrier and with no spacer between the front and rear pinion bearings, the pinion cage assembly can be removed from the carrier after the nuts which hold the cage to the front end of the carrier have been removed. Remove the cap at the front of the cage. Then remove the lock nut, lock washer and adjusting nut from the front of the pinion shaft and press the pinion shaft out of the cage. The rear bearing, nearest the pinion, should be a tight fit on the bearing surface while the front bearing should be a tight sliding fit in the cage to permit a bearing adjustment. Shims or a spacer of various thicknesses between the pinion shaft shoulder and the front bearing cone adjust bearing play. The bearings should be .000" to .002" tight after the adjusting nut has been tightened against the front bearing. When the bearing adjustment is correct, place the lock washer against the adjusting nut and with a hammer and punch, indent the washer into one of the holes of the adjusting nut. Then lock the adjustment with the Allen set screw in the lock nut or by bending the edge of the lockwasher over two flat sides of the lock nut, depending upon which type is used. The pinion can be moved toward or away from the ring gear by removing or adding shims between the pinion cage and the differential carrier.

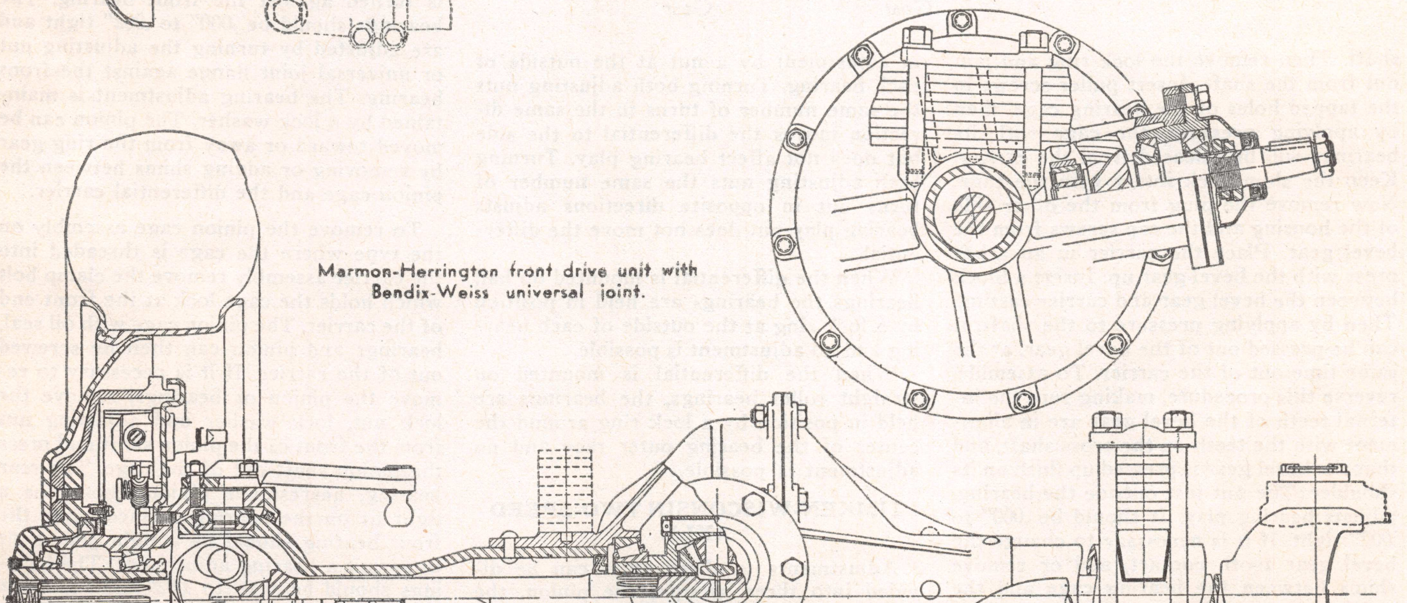
On the type with the cage bolted to the carrier and with a spacer between the front and rear pinion bearings, the pinion cage assembly can be removed from the carrier after the nuts which hold the cage to the front end of the carrier have been removed. Then remove the universal joint flange and the cap at the front of the cage. On some models an adjusting nut is also used which is turned against the front bearing. The bearings should be .000" to .002" tight and are adjusted by turning the adjusting nut or universal joint flange against the front bearing. The bearing adjustment is maintained by a lock washer. The pinion can be moved toward or away from the ring gear by removing or adding shims between the pinion cage and the differential carrier.

To remove the pinion cage assembly on the type where the cage is threaded into the carrier assembly remove the clamp bolt which holds the cage lock at the front end of the carrier. The pinion cage with oil seal, bearings and pinion can then be screwed out of the carrier. If it is necessary to remove the pinion or bearings, remove the lock nut, lock washer and adjusting nut from the front of the pinion shaft and press the pinion shaft out of the cage. The rear bearing, nearest the pinion, should be a tight fit on the bearing surface while the front bearing should be a tight sliding fit to permit a bearing adjustment. The bearings should be .000" to .002" tight and are adjusted by turning the adjusting nut against the front bearing. No shims are used. The pinion can be moved toward or away from the ring gear by turning the complete cage into or out of the differential carrier.

Cross Shaft: The cross shaft is mounted on taper roller bearings and has two rows of spur gear teeth which are integral with the shaft. The ring gear is mounted on splines at the right end of the shaft while the low speed and the high speed helical gears are mounted on the spur teeth of the shaft. The bearing cones, held in place by nuts at the end of the shaft, prevent side movement of



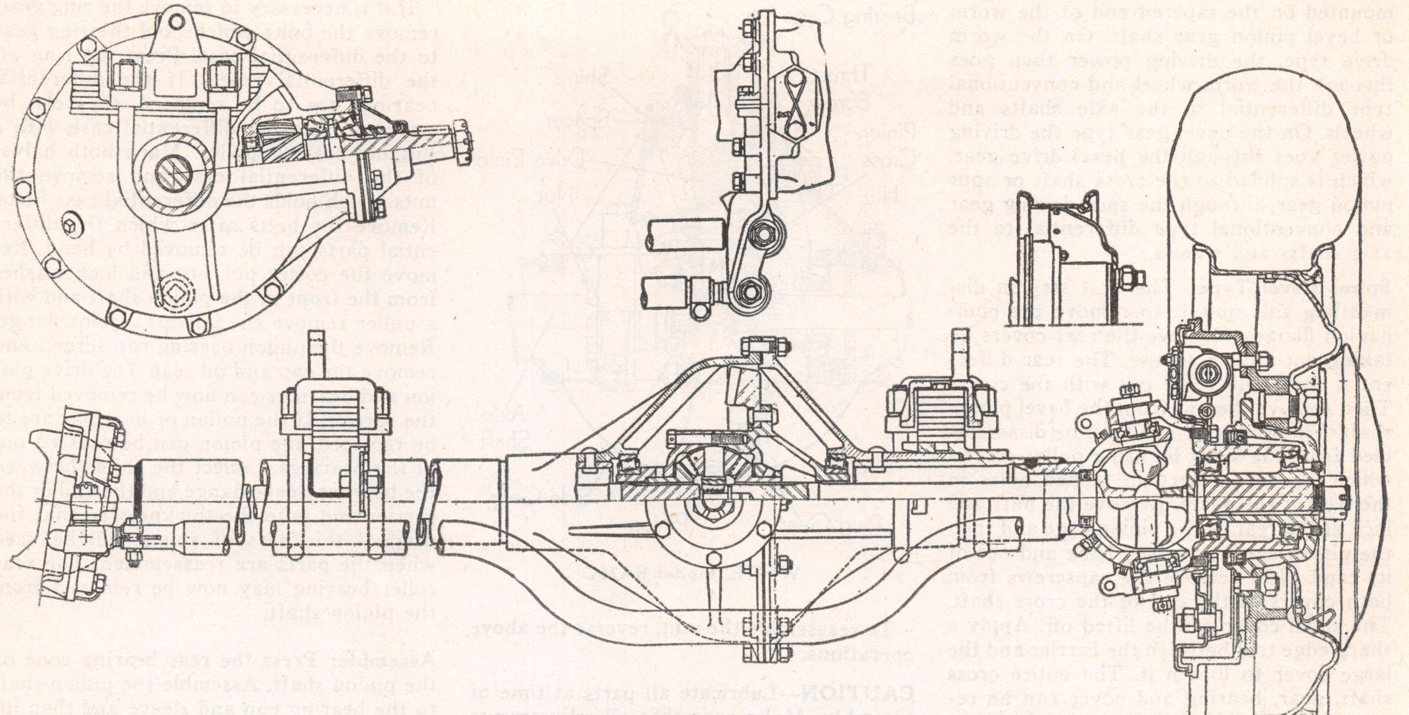
Marmon-Herrington front drive unit with Rzeppa universal joint.



Marmon-Herrington front drive unit with Bendix-Weiss universal joint.

the gears. Bearing caps at each end of the cross shaft hold the bearing cups in the carrier. The thickness of the shims under the bearing caps may be reduced or increased to provide proper gear tooth contact and bearing adjustment as described for the double reduction type of axle.

To disassemble the cross shaft, remove the nuts and lock washers from the bearing caps. A short bar can be used between the back of the bevel gear and the carrier to



Marmon-Herrington front drive unit.

remove the left bearing cap which is piloted to the carrier. The cross shaft can now be removed from the carrier by moving it to the left side of the carrier and pulling toward the rear on the right side. When the right side clears the opening in the carrier, the shaft may be removed from the carrier. The right bearing cap may now be removed from the carrier by tapping from the inside with a soft hammer. The thickness of the shims under each bearing cap should be noted so that the same amount will be used when the shaft is assembled The shifter yoke can be removed from the carrier after the cross shaft is removed.

To disassemble the cross shaft, remove the lock rings from the bearing nuts at each end. The nut at the left side must be removed first, to permit removal of the bearing, low speed gear, shifter sleeve, poppet balls and springs. Clamp the gears machined on the cross shaft in a vise equipped with copper jaws to protect the teeth and remove the bearing nut at the right end of the shaft. Replace the shifter sleeve on the shaft, allowing it to bear against the high speed pinion. Place the assembly in an arbor press with the shifter sleeve supporting the assembly and press the shaft downward through the bearing, bevel gear and high speed gear.

To assemble the cross shaft, install the high speed gear on the splined end of the cross shaft with the spur teeth toward the center. Apply light grease to the inner surface of the gear before installing it on the shaft. Start the bevel gear over the splines and place the assembly in an arbor press with the bevel gear supporting the assembly. Press the shaft into the high speed gear and the bevel gear until it is tight. Press the right bearing cone on the shaft, always pressing against the inner race. Place the machined gear on the shaft in a vise, install the bearing retaining nut and draw it up tight. Lock it in position with the nut locking wire. The shifter sleeve must be installed so that the side marked low side is toward the low speed gear. Install the poppet springs and balls in the shaft and compress the balls. Now install the shifter sleeve so that its three tapered teeth will register with the three poppet balls. It will only fit in one position. Lubricate the inside of the low speed gear and install it on the shaft. Place the left bearing on the shaft and tighten the retaining nut until clearance between the low speed gear and the bearing is .012" to .015". Lock the nut in place with its snap ring.

Install the shifter yoke and thread cross shaft assembly into the left hand bearing opening, at the same time fitting the shifter yoke to the shifter sleeve groove. Install the bearing race in the right side of the carrier and tap it in flush with the carrier. Install the bearing caps, gaskets and shims being careful that the lubrication openings line up. Shims under the bearing caps adjust the position of the bevel gear and bearing play.

Differential: Two piece differential cases are used with the high speed gear, either spur or herringbone, mounted on the differential case. The gear is either bolted or riveted to the differential case with the same bolts or rivets which hold the two piece differential case together. After the bolts or rivets are removed, the high speed gear can be removed and the differential can be disassembled by hand. When assembling the bolted type, be sure that the heads of the bolts are on the ring gear side of the differential. Separate rivets which hold the low speed gear to the left side of the differential case.

When the differential is mounted on taper roller bearings, the bearings are held in adjustment by a nut at the outside of each bearing. Turning both adjusting nuts the same number of turns in the same direction moves the differential to the side but does not affect bearing play. Turning both adjusting nuts the same number of turns but in opposite directions adjusts bearing play but does not move the differential.

When the differential is mounted on ball bearings the bearings are held in position by a lock ring at the outside of each bearing and no adjustment is possible.

When the differential is mounted on straight roller bearings, the bearings are held in position by a lock ring around the center of the bearing outer race and no adjustment is possible.

TIMKEN INTER-AXLE DIFFERENTIAL SPIRAL BEVEL TYPE

The purpose of the inter-axle differential is to divide the torque equally between the forward and rearmost axles, and is used in conjunction with the conventional differential in each axle to compensate for the variations in tire rolling radius.

When an inter-axle differential is used in the driving line, the gearing in the forward axle revolves counterclockwise, due to the power transfer from the differential to main unit. The rear axle gearing is direct and therefore, clockwise rotation is necessary.

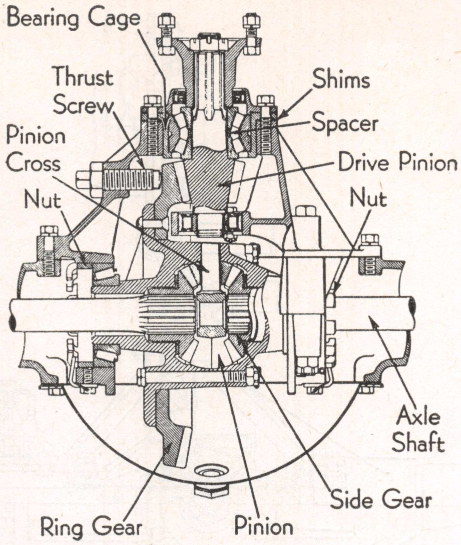
Engine torque is transmitted to the differential drive shafts, then through the inter-axle differential to the side gear, which has a spur gear mounted on its hub. This gear transfers power to the spur gear mounted on the tapered end of the worm or bevel pinion gear shaft. On the worm drive type, the driving power then goes through the worm wheel and conventional type differential to the axle shafts and wheels. On the bevel gear type the driving power goes through the bevel drive gear, which is splined to the cross shaft or spur pinion gear, through the spur driving gear and conventional type differential to the axle shafts and wheels.

Spiral Bevel Type: The first step in dismantling this unit is to remove the companion flanges. Remove the rear covers by taking out all cap screws. The rear differential shaft will come out with the cover. Then remove the nut from the bevel pinion shaft. The spur gear can then be disassembled from the shaft by using puller screws which can be inserted in tapped holes in the web of the gears. Remove the nuts and lock at the rear of the pinion cage and then the pinion can be pressed back and out of its cage. Now remove the capscrews from both covers at the end of the cross shaft. The small cover can be lifted off. Apply a sharp edge tool between the carrier and the large cover to loosen it. The entire cross shaft, gear, bearing and cover can be removed leaving the inner bearing in place. By removing the lock at the inner bearing, the bearing can be removed. The bevel pinion can now be pressed out of its bearing, leaving the bearing cage assembled in the carrier. Remove the differential and spur gear assembly. The cover, nuts, and lock can then be removed from the front of the shaft. The inter-differential can then be pressed back and out of the bearing and removed through the rear of the carrier.

TIMKEN INTER-AXLE DIFFERENTIAL

WORM DRIVE TYPE

Disassemble: The first step in dismantling this unit is to remove the companion flanges. Then take out the conventional type differential and drive gear assembly. Remove the rear cover by taking out its cap screws. This cover is included in a sub-assembly consisting of the differential rear shaft with double taper roller bearing and retainer. Next remove the nut from the rear of the worm shaft and remove the spur gear with a puller which can be attached in tapped holes in the web of the gear. Now remove the cover and retainer assembly at the front of the differential shaft by taking out the cap screws. Straighten the bearing nut locking washer and remove the bearing adjusting nuts, after which the inter differential sub-assembly can be taken out through the rear bore of the carrier. Remember that the outer bearing slides off the inter-differential shaft, while the inner bearing remains with the sub-assembly. Start removal by tapping on the end of the shaft with a soft hammer. Then remove the cover from the front of the worm by removing the stud nuts. By tapping the tapered end of the worm shaft with a soft hammer, the worm shaft with bearings can be removed through the forward bore of the carrier housing.



WHITE. Model RA25C

To reassemble the unit, reverse the above operations.

CAUTION—Lubricate all parts at time of assembly. Make sure that all adjustments are securely locked. Set the spur or bull gear flush with its pinion. Make sure all gaskets are in place. Make sure that all bearings are a tight fit on their shaft and that the cups are not loose in their cages. Oil seals must be in good condition. All cap screws and stud nuts must be tight. Make sure that companion flanges are drawn up on the tapered ends of the inter-axle differential shafts. If a plug is provided in the pinion bearing cage, pour one pint of oil through the plug hole to insure immediate lubrication of the pinion bearings. When replacing or renewing lubricant in the forward axle, pour the lubricant through the filler hole in the top of the carrier directly above the inter-axle differential.

WHITE

MODEL RA-25C

Full Floating Axle with Three Pinion Differential, Riveted Ring Gear and Straddle Mounted Ring Gear.

Disassemble: Disconnect the propeller shaft from the pinion shaft flange. Remove the axle shaft flange nuts and pull out the axle shafts. Straighten the tabs on the wheel bearing lock washers and remove the lock nuts, washers and adjusting nuts, after which the hubs may be removed. Remove the cap screws which fasten the differential carrier to the axle housing and remove the carrier assembly. Before removing any parts, mark both differential bearing adjusting nuts and caps to indicate on which side each is mounted and also its location in the carrier so that they can be assembled with approximately the same drive gear adjustment. Remove the differential bearing cap screws and lift off the caps. Loosen the thrust block lock screw on the side of the differential carrier. Lift out the differential and ring gear.

If it is necessary to remove the ring gear, remove the bolts which hold the ring gear to the differential case. Press the ring off the differential case. If the differential bearings are to be replaced, they can be removed from the differential case with a suitable bearing puller. Mark both halves of the differential case and remove the nuts which holds the differential case bolts. Remove the bolts after which the differential parts can be removed by hand. Remove the cotter pin, nut and lock washer from the front of the pinion shaft and with a puller remove the universal joint flange. Remove the pinion bearing cap screws and remove the cap and oil seal. The drive pinion and bearings can now be removed from the carrier. If the pinion or bearings are to be replaced, the pinion can be pressed out of the bearings. Collect the shims between the bearing sleeve flange and the end of the carrier and note the thickness so that the original thickness of shims will be used when the parts are reassembled. The rear roller bearing may now be removed from the pinion shaft.

Assemble: Press the rear bearing cone on the pinion shaft. Assemble the pinion shaft to the bearing cup and sleeve and then install the bearing spacer and front bearing cone on the pinion shaft. Tighten the companion flange in place on the pinion shaft. The bearing sleeve is a snug sliding fit in the housing to permit its movement when making adjustments. Play can be taken up by grinding down the spacer between the bearing cones or by installing a shorter spacer and shims. Assemble the differential case, using new thrust washers and lubricate all parts before assembling them. Before bolting the halves of the differential case together, be sure to align the marks which were made before the case was disassembled. After the case is securely fastened, be sure to lock the nuts in place. Assemble the drive pinion and bearings with sleeve, to the carrier, using the original shims between the end of the carrier and the sleeve flange. Assemble the drive pinion and bearings to the carrier housing, using the original shims between the bed of the carrier and the bearing cup flange. Replace the bearing cap and oil seal and tighten the companion flange in place, using a cotter pin in the nut to hold it in position. Assemble the differential and bearings assembly in the carrier housing. Replace the bearing adjusting nuts and the bearing caps, and tighten the caps in position. Turn the adjusting nuts until the marks on them indicate that they are in their original position. Then tighten the bearing cap screws and adjusting screw locks.

There should be no play in the differential bearings. If an adjustment is necessary, tighten the bearing adjusting nuts with sufficient force to seat the bearing cups solidly against the rollers. Back off the adjusting nuts to relieve strain and tighten them again slightly against the bearing cups. Loosen the right adjusting nut and tighten the left nut, at the same time turning the ring gear, until all lash is removed.

Then back off the left nut one turn. Tighten the right nut until it is snug and continue for one or two more notches, until a locking position is reached.

Check the tooth contact and if it is necessary to move the ring gear away from the pinion tighten the right nut and loosen the left nut an equal number of notches until the contact is correct. If the ring gear must be moved toward the pinion, tighten the left nut and loosen the right nut an equal number of notches. By turning both nuts the same amount, the bearing play will not be changed. The pinion can be moved toward or away from the ring gear by changing the thickness of the shims between the pinion bearing sleeve flange and the end of the carrier. Adding shims moves the pinion away from the ring gear and reducing the thickness of the shims moves the pinion toward the ring gear.

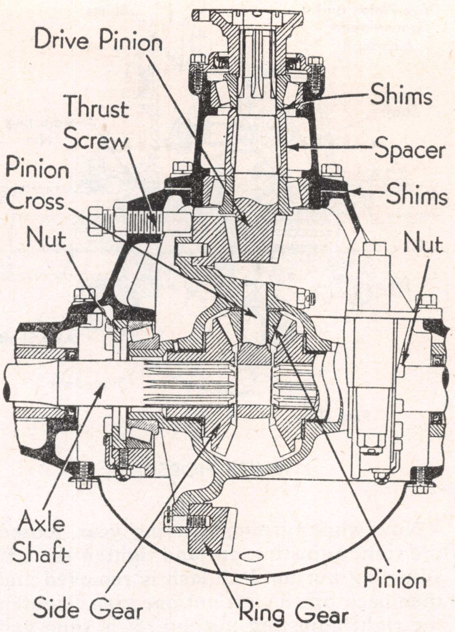
When this adjustment is completed, turn the thrust block screw in until it contacts the ring gear and then back it off just slightly. The clearance between the ring gear and the thrust block should be .010" to .012".

Assemble the carrier to the housing, using a new gasket and tighten the cap screws securely, using new lockwashers under the screws. Lubricate the wheel bearings and assemble the hubs, bearings and adjusting nuts, using new oil seals. Adjust the bearings by tightening the bearing adjusting nuts until the wheel binds and then back them off just enough to permit the wheel to turn freely without end play. Install the axle shafts and tighten the flange nuts securely. Complete the assembly by attaching the universal joint flanges.

MODEL RA-20C

Full Floating Axle with Three Pinion Differential, Riveted Ring Gear and Drive Pinion Mounted on Two Taper Roller Bearings.

Disassemble: To remove the axle shaft, remove the axle drive flange screws. Pull out the shaft. Straighten the tabs on the wheel bearing lockwashers and remove the lock nut, washer and adjusting nut, after which the hub may be removed. Remove the cap screws which hold the differential carrier assembly to the axle housing. Lift out the differential carrier. Before removing any parts, mark both differential bearing adjusting nuts and caps to indicate on which side each is mounted and also its location in the carrier so that they can be assembled with approximately the same drive gear adjustment. Remove the differential bearing cap screws and lift out the caps. Lift out the differential and ring gear assembly. With a puller, remove the differential bearings. To disassemble the ring gear from the case, remove the lock wire and the screws which hold the ring gear in place. Press the ring gear off the differential case.



WHITE. Model RA20C

Mark both halves of the differential case so that they can be assembled in their original position and remove the nuts from the differential case bolts. Remove the bolts, after which the differential parts can be removed by hand. Remove the cotter pin, nut and washer from the front of the pinion shaft and with a puller, remove the universal joint flange. Remove the pinion bearing cap screws and remove the cap and oil seal. Remove the bolts holding the pinion shaft housing to the differential carrier housing and lift out the pinion and its housing. If the pinion or bearings are to be replaced, the pinion can be pressed out of the bearings. If it is necessary to replace the pinion or the rear bearing the pinion can be pressed out of the rear bearing cone. Both bearing cups can be removed from the housing with a bearing puller. Loosen the ring gear thrust screw lock nut at the side of the carrier housing and remove the screw.

Assemble: Press the rear bearing cone on the pinion shaft. Assemble the bearing cups in the pinion shaft housing, if they have been removed. Then install the pinion in its housing and slide the spacer and front bearing cone on the shaft. Replace the bearing cap and oil seal on the pinion housing and tighten its fastening screws. Then tighten the companion flange in place to take up play in the bearing. Assemble the differential case, using new thrust washers and lubricate all parts before assembling them. Before bolting the halves of the differential case together, be sure to align the marks which were made before the case was disassembled. After the case is securely fastened, be sure to lock the nuts in place. Lubricate the differential bearings and press them in the differential case.

Assemble the drive pinion and housing to the differential carrier with a new gasket and tighten the bolts. Assemble the differential assembly and bearings in the carrier in the housing. Replace the bearing adjusting nuts and the bearing caps and tighten the caps in position. Turn the adjusting nuts until the marks on them indicate that they are in their original position. Then tighten the adjusting nut locks. There should be no play in the differential bearings. If an adjustment is necessary, tighten the bearing adjusting nuts with sufficient force to seat the bearing cups solidly against the rollers. Back off the adjusting nuts to relieve strain and tighten them again slightly against the bearing cups. Loosen the right adjusting nut and tighten the left nut, at the same time turning the ring gear, until all lash is removed. Then back off the left nut one turn. Tighten the right nut until it is snug and continue for one or two more notches, until a locking position is reached.

Check the tooth contact and if it is necessary to move the ring gear away from the pinion, tighten the right nut and loosen the left nut an equal number of notches until the contact is correct. If the ring gear must be moved toward the pinion, tighten the left nut and loosen the right nut an equal number of notches. By turning both nuts the same amount, the bearing play will not be changed. The pinion can be moved toward or away from the ring gear by shims between the differential carrier and the pinion shaft housing. Removing shims moves the pinion toward the ring gear and increasing the thickness of the shims moves the pinion away from the ring gear. When this adjustment is complete turn the thrust screw in until it contacts the ring gear and then back it off just slightly. The clearance between the ring gear and the thrust block should be .010" to .012".

Assemble the carrier to the housing, using a new gasket and tighten the cap screws securely, using new lock washers under the screws. Lubricate the wheel bearings and assemble the hubs, bearings and adjusting nuts. Use new oil seals. Adjust the bearings by tightening the bearing adjusting nuts until the wheel binds and then back them off just enough to permit the wheel to turn freely without end play. Install the axle shaft and tighten the flange nuts securely. Complete the assembly by attaching the universal joint flange.

WHITE-HORSE

Two Pinion Differential with Riveted Ring Gear and Straddle Mounted Drive Pinion at End of Transmission Shaft.

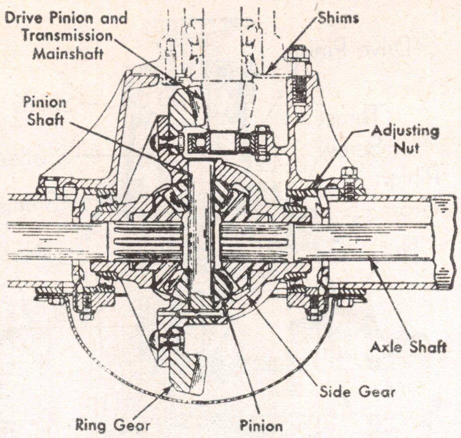
NOTE—The drive pinion shaft is integral with the transmission mainshaft and if the shaft is to be removed, see the "Transmission" chapter for instructions.

Disassemble: After removing the assembly from the chassis, remove the axle shaft flange nuts and pull out the shafts. Remove the wheel bearing nuts and washers and remove the hubs. Take off the differential inspection cover. Remove the cap screws which fasten the transmission case to the differential carrier and separate the two units.

NOTE—Be sure to collect the shims which are located between these two housings as they control the relationship between the ring gear and pinion tooth contact. Remove the cap screws which fasten the carrier to the axle housing and withdraw the carrier. Remove the differential lock pin and pull out the differential shaft. All the differential parts are now loose and can be removed by hand. If the ring gear is to be replaced, use a drill which is smaller in diameter than the rivet and drill the rivets from the differential case side, then punch them out.

Assemble: Lubricate the differential side gears, pinions and thrust washers and assemble these parts in the differential case. Push in the differential shaft, lining up the hole in the shaft with the hole in the case, then install the lock pin. Locate the differential case in the carrier and install the bearing caps and adjusting nuts, tightening the cap screws until the lock washers just flatten out.

NOTE—If new parts were installed or an adjustment is necessary, the adjusting nuts should be tightened with sufficient force to drive the bearing cups solidly against the rollers. Then back off the adjusting nuts to relieve the strain and tighten them again slighty against the bearing cup.

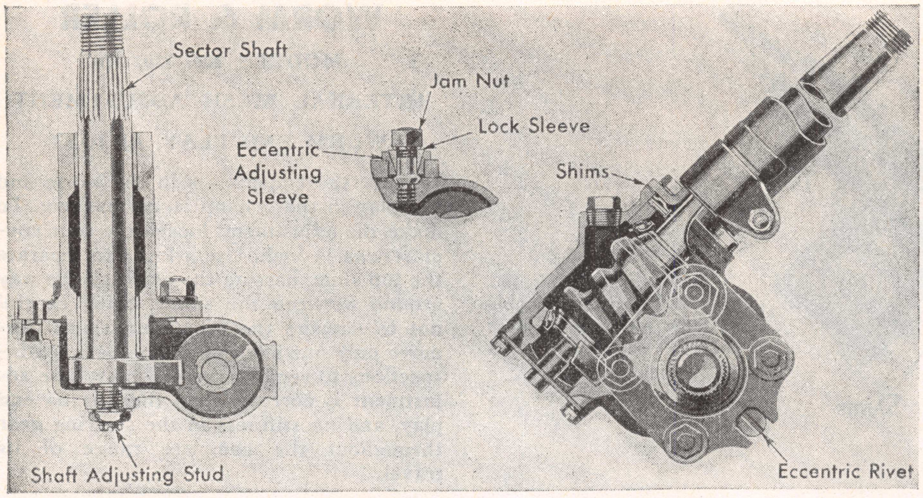


WHITE HORSE

Now while turning the ring gear, loosen the right adjusting nut and tighten the left adjusting nut until all lash is removed and then back off the left nut one turn. Tighten the right adjusting nut until it is snug and continue for one or two notches more, or until a locking position is reached. Assemble the carrier to the transmission, installing the shims between the two housings and fasten the housing securely together.

Check the relationship between the ring gear and pinion tooth contact and if the drive pinion is too deep in the ring gear, install the required thickness of shims between the two housings. Similarly, if the pinion is not deep enough, remove the necessary shims. When the correct tooth contact is established, check the backlash. Mount a dial indicator on the carrier and check the backlash between the ring gear and pinion, which should be about .007". If the backlash exceeds this amount, loosen the right adjusting nut one notch and tighten the left nut one notch. If the backlash is less than specified, loosen the left nut one notch and tighten the right nut one notch. Now tighten the bearing cap lock screws securely and recheck the lash. When correct, install the adjusting nut locks and lock the adjustment.

Assemble the carrier in the axle housing, using a new gasket and lockwashers under the cap screws, being sure to draw up the cap screws evenly and securely. Lubricate the wheel bearings and assemble the hubs, bearings and adjusting nuts, using new oil seals. Adjust the bearings by tightening the adjusting nut until the wheel binds, then back off just enough to permit the wheel to turn freely, yet without end play. Install the axle shafts and tighten the stud nuts securely.



GEMMER. Models 120, 140. Worm and three-tooth sector.

STEERING GEARS

Before making an adjustment for play or binding in the steering gear, jack up the front wheels and make sure that the complaint is not due to some other cause. Do not make adjustments in the steering gear to correct any erratic action of the front wheels, as evidenced by wheel shimmy or steering wheel fight. If these conditions exist, check the tires for proper inflation and see that the camber, caster and toe-in are according to specifications. Shock absorber tension or adjustment should be according to the recommended standard. Tie rod and drag link sockets or connections should also be adjusted to the correct tension and freedom. Make sure that the pitman arm is tight on the cross shaft and that its lockwasher and nut are tight also.

End play in the worm (or cam) shows up as play in the steering tube, indicated by up and down movement of the steering wheel. When this adjustment is correct, the steering wheel should turn freely with the thumb and forefinger lightly gripping the steering wheel rim, and without any up and down movement of the column tube. If end play is less than .010", no adjustment is required.

To correct misalignment of the steering column, loosen the frame bracket bolts enough to allow the gear to shift, and to line up at the angle determined by the setting of the steering column bracket at the instrument board. Then tighten the frame bracket bolts. Now, loosen the instrument board bracket and allow it to match the position of the steering column, and then tighten the bracket. If the bracket is of the single-position type, change the bracket to the position of the steering column. Do not spring the column to the bracket.

To locate the steering gear in its central position, turn the steering wheel from one extreme to the other and count the number of turns required. Now, turn the steering wheel just one-half the distance of the total movement. Most steering wheels have a trade mark, or depression, on the under side of the spoke that should point directly up or down, whichever location is nearest when the steering gear is in its central position.

While making any adjustment, free the steering gear of any load by disconnecting the drag link from the pitman arm.

When the adjustment is completed, the gear should be free from backlash in its straight-ahead position, and must be free to move throughout its complete travel without binding at any point. Now, turn the steering wheel to its central position and place the front wheels in their straight-ahead position. It should be possible to connect the drag link to the ball end of the pitman arm, without moving the steering gear any appreciable amount. If this cannot be accomplished, remove the pitman arm from the steering gear cross shaft and place it on the splines in the correct position. If this is not done, the front wheels will not be able to swing equally to the right and left.

GEMMER WORM & SECTOR

MODELS 120, 140, 170

WORM END PLAY, ADJUST

Loosen the jacket clamp bolt and move the clamp up about 3/8" above the lower end of the jacket. Loosen the instrument board bracket clamp from the column jacket. Work the jacket down until its lower end is against the steering gear housing cap. Remove the housing cap screws and work the jacket up, until it is stopped by the bottom of the steering wheel recess. There should now be 3/8" clearance between the top of the housing and the housing cap, which will permit the removal of the adjusting shims.

Use a knife to separate the top shim, passing the blade all the way around between the shims, using care to avoid damage to the remaining shims. Now, cut the shim near one of the holes—on an angle—and remove.

Reverse the operations to assemble, being careful to locate the column jacket so the top end will clear the bottom of the steering wheel recess, thus preventing friction at this point. Locate the jacket clamp as near to the bottom end of the jacket as possible.

CROSS SHAFT END PLAY, ADJUST

See that the housing cover nuts and the eccentric sleeve jam nut are tightened securely. Turn the steering wheel to either extreme position and then back an eighth of a turn. Gripping the pitman arm at the hub, the cross shaft should rotate freely without any end play. Adjust as required by means of the adjusting screw at the side of the housing, next to the engine. Be sure to lock securely with the lock nut, after which, re-inspect for end play and freedom of the steering gear throughout its range.

WORM & SECTOR MESH, ADJUST

Turn the steering gear to the central position of its complete travel (drag link disconnected). Place the marked spoke of the steering wheel in the correct position and shake the pitman arm to determine the amount of lost motion.

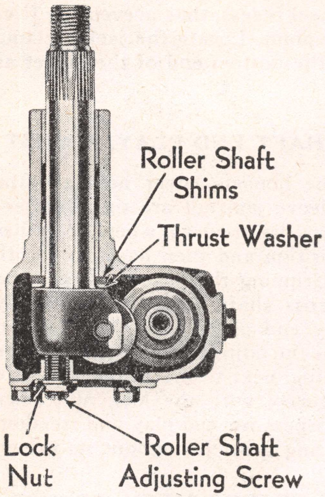
Loosen the housing cover nuts 1/4 turn, and the eccentric sleeve jam nut 1/2 turn. Turn the eccentric adjusting sleeve very slowly, checking at each movement, the amount of lost motion still existing at the pitman arm. Adjust to the point where the lash can just be felt at the end of the pitman arm, being sure to finish the movement of the eccentric sleeve in the clockwise direction. Turn the steering wheel throughout its full travel to check for free operation. If it is too tight, turn the eccentric sleeve in a counter-clockwise direction until the gear is free, and make the adjustment again more carefully. Tighten the eccentric sleeve jam nut securely first, and then, tighten the housing cover nuts.

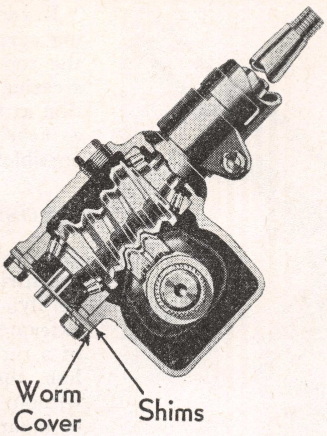
TOOTH CONTACT, CENTRALIZE

The worm is machined in such a manner that close mesh with the sector teeth is provided at the central position. This corresponds to the straight-ahead driving range, with gradual relief toward the extremes of the worm. Since any normal wear is more pronounced at the central position, this provision allows for subsequent adjustment without fear of binding toward the extremes.

When the sector teeth are properly centralized in relation to the worm thread, there should be an equal amount of lash in the mesh of these parts at 1/3-turn of the steering wheel at each side of the central position. If this is not the case, the sector shaft can be shifted to either side of the central position of the worm by means of an eccentric rivet adjustment, which is located at the lower portion of the cross shaft cover.

In making this adjustment, the check must start with the sector shaft teeth meshed at the central position of the worm.





GEMMER. Models 300, 330. Worm and double roller with internal mesh adjustment.

The central position is found by turning the steering wheel to the central position of its complete travel and locating the marked spoke of the wheel as previously described.

Turn the steering column 1/3-revolution to the right and shake the pitman arm, noting the amount of play at this point. Now, turn the steering column 2/3-revolution to the left—which is really 1/3-revolution to the left of the central position—and shake the pitman arm. The lash at this position should be the same as when turned to the right of center. If there is more lash at the left position, turn the eccentric rivet slightly in a counter-clockwise direction. If the lash is more at the right, turn the rivet in a clockwise direction.

After these positions have been equalized, adjust for proper mesh of the shaft teeth in the worm as described under WORM & SECTOR, MESH. After making the final adjustment, tighten the eccentric sleeve jam nut securely, and then, the housing cover nuts. Be sure to tighten the sleeve jam nut first.

STEERING GEAR, OVERHAUL

Disassemble: Remove the housing cover and sector shaft by removing the three cover nuts, the eccentric sleeve jam nut and the eccentric sleeve. Unscrew the nuts from the studs which hold the worm shaft upper bearing to the housing, and remove the housing cap and shims—which will permit the withdrawal of the worm and tube assembly. Remove the lower bearing cage. Inspect all parts.

Inspection: The bearing rollers and races must be free from pits and wear. The pressure faces of the worm, as well as the sector teeth, should be polished, but should show no irregular wear. The sector shaft and its bearings should not be scored, and the bearings should fit on the sector shaft without appreciable radial looseness. Make sure that the main tube is not bent.

NOTE—A used worm can be fitted to a new main tube, but, if the worm is to be replaced, a new tube must also be replaced, as it cannot, again, be pressed on the used tube, and held securely.

Assemble: Press the lower worm bearing cup into the housing. Lubricate the worm lower bearing cage with gear oil and install it into position. Replace the worm and tube, and assemble the upper bearing cage, bearing cup and spacer. The balance of the assembly is contained in the adjustments already described.

Lubrication: Remove the steering gear housing plug and the vent hole cover. Fill the housing with approved lubricant until it comes out of the vent. Replace the plug and the vent cover to prevent dirt from entering the housing. Avoid the use of graphite, white lead or heavy solidified oil.

WORM & ROLLER

MODELS 300, 330, 370

INTERNAL MESH ADJUSTMENT

WORM END PLAY, ADJUST

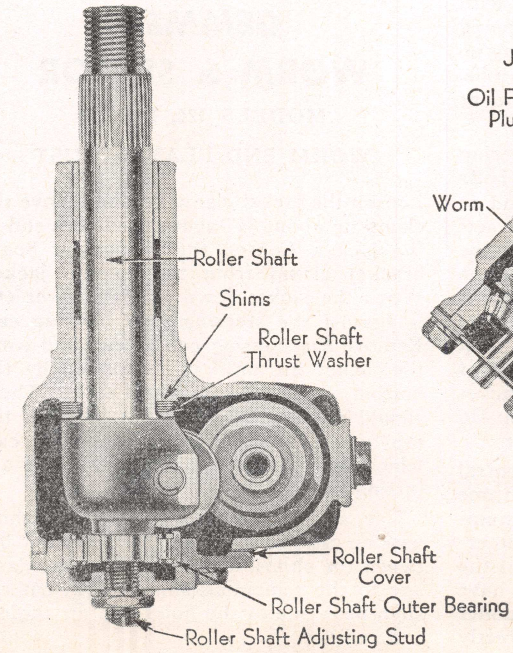
Be sure the end play is in the worm and not play in the column jacket bushing. To make the adjustment, loosen the four cover screws ⅛ inch. Use a knife to separate the top shim, passing the blade all the way around between the shims, being careful not to damage the remaining shims. Remove only one shim at a time between inspections to remove the end play. The adjustment is correct when there is no end play, and no stiffness in the steering gear throughout the complete range of its travel.

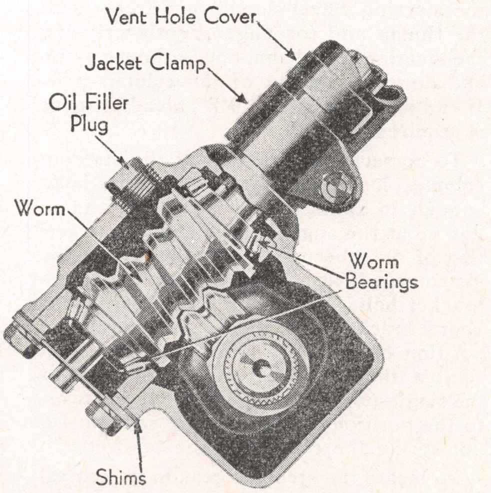
ROLLER SHAFT END PLAY, ADJUST

Turn the steering wheel to either extreme, and then, back ⅛ of a turn. Gripping the pitman arm at the hub, the roller shaft should rotate freely without a particle of end play. If end play exists, adjust as required by means of the roller shaft adjusting screw located at the back of the housing. Be sure to tighten the lock nut securely and then, re-inspect for end play and free rotation throughout the entire range of the steering gear.

WORM & ROLLER MESH, ADJUST

This adjustment should never be made without first correcting the roller shaft and column adjustments. Proceed as follows: Turn the steering wheel to the central position of its complete travel (drag link disconnected) and shake the pitman arm to determine the amount of lost motion. If this motion exceeds 1/32", roller shaft adjustment should be made, in which


Roller Shaft
Shims
Roller Shaft Thrust Washer
Roller Shaft Cover
Roller Shaft Outer Bearing
Roller Shaft Adjusting Stud



GEMMER. Models 330, 370. Worm and double roller with straddle-mounted shaft and internal mesh adjustment.

case, the steering gear should be removed from the vehicle.

Place the gear assembly in a vise with the column in a position to the right of the vise. Remove the roller shaft, using care to see that all the shims remain on the shaft. This will prevent them from dropping into the housing behind the worm, which may cause interference with proper gear operation.

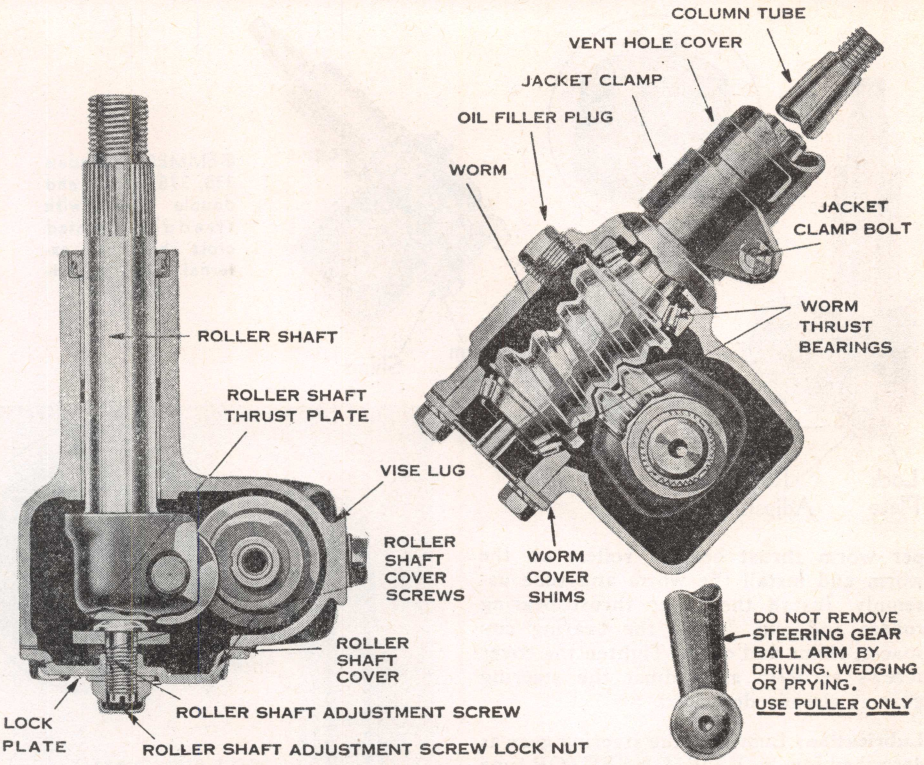
Remove the column jacket and replace the steering wheel on the tube. If proper worm bearing adjustment has not been made, re-adjust as already described. Note that the roller shaft thrust washer is assembled with the chamfered side next to the roller shaft thrust face.

To make the adjustment, remove shims which are in place behind the roller shaft thrust washer. The position of the roller contact with the worm is offset from the center line of the worm, therefore, when a shim is removed, the roller is moved into closer mesh with the worm.

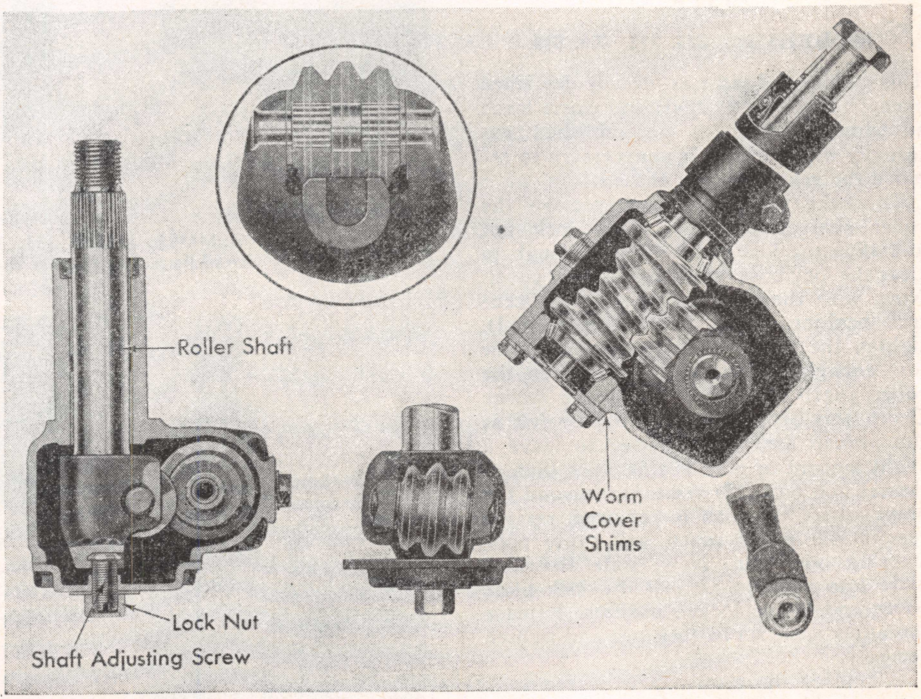
Select, through trial, the proper amount of shims to produce not more than .006" play, measured at the end of the pitman arm, and without heavy drag at the steering wheel. Remove only one shim from the roller shaft, and insert the shaft in the housing. Then, turn the steering wheel nearly all the way to the left stop. Hold the roller shaft in place with thumb pressure on the head end of the roller shaft, and revolve the steering wheel to the right, until the shaft roller is in the center of the worm. (Do not reverse the turn to the left.) While still holding the roller shaft in place, grip the splined end of the shaft with the other hand and try to rotate it. If any play exists, remove another shim, and repeat the operation until play by hand in the center of the gear is removed.

When the proper amount of shims have been selected, turn the steering wheel close to either extreme, and re-assemble the shaft roller cover and tighten the screws securely. Assemble the pitman arm on the roller shaft. Now, loosen the roller shaft adjustment screw lock nut and tighten the screw until all end play in the roller shaft has been removed, when the shaft is rotated in this lash position, close to the end of the worm. Tighten the lock nut securely and re-inspect the gear for freedom of operation throughout, and at the same time, being sure that no end play exists in the roller shaft.

When reassembling the jacket on the gear, use nothing but castor oil to lubricate the column jacket bushing. Be sure to align the gear in the vehicle as already described.


COLUMN TUBE
VENT HOLE COVER
JACKET CLAMP
OIL FILLER PLUG
WORM
JACKET CLAMP BOLT
WORM THRUST BEARINGS
ROLLER SHAFT
ROLLER SHAFT THRUST PLATE
VISE LUG
ROLLER SHAFT COVER SCREWS
WORM COVER SHIMS
DO NOT REMOVE STEERING GEAR BALL ARM BY DRIVING, WEDGING OR PRYING. USE PULLER ONLY
ROLLER SHAFT COVER
ROLLER SHAFT ADJUSTMENT SCREW
LOCK PLATE
ROLLER SHAFT ADJUSTMENT SCREW LOCK NUT

GEMMER. Models 305, 335. Worm and double roller with single bearing cross shaft and external mesh adjustment.


Roller Shaft
Lock Nut
Shaft Adjusting Screw
Worm Cover Shims

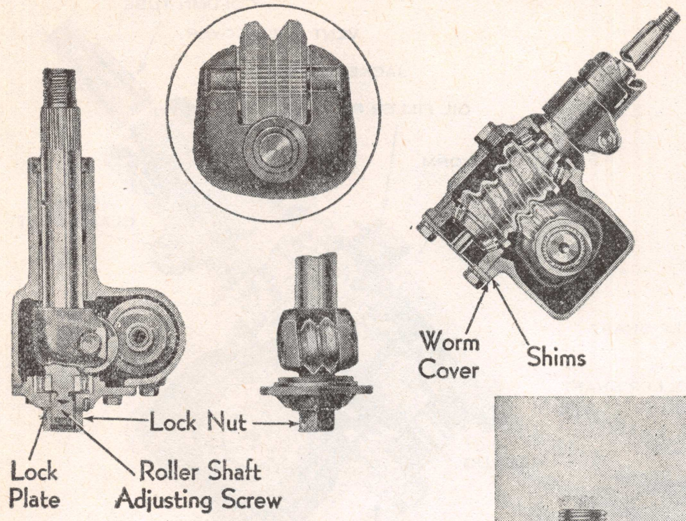
GEMMER. Model 335. Worm and triple roller with single bearing cross shaft and external mesh adjustment.

STEERING GEAR, OVERHAUL

Disassemble: Remove the roller shaft cover screws and the cover plate and gasket. Take out the roller shaft, its thrust washer and shims. Remove the worm cover plate screws, cover plate and shims. Push the column tube out of the bottom of the housing, which will release the lower thrust bearing cup, spacer cup, rollers and the worm upper thrust bearing rollers. Pull the upper bearing cup.

Inspection: If the roller bushings are worn, replace the housing assembly. If the roller shaft is worn or scored, it should be replaced. If the roller is worn, or if the bearing is worn or loose, replace the shaft and roller assembly. If the worm is worn, the worm and tube should be replaced. If the column tube is worn or bent, it should be replaced. Before re-assembling, dip all wearing surfaces into steering gear lubricant.

Assemble: Install the upper worm thrust bearing cup in the housing. Place the up-



GEMMER. Models 335, 375. Worm and double roller with straddle-mounted cross shaft and external mesh adjustment.

per worm thrust bearing rollers on the worm and install the worm and tube assembly. Install the lower thrust bearing rollers and cup. Install the bearing cup spacer, shims and cover. Tighten the cover screws securely and adjust the steering gear as already described.

Lubrication: Lubricate the steering gear as described for the WORM & SECTOR type and adhere to the same precautions.

EXTERNAL MESH ADJUSTMENT TYPE

MODELS 305, 335, 375, 400, 500

This gear is the same as already described except for the roller shaft and worm mesh adjustment, which is accomplished externally which makes it unnecessary to remove the gear from the chassis.

To make the adjustment, remove the roller shaft adjustment screw lock nut and slide the lock plate off far enough to clear the lock boss on the roller shaft cover. Now, with the steering wheel in its central position (drag link disconnected), tighten the roller shaft adjustment screw just enough to remove play between the roller shaft roller tooth and the worm. Check this by the amount of play felt at the pitman arm. It is better to leave a slight amount of play at this point than to tighten too much. If tightened beyond the point where the lash is removed, serious results will occur which will cause poor steering operation. Now, slide the lock plate into position against the lock plate cover and in the locked position. Replace the adjustment screw lock nut and tighten securely.

Whenever the pitman arm is removed, use a suitable puller, as any other means of removal will cause damage to the adjustment parts.

MACK

WORM & SECTOR PLATE

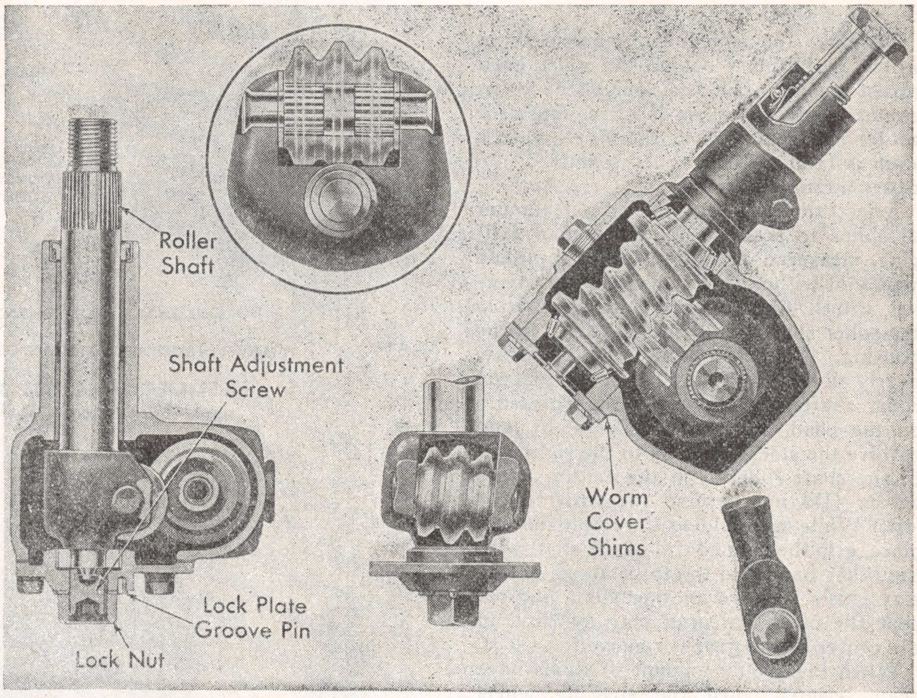
MODEL SG-12

NOTE—When making adjustments, disconnect the drag link from the pitman arm to free the steering gear of all load, and loosen the instrument board bracket clamp on the steering column. Always adjust the worm shaft end play before adjusting the mesh of the worm and sector.

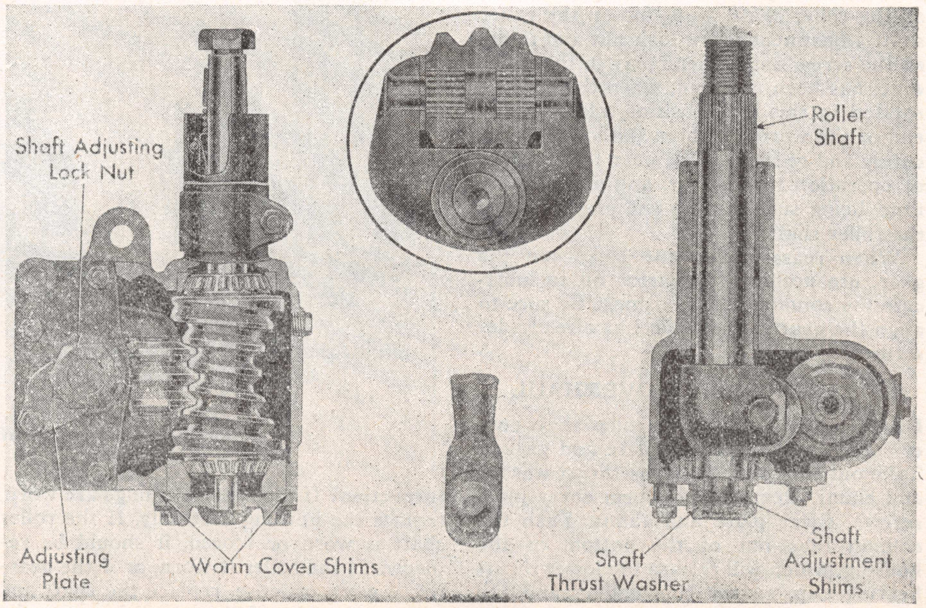
WORM SHAFT END PLAY, ADJUST

Remove the capscrews and the horn wire tube flange from the bottom of the housing, then take out the shim pack which contains three shims of .003", .005" and .020" thickness.

Add or remove shims as required until an adjustment is obtained which—when



GEMMER. Models 335, 375. Worm and triple roller with straddle-mounted cross shaft and external mesh adjustment.



GEMMER. Models 400, 450. Worm and triple roller with straddle-mounted cross shaft and external mesh adjustment.

the four capscrews are tightened securely—will provide a very slight drag in the gear when the wheel is turned with the thumb and forefinger gripping the rim of the steering wheel.

WORM & SECTOR, ADJUST

With the steering gear in the straight-ahead position, turn the backlash adjusting screw either in or out until all backlash in excess of .002" is eliminated. When the desired result is obtained, tighten the locking nut securely and re-check the adjustment. The correct setting is one which will provide from .000" to .002" end play, being sure there is no additional drag at the steering wheel.

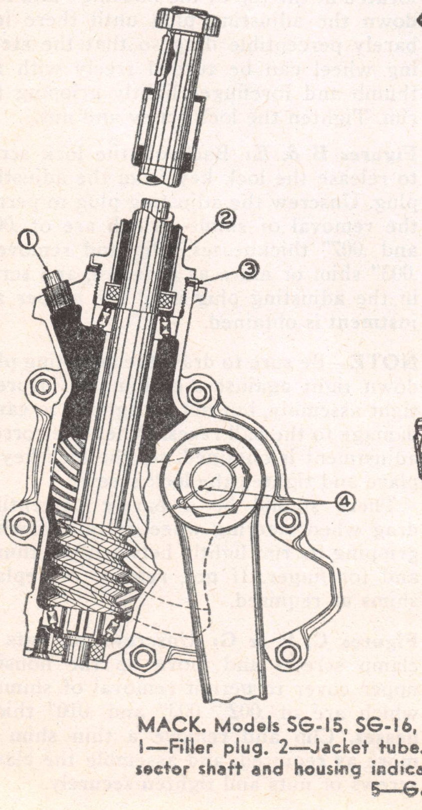
STEERING GEAR, OVERHAUL

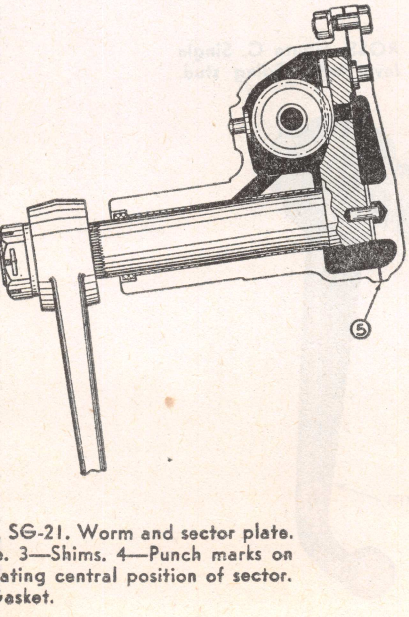
Remove the capscrews which fasten the cover to the gear housing and pull out the sector shaft. Disconnect the column jacket from the gear housing and the bottom cover and horn wire flange tube. All parts will then be accessible and may easily be removed.

Assemble in the reverse order and make the adjustments as described above, after which, fill the housing to the correct level with the proper lubricant.

MODELS SG-15, SG-16, SG-21

NOTE—When making adjustments, disconnect the drag link from the pitman arm to free the steering gear of all load, and loosen the instrument board bracket clamp on the steering column. Always adjust the worm shaft end play before adjusting the mesh of the worm and sector.





MACK. Models SG-15, SG-16, SG-21. Worm and sector plate. 1—Filler plug. 2—Jacket tube. 3—Shims. 4—Punch marks on sector shaft and housing indicating central position of sector. 5—Gasket.

WORM SHAFT END PLAY, ADJUST

The correct adjustment is one which provides free rolling bearings without end play. When turning the steering gear, a slight drag should be felt with the thumb and forefinger gripping the rim of the steering wheel.

To eliminate end play, unscrew the column jacket out of the gear housing far enough to remove a shim, which can be accomplished by cutting the shim on two sides and removing it in two pieces. A shim pack of .003", .005" and .020" thickness is provided between the tube and the housing.

CAUTION—Be sure to bend up the lip of the lockwasher before screwing the jacket out of the housing, because if this washer is broken, the entire column will have to be removed in order to replace a new one.

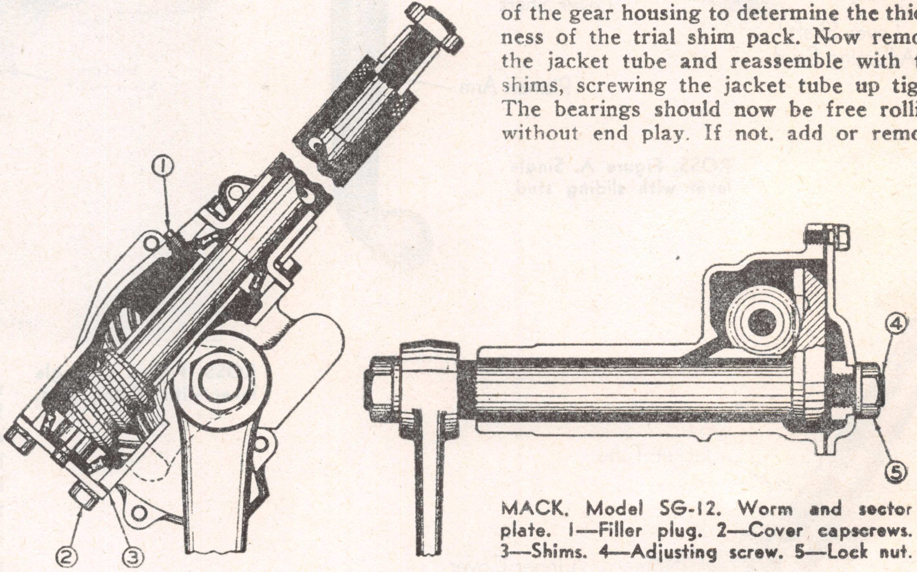
WORM & SECTOR, ADJUST

With the steering gear in the straight-ahead position, adjustment is made by varying the thickness of the gasket which is located between the gear housing and the cover. When the adjustment is correct, the sector should be from .001" tight to .002" loose against the worm. Usually a .021" gasket will provide the correct setting but if not, a .015" gasket, or a combination of the two will give the desired result.

NOTE—The sector shaft is punch-marked on its outer end, which, when lined up with the punch-mark on the housing, the sector is in the center of its travel.

STEERING GEAR, OVERHAUL

When overhauling the gear, assemble as follows: Assemble the column which consists of the worm shaft with bearings, column jacket and gear housing, leaving out the shims but **not** the lockwasher. Adjust the bearing cups by screwing down the jacket tube until contact with the bearings becomes noticeable. Then measure the gap between the lockwasher and the upper end of the gear housing to determine the thickness of the trial shim pack. Now remove the jacket tube and reassemble with the shims, screwing the jacket tube up tight. The bearings should now be free rolling without end play. If not, add or remove shims as required to obtain the desired result.



MACK. Model SG-12. Worm and sector plate. 1—Filler plug. 2—Cover capscrews. 3—Shims. 4—Adjusting screw. 5—Lock nut.

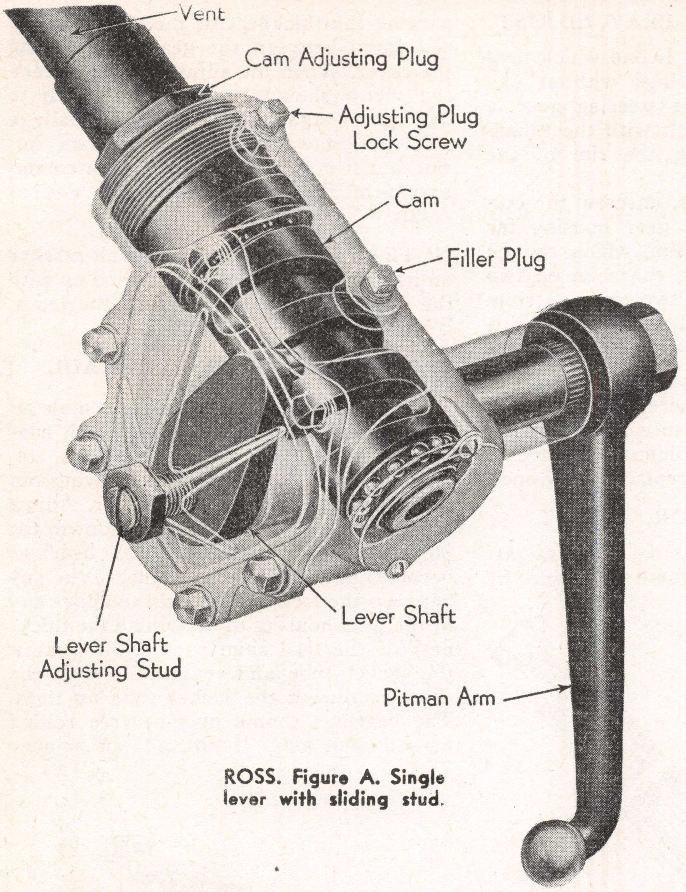
NOTE—Worms and gears are lapped together and are procurable in matched sets only. Each part is marked for the correct relative position of assembly. The sector mark will be found at the second tooth space, which should be assembled to the mark on the end of the worm thread.

ROSS CAM & LEVER

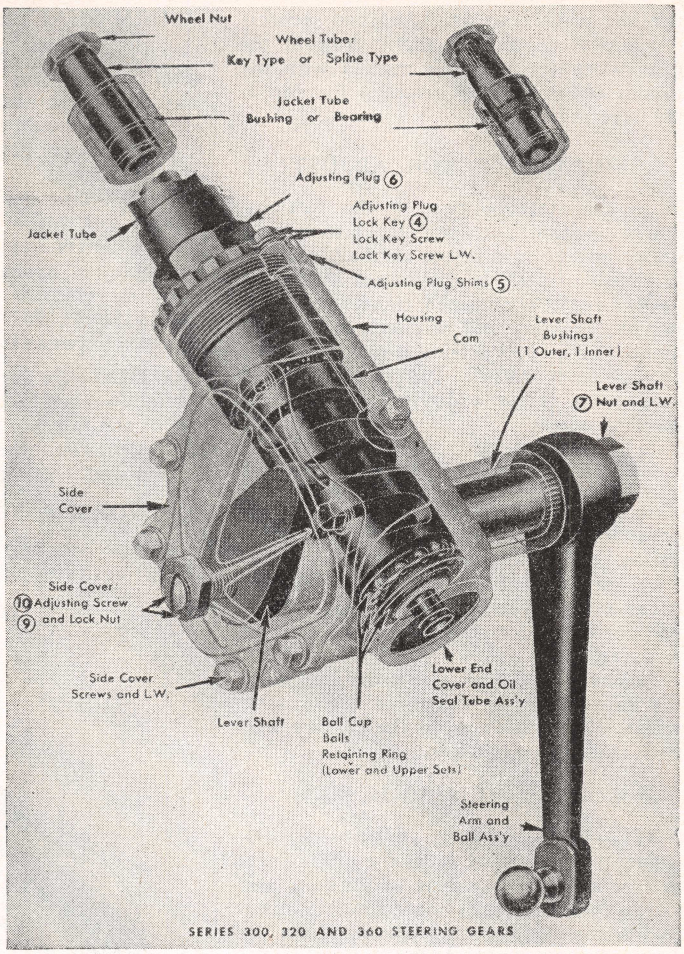
NOTE—When making adjustments, disconnect the drag link from the pitman arm to free the steering gear of all load, and loosen the instrument board bracket clamp on the steering column. Always adjust the cam end play before adjusting the lever shaft stud backlash.

CAM END PLAY, ADJUST

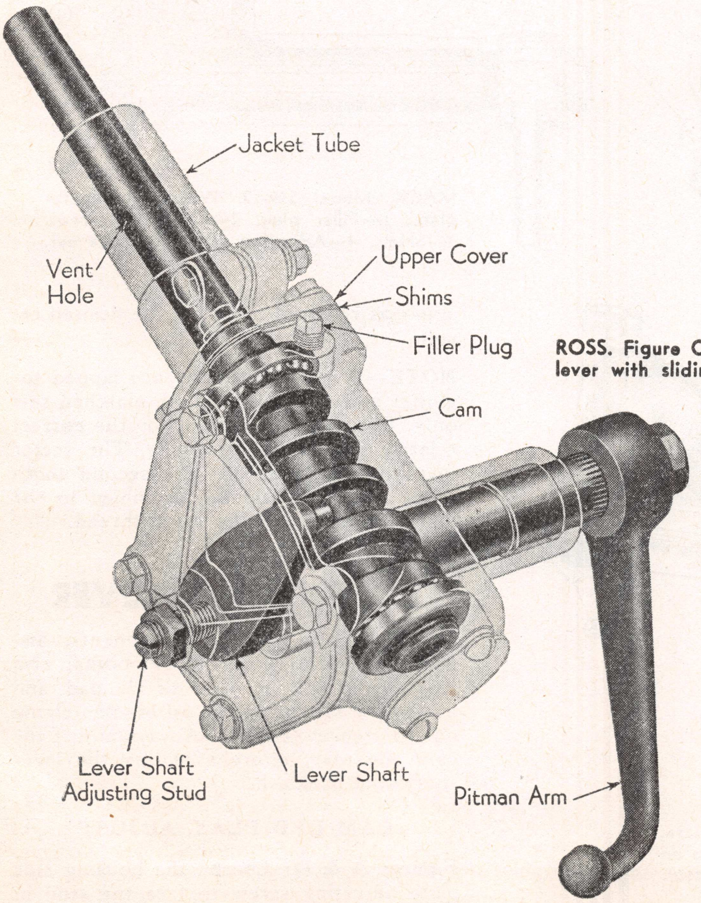
Figures A & D: Loosen the housing side plate adjusting screw to free the stud in


Vent
Cam Adjusting Plug
Adjusting Plug
Lock Screw
Cam
Filler Plug
Lever Shaft
Lever Shaft
Adjusting Stud
Pitman Arm

ROSS. Figure A. Single lever with sliding stud.


Wheel Nut
Wheel Tube:
Key Type or Spline Type
Jacket Tube
Bushing or Bearing
Adjusting Plug ⑥
Jacket Tube
Adjusting Plug
Lock Key ④
Lock Key Screw
Lock Key Screw L.W.
Adjusting Plug Shims ⑤
Housing
Cam
Lever Shaft
Bushings
(1 Outer, 1 Inner)
Lever Shaft
⑦ Nut and L.W.
Side
Cover
Side Cover
⑩ Adjusting Screw
⑨ and Lock Nut
Side Cover
Screws and L.W.
Lever Shaft
Ball Cup
Balls
Retaining Ring
(Lower and Upper Sets)
Lower End
Cover and Oil
Seal Tube Ass'y
Steering
Arm and
Ball Ass'y
SERIES 300, 320 AND 360 STEERING GEARS

ROSS. Figure B. Single lever with sliding stud.


Jacket Tube
Vent
Hole
Upper Cover
Shims
Filler Plug
Cam
Lever Shaft
Adjusting Stud
Lever Shaft
Pitman Arm

ROSS. Figure C. Single lever with sliding stud.

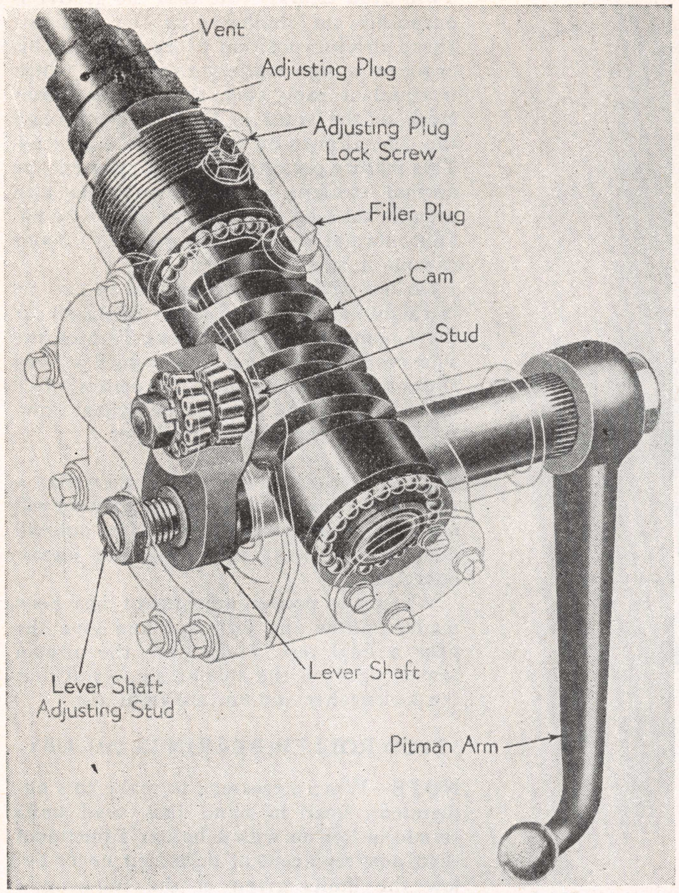
the cam groove. Back off the lock screw—located at the top of the housing—and turn down the adjusting plug until there is a barely perceptible drag so that the steering wheel can be turned freely with the thumb and forefinger lightly gripping the rim. Tighten the lock screw and nut.

Figures B & E: Back off the lock screw to release the lock key from the adjusting plug. Unscrew the adjusting plug to permit the removal of shims—which are of .003" and .007" thicknesses. Clip and remove a .003" shim or more as required, and screw in the adjusting plug until the proper adjustment is obtained.

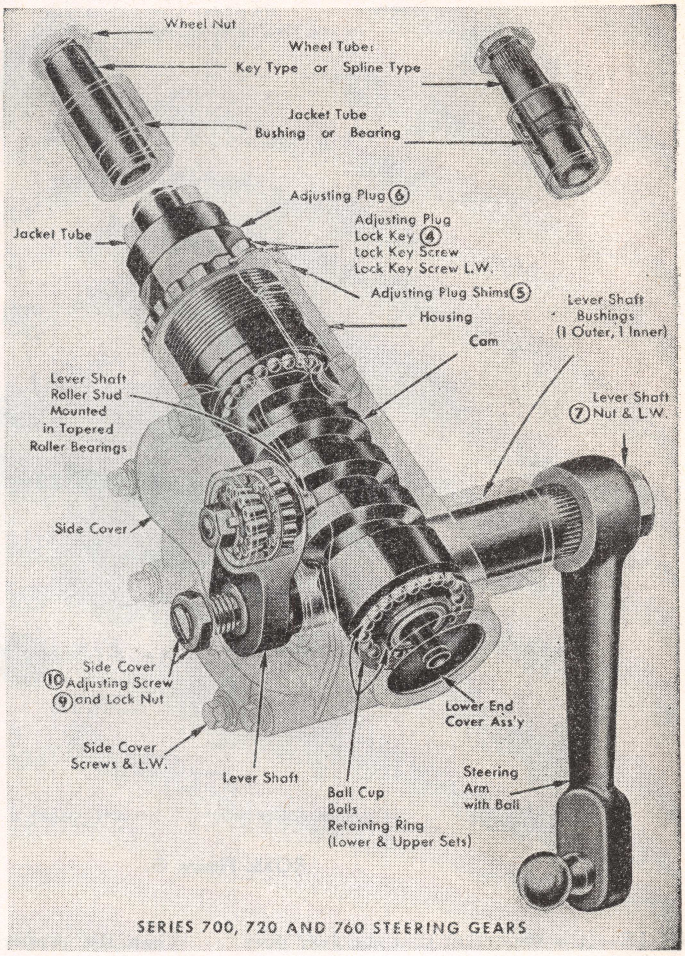
NOTE—Be sure to draw the adjusting plug down tight against the shims to insure a tight assembly, but not so tight as to cause damage to the ball races. When the correct adjustment is obtained, set the lock key in place and tighten the lock screw.

There should be a barely perceptible drag when steering wheel is turned when gripping its rim lightly between the thumb and forefinger. If not, remove or replace shims as required.

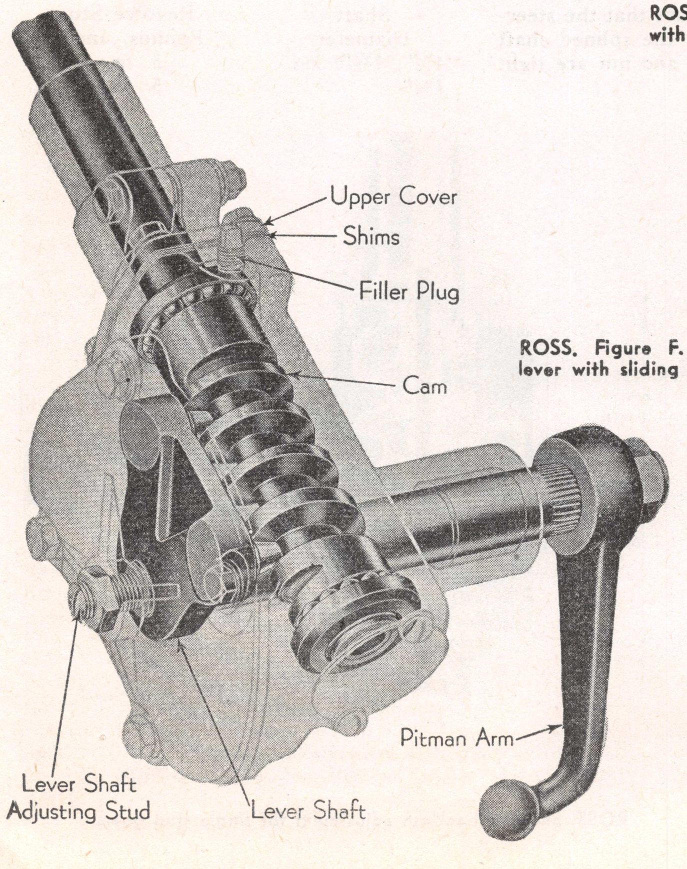
Figures C, F & G: Unscrew the nuts or clamp screws and move up the housing upper cover to permit removal of shims—which are of .002" .003" and .010" thicknesses. Clip and remove a thin shim or more as required, and assemble the clamp screws or nuts and tighten securely.


Vent
Adjusting Plug
Adjusting Plug Lock Screw
Filler Plug
Cam
Stud
Lever Shaft
Lever Shaft Adjusting Stud
Pitman Arm

ROSS. Figure D. Single lever with roller-mounted stud.


Wheel Nut
Wheel Tube: Key Type or Spline Type
Jacket Tube Bushing or Bearing
Adjusting Plug ⑥
Jacket Tube
Adjusting Plug Lock Key ④
Lock Key Screw
Lock Key Screw L.W.
Adjusting Plug Shims ⑤
Housing
Cam
Lever Shaft Bushings (1 Outer, 1 Inner)
Lever Shaft Roller Stud Mounted in Tapered Roller Bearings
Lever Shaft ⑦ Nut & L.W.
Side Cover
Side Cover ⑩ Adjusting Screw ⑨ and Lock Nut
Lower End Cover Ass'y
Side Cover Screws & L.W.
Lever Shaft
Ball Cup Balls Retaining Ring (Lower & Upper Sets)
Steering Arm with Ball
SERIES 700, 720 AND 760 STEERING GEARS

ROSS. Figure E. Single lever with roller-mounted stud.


Upper Cover
Shims
Filler Plug
Cam
Pitman Arm
Lever Shaft Adjusting Stud
Lever Shaft

ROSS. Figure F. Twin lever with sliding studs.

NOTE—To assure a tight assembly, the cover should always be drawn down tight against the shims. In the event that too many shims have been removed, use care to see that the cover is not drawn down so tight as to damage the ball races.

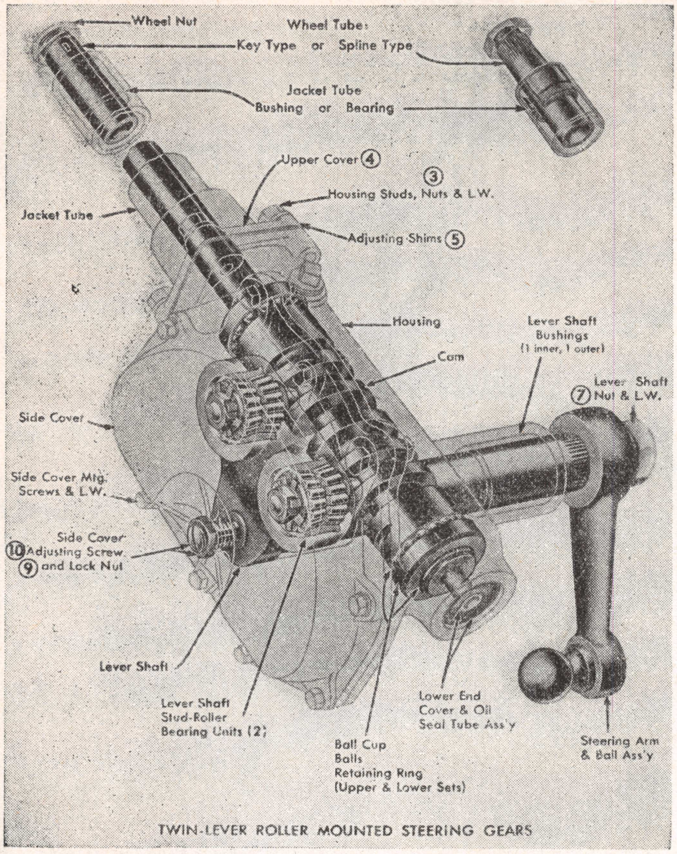
There should be a barely perceptible drag so that the steering wheel can be turned freely with the thumb and forefinger lightly gripping the rim, without any up and down movement of the column tube. If this result is not obtained, remove or replace shims as required.

LEVER SHAFT STUD BACKLASH, ADJUST

Single Stud Gears: Backlash at this point shows up as end play of the lever shaft and also as backlash at the steering wheel and at the ball of the steering arm.

Note that the groove is purposely cut deeper in the ends of the cam than in the mid-position. This produces a high range through the mid-position and makes the groove narrower through this range. This permits take-up of backlash in the mid-position, where maximum wear occurs, without causing a bind in the ends.

The adjustment should always be made to the mid-position of the cam. Tighten the side cover adjusting screw until a very slight drag is felt through the mid-position high range, when turning the steering wheel slowly from one extreme to the other.


Wheel Nut
Wheel Tube:
Key Type or Spline Type
Jacket Tube
Bushing or Bearing
Upper Cover ④
③
Housing Studs, Nuts & L.W.
Jacket Tube
Adjusting Shims ⑤
Housing
Lever Shaft
Bushings
(1 inner, 1 outer)
Cam
Lever Shaft
⑦ Nut & L.W.
Side Cover
Side Cover Mtg.
Screws & L.W.
Side Cover
⑩ Adjusting Screw
⑨ and Lock Nut
Lever Shaft
Lever Shaft
Stud-Roller
Bearing Units (2)
Lower End
Cover & Oil
Seal Tube Ass'y
Ball Cup
Balls
Retaining Ring
(Upper & Lower Sets)
Steering Arm
& Ball Ass'y

TWIN-LEVER ROLLER MOUNTED STEERING GEARS

ROSS. Figure G.

NOTE—It is important that the gear does not bind at any point. A closer adjustment than just a very slight drag will not correct any steering condition, but will damage and wear the parts and impair the operation of the gear.

When the proper adjustment has been made, tighten the lock nut and give the gear a final test. Make sure that the steering ball arm is tight on the splined shaft and that the lockwasher and nut are tight also.

Twin Stud Gears: Note that the groove is purposely cut shallower in the straight-ahead driving position of each stud. This produces a high range in the groove, which is equal at each stud, that causes closer mesh of the studs in the groove through the central position of travel of each stud. This feature permits a close adjustment for normal straight ahead driving and also permits take-up of backlash at this point. after normal wear of the groove, without causing a bind elsewhere.

Do not make the adjustment in the off "straight ahead" positions. Backlash at these points is not objectional. Tighten the side cover adjustment screw until a very slight drag is felt through the central position when turning the steering wheel slowly from one extreme to the other.

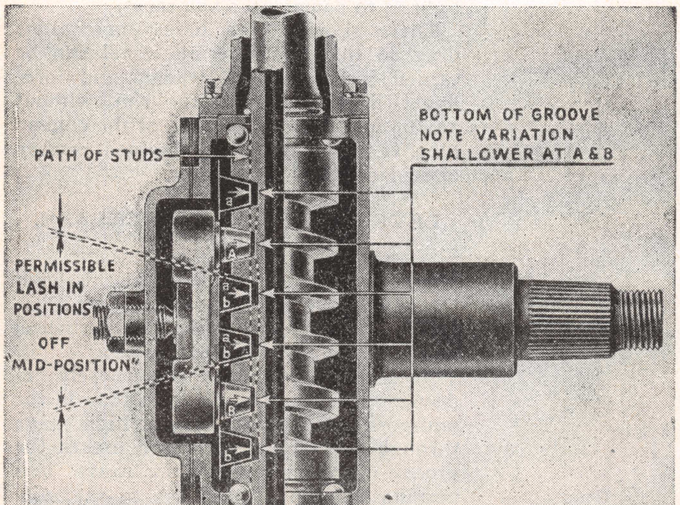
NOTE—A closer adjustment other than a very slight drag at this central position will not correct any steering condition, but will damage and wear the parts and impair operation.

When the proper adjustment has been made, tighten the lock nut and give the gear a final test. Make sure the pitman arm is tight on the splined shaft and that the lockwasher and nut are tight also.

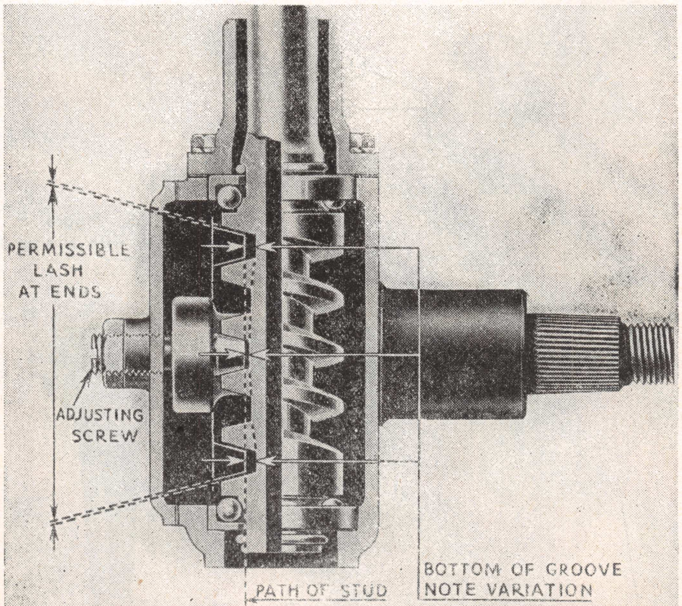
STUD ROLLER BEARINGS, ADJUST

NOTE—When necessary to make this adjustment, bear in mind that used units should be set up with a lighter adjustment than new replacement units, but never below the limits given in the following—which are factory adjustments on new units.

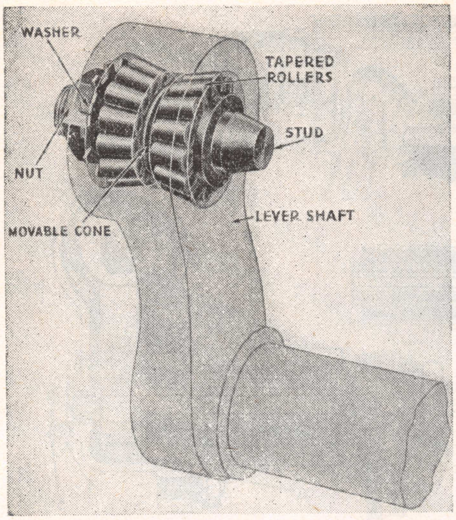
Shaft Diameter	Torque to Revolve Stud. Pounds, Inches
1¼", 1⅜", 1½"	3 to 4
1¾"	5 to 11


BOTTOM OF GROOVE
NOTE VARIATION
SHALLOWER AT A & B
PATH OF STUDS
PERMISSIBLE
LASH IN
POSITIONS
OFF
"MID-POSITION"
a
A
a
a
b
a
B
b
b
GEAR (Studs A & B) SHOWN AT MID-POSITION OF TRAVEL
a shows VARIOUS POSITIONS OF STUD A ON TURNS
b shows VARIOUS POSITIONS OF STUD B ON TURNS
IMPORTANT—ADJUST THRU THE MID-POSITION

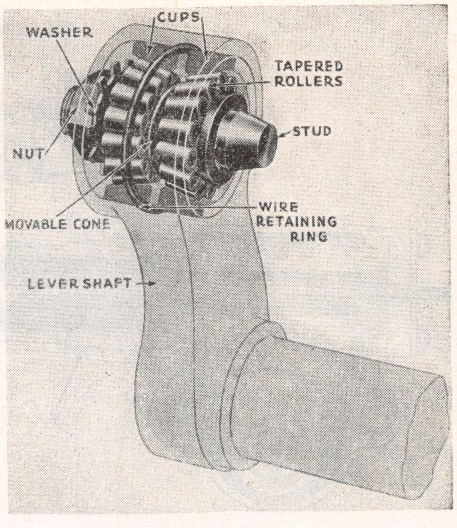
ROSS. Showing backlash adjustment for twin-stud gears.


PERMISSIBLE
LASH
AT ENDS
ADJUSTING
SCREW
PATH OF STUD
BOTTOM OF GROOVE
NOTE VARIATION
GEAR SHOWN AT MID POSITION
IMPORTANT —ADJUST THRU THE MID-POSITION

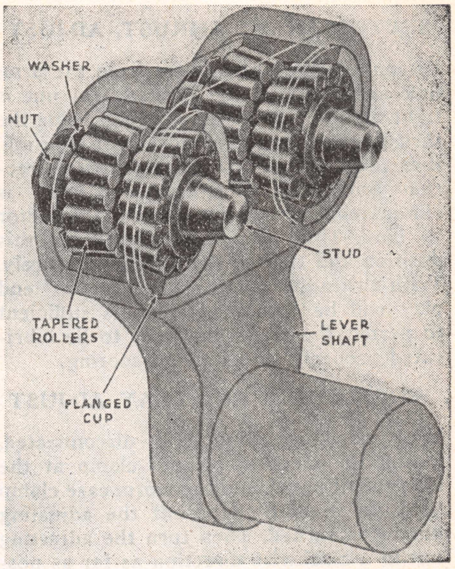
ROSS. Showing backlash adjustment for single stud gears.



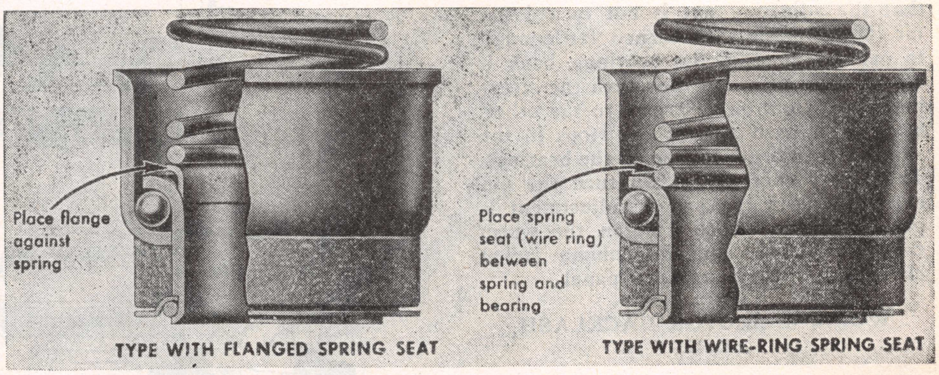
ROSS. Showing cupless type bearings in single lever gears.



ROSS. Showing cup type bearings in single lever gears.



ROSS. Showing cup type bearings in twin lever gears.


Place flange against spring
Place spring seat (wire ring) between spring and bearing
TYPE WITH FLANGED SPRING SEAT
TYPE WITH WIRE-RING SPRING SEAT

ROSS. Showing two types of jacket tube bearings.

To make the adjustment, straighten out the prong of the locking washer and tighten the nut as required, while holding the stud to keep it from turning. Use care to avoid damage to the bearing surface. Tap each end of the stud to test the adjustment and if correct, lock the adjustment by bending the prong of the locking washer against the side of the nut. Make sure to use a prong of the washer that has not been bent at some previous adjustment. Wash the bearings in gasoline and give a final test.

STEERING GEAR, OVERHAUL

NOTE—Before removing the pitman arm, punch-mark the relationship between the ball arm and the end of the lever shaft so that assembly can readily be made in the same position, then use a puller to remove the arm. Pull off the steering wheel and remove the gear from the chassis.

To disassemble the gear, loosen the side cover lock nut, and the adjusting screw a few turns. Then take off the side cover and slide the lever shaft from the housing, first being sure the outer end of the shaft is free from any burrs which may damage the lever shaft housing bushings as the shaft is being withdrawn.

To remove the column jacket tube on Figures A and D, loosen the adjusting plug lock nut and set screw, then unscrew the adjusting plug and slide off the jacket tube assembly.

On Figures B and E, loosen the lock key screw and remove the key, after which, the jacket tube can be removed after unscrewing the adjusting plug.

On Figures C, F and G, the jacket tube can be removed after unscrewing the upper cover screws or stud nuts, and taking off the cover.

Inspection: See that the cam thread is not dented, chipped or scored. Examine the ball races and ball cups for deep wear, pits or dents. Inspect the lever shaft at all bearing points for wear, twisted splines, wear from a loose steering arm and for stripped threads. See that the lever shaft stud or studs are free from flat spots or a chipped condition. If small flat spots are evident, they may be disregarded provided a satisfactory adjustment can be obtained.

If the stud roller bearing units are unduly rough, remove the stud nut and press out the stud, which will permit the inspection of the cone and cups. See that the lever shaft bushings in the housing are not scored and that the shaft is a good fit in the bushings, or within from .0005" to .0025" clearance.

After checking all the above items, reassemble the gear in the reverse order and make the adjustments in the order described.

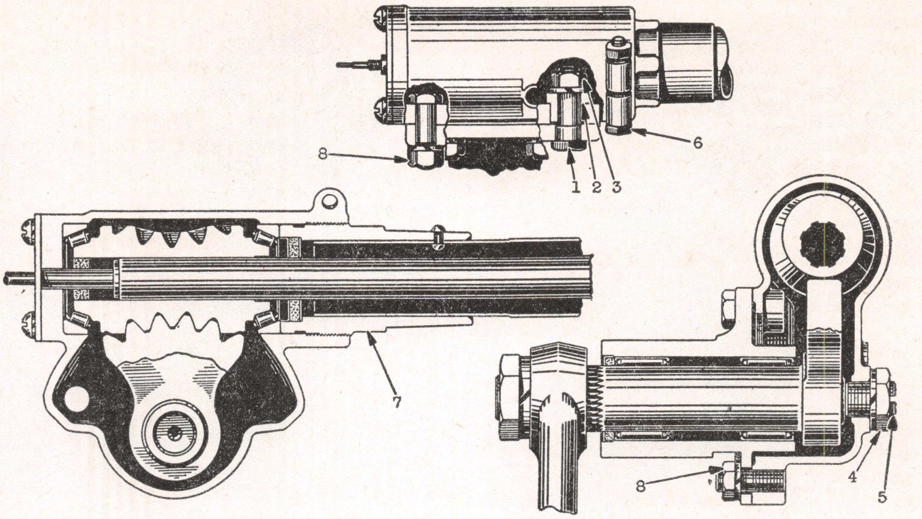
SAGINAW WORM & SECTOR

ECCENTRIC STUD & BUSHING TYPE

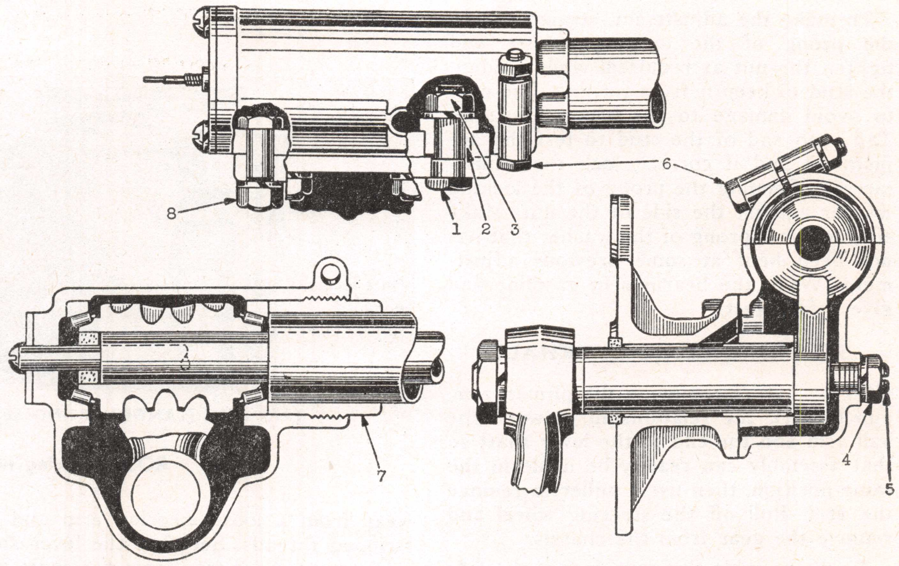
If an inspection of front end alignment, steering geometry, insufficient lubrication and the other factors which affect steering, indicates that the gear itself requires adjustment, it should be accomplished in the following sequence: Sector shaft thrust adjustment, worm shaft end play, and backlash between the worm and sector.

To secure the proper adjustment of the worm and sector, the worm case is attached to the sector shaft housing with studs and nuts in such a manner that the relative position of the case and housing can be changed by means of an eccentric stud and bushing which can be turned to swing the worm case on the pivot bolt—at the lower point of the sector shaft housing—to bring the worm and sector into closer relationship.

The notches which are on the flats of the eccentric stud and bushing are in line with the high side of the eccentric on each. When the notch on the stud is farthest from the steering column, and the notch on the bushing is nearest to the column, maximum backlash exists between the worm and sector. When the position of these notches is reversed, and the maximum backlash again exists, no further adjustment is possible, therefore, the steering gear will have to be dismantled and worn parts replaced.



SAGINAW. Worm and six-tooth sector.



SAGINAW. Worm and three-tooth sector.

SECTOR SHAFT THRUST, ADJUST

Disconnect the pitman arm from the drag link and see that the pitman arm nut is tight. Loosen the lock nut which holds the thrust screw in the sector shaft housing, turn the thrust screw in a clockwise direction until all perceptible end play is eliminated, yet without causing the sector to bind. Hold the thrust screw in this position and tighten the lock nut securely. With this adjustment, a .002" to .003" end play will be obtained, which is sufficient to permit the thrust surfaces to be lubricated properly, and prevent scoring.

WORM SHAFT END PLAY, ADJUST

With the drag link still disconnected, loosen the steering column clamp at the instrument panel, and the worm case clamp bolt just enough to permit the adjusting nut to be turned. Then turn the adjusting nut in a clockwise direction as far as possible without causing a drag on the steering wheel.

NOTE—Care should be exercised to see that the adjusting nut is not turned too far. However, if it is turned far enough to cause a bind in the bearings, back it off one-half turn and then turn the steering wheel from one extreme to the other, bringing it hard against the stops in the worm case in order to free up the bearings. Then, very carefully, again turn the nut clockwise until the proper adjustment is obtained, after which, tighten the worm case clamp bolt and the column jacket clamp bolt at the instrument panel.

WORM & SECTOR BACKLASH, ADJUST

Turn the steering wheel to either extreme, and then all the way back to the other extreme, counting the number of turns required to turn it from one extreme to the other. Then bring the wheel back to its central position by turning it exactly half the amount of the extreme-to-extreme positions, and mark the wheel at the top or bottom center, using a piece of tape for the purpose.

Move the pitman arm back and forth to determine the amount of backlash (drag link disconnected). Loosen the bolts in the mounting bracket, and then back off the housing stud nuts only ¼ turn, and the eccentric lock nut ½ turn. Using one wrench on the eccentric sleeve and another on the eccentric stud, turn the nut and sleeve in opposite directions in gradual stages until all backlash is eliminated at the lower end of the pitman arm.

NOTE—The sleeve and stud must be turned exactly the same amount, otherwise the eccentrics will lock. If the eccentrics lock, back up either the sleeve or stud slightly, which will permit both to be turned again—usually, ⅛ turn on each is sufficient. Use extreme care to see that the eccentrics are not turned too far to avoid damage to the worm and sector.

When all backlash has been eliminated, there should be a slight drag on the steering wheel when on the high-spot or straight-ahead position. If this central position—as indicated by the tape—does not coincide with the high-spot, move the tape so that it is in the center of the wheel travel through the high-spot of the gear.

If there is too much drag on the steering wheel, back off on the eccentric adjustment again until there is a slight backlash at the end of the pitman arm with the gear at the right or left-hand positions, but none at the high-spot or central position.

When the desired result is obtained, tighten the eccentric lock nut securely, being sure to hold the eccentric sleeve and stud to prevent their turning. Then tighten the housing stud nuts and re-check the adjustment to be sure it has not been changed during the tightening operation. Tighten the steering column clamp at the instrument panel, the mounting bolts at the frame and connect the drag link.

STEERING GEAR, OVERHAUL

After removing the assembly from the chassis, loosen the mast jacket clamp bolt and remove the mast jacket. Unscrew the bolts holding the pitman arm shaft housing and remove this housing from the gear case. Take out the sector shaft. Remove the adjusting nut clamp screw and pry the slot apart with a screw driver and remove the worm adjusting nuts. Remove the worm and tube. Remove the roller bearings from the tube and the gear housing.

If the mast jacket bushing is worn, replace by driving the bushing from the mast jacket from the bottom end. When installing a new bushing, it is recommended that a special bushing driver be used as it seats the bushing in the proper place in the mast jacket.

If the cross shaft housing bushings are worn, replace the new ones with the open end of the oil grooves toward the inside of the housing. This housing is serviced with the bushings as an assembly, but if new bushings have been installed in an old housing, they should be line-reamed to insure proper alignment of the cross shaft.

Assemble in the reverse order and adjust the steering gear as already described.

WORM & SECTOR TYPE WITH ECCENTRIC SLEEVE & ADJUSTING PLATE

Before making any adjustments on this gear, disconnect the drag link from the pitman arm and tighten the pitman arm nut with an 18" wrench. Check the alignment of the mast jacket at the instrument panel in the following manner:

Make sure that the mast jacket clamp at the instrument panel is tight, then back off the frame mounting bolts until quite free. With a feeler gauge, check the clearance between the bracket and the frame side rail. If this clearance is excessive at either the front or rear of the housing bracket, install a shim so that the gear assembly will be in correct alignment with the instrument panel. Be sure the frame mounting bolts are tightened securely.

WORM SHAFT END PLAY, ADJUST

Tighten the three machine screws holding the end cover to the housing. Loosen the adjusting screw lock nut at the bottom of the housing. With the steering gear close to one extreme position, tighten the adjusting screw at the bottom of the housing until a slight load is felt on the steering wheel when turning; then check in the other extreme position.

NOTE—Use care when making this adjustment, so as to avoid backing out the adjusting screw too far, which may cause the worm bearings to get out of line. When the adjustment is made, tighten the lock nut.

Check the worm bearing adjustment by measuring the drag on the steering gear by attaching a spring scale to the rim of the steering wheel. With the gear turned close to either extreme end position, a pull of about 1½ pounds should be required to turn the steering wheel.

SECTOR SHAFT END PLAY, ADJUST

Tighten the four machine screws which hold the side cover to the housing. Loosen the adjusting screw lock nut at the side of the housing, next to the engine and turn the adjusting screw to the right by hand until all end play is removed. Tighten the lock nut securely, being careful not to allow the adjusting screw to turn while tightening the nut. Do not tighten the adjusting screw with a wrench.

Turn the gear to each extreme, but not against the stops, and check to make sure that the adjustment has not caused binding in the sector shaft.

WORM & SECTOR BACKLASH, ADJUST

Center the steering gear, then move the pitman arm back and forth to determine the amount of lash between the worm and the sector. Loosen the lash adjuster lock screw and with a soft hammer tap lightly on the lash adjuster in the direction indicated by the arrow which is cut out of the adjuster. Do not move the adjuster more than 1/16" at a time.

Rotate the steering wheel to the right or left to see whether or not it passes through the center position freely. If it does not, it will be necessary to tap the adjuster back just enough to allow the wheel to be turned through the center position without binding. Tighten the lash adjuster lock screw securely.

When the steering gear is properly adjusted, the load required to turn the gear through the center position should be about 1¾ pounds as measured by a spring scale hooked to one of the spokes of the steering wheel. The gear should be without backlash in the straight ahead position only. Check this by moving the pitman arm. There should be no fore and aft movement at this point.

STEERING GEAR, OVERHAUL

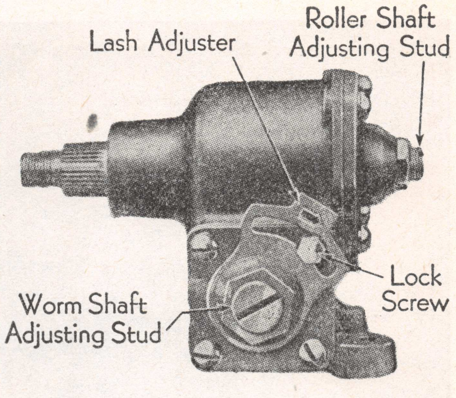
After removing the gear assembly from the car, loosen the lock nut on the sector shaft end play adjustment screw. Remove the four machine screws from housing side cover and take off the cover and gasket. Now, remove the sector shaft, thrust washer and housing bushing.

Loosen the lock nut on the worm shaft end play adjustment screw. Remove the three machine screws and the lash adjuster lock screw from the end cover and remove the cover.

Tap the end of the worm shaft lightly with a soft hammer. Then remove the thrust washer, lower bearing race and bearing, worm and shaft, and the upper bearing.

The eccentric sleeve may now be removed from the housing with the fingers. Remove the upper bearing race from the eccentric sleeve. Remove the oil seal and retainer from the housing and wash all parts thoroughly with clean gasoline.

Inspection: Examine the worm and shaft for worn or damaged bearing surfaces.



SAGINAW. Worm and roller.

Check the fit of the sector shaft in the side cover bushing. If this bushing is worn, the side cover with the bushing will have to be replaced. Check the fit of the sector shaft floating bushing on the shaft and in the housing. Examine the worm and inner bearing cones for wear or damage, and also all bearings and races.

NOTE—The thick side of the eccentric sleeve should be toward the sector shaft, to provide worm and sector clearance when assembling. Make sure that the upper worm bearing seats properly in its race when installing the worm and shaft.

When installing the worm thrust washer, be sure to place the concaved side toward the worm. Make sure the lugs of the adjuster plate engage the notches of the eccentric sleeve.

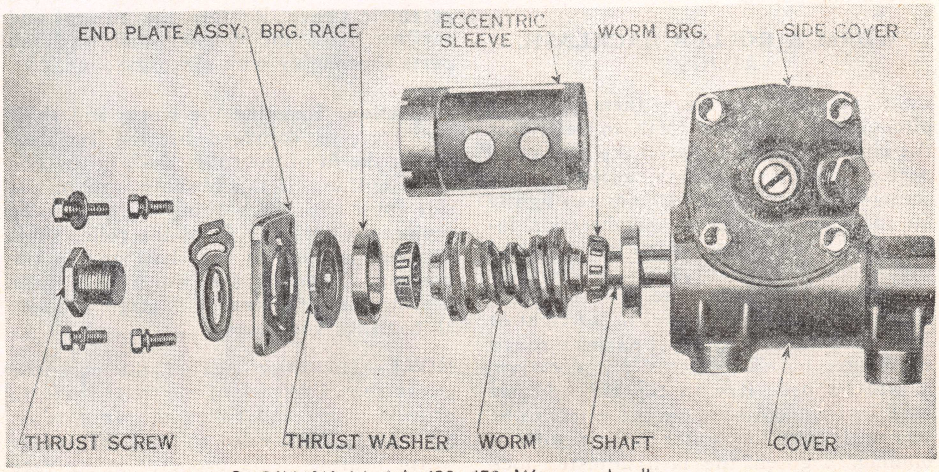
Make the adjustments as described in the preceding paragraphs and install the assembly in the vehicle.

WORM & ROLLER TYPE

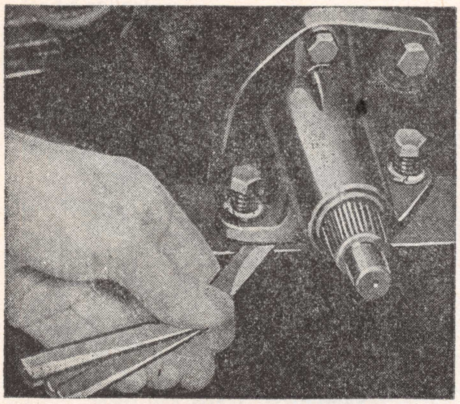
MODELS 420, 450

CROSS SHAFT END PLAY, ADJUST

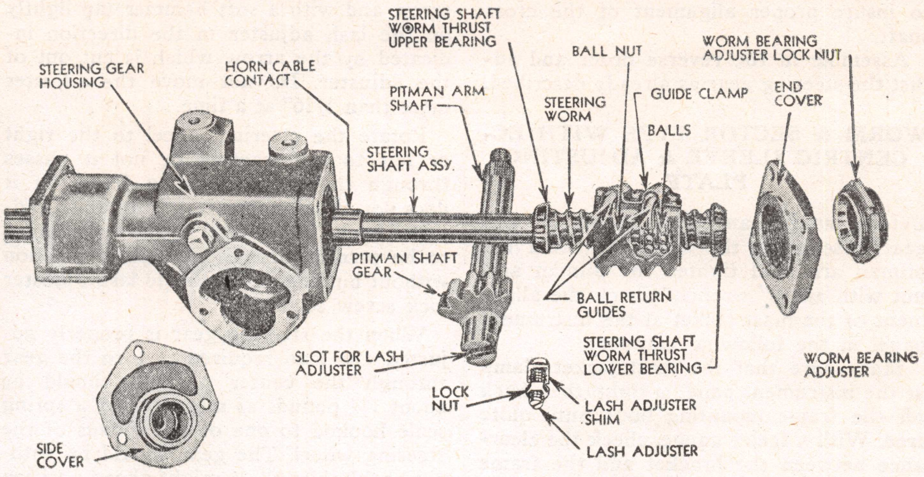
Tighten the four machine screws which hold the side cover to the housing. Loosen the adjusting screw lock nut at the side of



SAGINAW. Models 420, 450. Worm and roller.



SAGINAW. Method of checking clearance between bracket and frame.



SAGINAW. Recirculating ball and nut.

the housing, next to the engine and turn the adjusting screw to the right by hand until all end play is removed. Tighten the lock nut securely, being careful not to allow the adjusting screw to turn while tightening the nut. Do not tighten the adjusting screw with a wrench.

Turn the gear to each extreme, but not against the stops, and check to make sure that the adjustment has not caused binding in the roller shaft.

WORM SHAFT END PLAY, ADJUST

Tighten the three machine screws holding the end cover to the housing. Loosen the adjusting screw lock nut at the bottom of the housing. With the steering gear close to one extreme position, tighten the adjusting screw at the bottom of the housing until a slight load is felt on the steering wheel when turning; then check in the other extreme position.

NOTE—Use care when making this adjustment, so as to avoid backing out the adjusting screw too far, which may cause the worm bearings to get out of line. When the adjustment is made, tighten the lock nut.

Turn the gear to its extreme end position, just off the stop. Hook a spring scale to a spoke of the steering wheel at the rim. The load on the worm bearings should not exceed one pound.

WORM & ROLLER BACKLASH, ADJUST

Center the steering gear, then move the pitman arm back and forth to determine the amount of lash between the worm and sector. Loosen the lash adjuster lock screw and with a soft hammer tap lightly on the lash adjuster in the direction indicated by the arrow which is cut out of the adjuster. Do not move the adjuster more than 1/16" at a time.

Rotate the steering wheel to the right or left to see whether or not it passes through the center position freely. If it does not, it will be necessary to tap the adjuster back just enough to allow the wheel to be turned through the center position without binding. Tighten the lash adjuster lock screw securely.

When the steering gear is properly adjusted, the load required to turn the gear through the center position should be about 1¾ pounds as measured by a spring scale hooked to one of the spokes of the steering wheel. The gear should be without backlash in the straight ahead position only. Check this by moving the pitman arm. There should be no fore and aft movement at this point.

STEERING GEAR, OVERHAUL

After removing the gear assembly from the vehicle, loosen the lock nut on roller shaft end play adjustment screw. Remove the four machine screws from housing side cover and take off the cover and gasket. Now, remove the roller shaft, thrust washer and housing bushing.

Loosen the lock nut on the worm shaft end play adjustment screw. Remove the three machine screws and the lash adjuster lock screw from the end cover and remove the cover.

Tap the end of the worm shaft lightly with a soft hammer. Then remove the thrust washer, lower bearing race and bearing, worm and shaft, and the upper bearing.

The eccentric sleeve may now be removed from the housing with the fingers. Remove the upper bearing race from the eccentric sleeve. Remove the oil seal and retainer from the housing and wash all parts thoroughly with clean gasoline.

Inspection: Examine the worm and shaft for worn or damaged bearing surfaces. Check the fit of the roller shaft in the side cover bushing. If this bushing is worn, the side cover with the bushing will have to be replaced. Check the fit of the roller shaft floating bushing on the shaft and in the housing. Examine the worm and inner bearing cones for wear or damage, and also all bearings and races.

NOTE—The thick side of the eccentric sleeve should be toward the roller shaft, to provide worm and roller clearance when assembling. Make sure that the upper worm bearing seats properly in its race when installing the worm and shaft.

When installing the worm thrust washer, be sure to place the concaved side toward the worm. Make sure the lugs of the adjuster plate engage the notches of the eccentric sleeve.

Make the adjustments as described in the preceding paragraphs and install the assembly in the vehicle.

RECIRCULATING BALL TYPE

MODELS 530, 540, 550, 560, 565, 580

With this type gear, rotation of the worm causes the nut to rise or fall, and the balls provide an almost friction-less rolling contact.

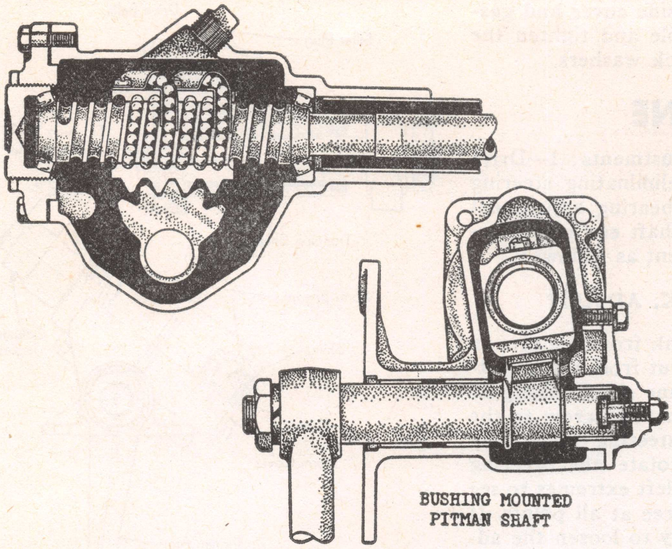
When the steering gear is turned to the left, the worm turns in the same direction and moves the nut downward. The balls, meanwhile, roll between the worm and the nut, working their way up the steering shaft. As they reach the top of the nut, they enter one of the two return chambers through which they are directed downward, to be re-introduced to a lower point. When a right turn is made, the nut moves upward and the balls circulate in the reverse direction.

This type gear requires only two adjustments, which must be made according to the following instructions.

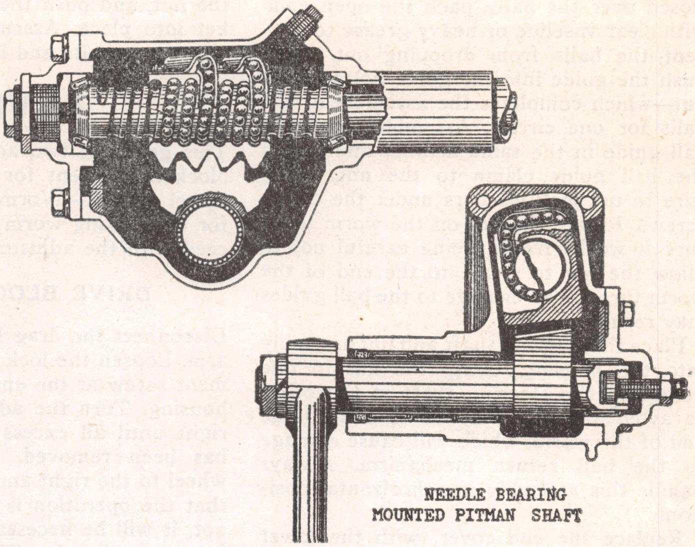
SCREW BEARINGS, ADJUST

Note the relative position of the drag link adjustment on the pitman arm before removing so that assembly may readily be made when the adjustments are completed. Loosen the steering column bracket at the instrument panel. Loosen the cross shaft adjusting screw lock nut and turn the screw out (counter-clockwise) a few turns, which removes the load from the screw bearings.

NOTE—Turn the steering wheel very carefully in one direction to the end of its travel and back up about one turn. Never turn the steering gear hard against its stops as damage to the ball guides may result.



SAGINAW. Recirculating ball and nut.



SAGINAW. Recirculating ball and nut.

Measure the pull at the rim of the wheel which is required to keep the wheel in motion off the high spot. This can be accomplished by attaching a spring scale with a piece of cord to the rim of the steering wheel, then pull on the spring scale to turn the wheel. The pull required to turn the wheel should be between 1 and 1½ pounds on models 530, 540, 550 and 560; between 1¾ and 2¼ on models 565, and from 2 to 2½ pounds on model 580. If not within these limits, an adjustment of the screw bearings is required.

To adjust the screw bearings, loosen the adjusting screw lock nut and turn the adjusting screw in (clockwise) until all end play is eliminated. Check the pull at the steering wheel as described above, making another adjustment if necessary, to obtain the proper pull. Then tighten the lock nut and again check the pull, being sure it is within the specified limits after the nut is tightened.

NOTE—If the gear feels rough or "lumpy" after the screw bearing adjustment, the bearings are probably damaged due to the improper adjustment or, it may be caused by a severe impact, in which case, the gear will have to be dismantled and damaged parts replaced.

Before re-attaching the steering column bracket, note whether or not the bracket can be tightened without springing the column. If not, shim the bracket or loosen the steering gear mounting bolts and shift the gear to eliminate the condition. Then, tighten the bracket and re-check the pull at the steering wheel rim. If it has increased materially, there is still a sprung condition in the column which must be corrected.

CROSS SHAFT END PLAY, ADJUST

With the screw bearings properly adjusted and all mounting bolts tightened securely, turn the steering wheel very carefully to either extreme end position and then all the way back to the opposite end position, counting the exact number of turns required from the extreme-to-extreme positions. Then turn the wheel back exactly half the number of turns to the central position, marking the wheel at the top or bottom, using a piece of tape for the purpose.

Turn the cross shaft adjusting screw in (clockwise) until all lash is eliminated and tighten the lock nut. Check the pull at the rim of the steering wheel with the spring scale in the same manner as already described, taking the highest reading on the scale as the wheel is turned through the central position. For models 530 and 540, the reading should be from 2 to 2½ pounds; from 2½ to 3 pounds on models 550 and 560; from 2¾ to 3¼ on model 565, and from 3¼ to 3¾ on model 580.

If not within the above limits, make another adjustment, and after the lock nut is tightened, again check the pull.

STEERING GEAR, OVERHAUL

After the gear has been removed from the chassis, remove the steering column upper bearing. Loosen the lock nuts and back off both steering gear adjusting nuts. Remove the side cover bolts and pull the cover about 2" out of the housing. This will draw the cross shaft partially out of the housing and will disengage the gear and nut. Remove the end cover bolts and take off the end cover, with the lower worm bearing, cup and thrust washer.

NOTE—Be sure the shaft is held in a horizontal position so that the nut does not move against the stops. To avoid this, tape the nut in position on the worm, otherwise it will run to the end of the worm by its own weight.

If necessary to disassemble the ball bearing nut, remove the screws and clamp which retains the ball guides in the nut. Turn the nut upside down and rotate the shaft back and forth until all the balls have dropped out of the nut, using a clean pan to catch the balls. Then pull the nut from the shaft endwise.

Inspection: Examine the roller bearing cones, worm and nut grooves, as well as the surfaces of all balls for any evidence of indentation—a magnifying glass is useful for this purpose. Check for any signs of chipping or breakdown of the surfaces. Inspect the sector shaft for wear and check the fit of the shaft in the housing bushings or bearings.

Examine the fit of the pilot on the end of the sector shaft in its bushing in the side cover, and if the bushing is worn, it is recommended that a new side cover and bushing assembly be installed.

See that the ends of the ball guides are not damaged, as they pick up and deflect the balls from their helical path at these points. If any sign of damage is evident, replace the guides.

Assemble: To assemble the ball nut, place the worm shaft flat on the bench and slip the nut over the worm with the holes in the ball guides facing upward. Align the grooves in the worm and nut by sighting through the bottom of the ball guide holes.

NOTE—Count the total number of balls and divide them equally, placing each half of the total into clean pans. Then drop the contents of one pan into one of the guide holes while turning the worm gradually away from that hole. Continue until this ball circuit is full from the bottom of one guide hole to the bottom of the other —or until stopped by reaching the end of the worm. If the balls are stopped by the end of the worm, use the blunt end of a clean rod or punch to hold down those balls already dropped into the nut, turning the worm in the reverse direction a few turns, then continue with the filling of the ball circuit. It may be necessary to work the worm back and forth, holding the balls down first in one hole and then the other, to close up the spaces between the balls and fill the circuit completely and solidly.

With the circuit filled, there should be enough balls left over to fill the ball guides. With the two halves of the ball guides closed over the balls, pack the open ends with clear vaseline or heavy grease to prevent the balls from dropping out. Then push the guide into the guide holes in the nut—which completes the assembly of the balls for one circuit. Assemble the other ball guide in the same manner and fasten the ball guide clamp to the nut, being sure to use lock washers under the clamp screws. Rotate the nut on the worm to be sure it works freely, being careful not to allow the nut to rotate to the end of the worm threads, as damage to the ball guides may result.

Place the steering shaft and nut assembly into the housing. Grasp the nut in one hand and the steering shaft in the other to avoid allowing the nut to run to the end of the worm, which will cause damage to the ball return mechanism. Always handle this assembly in a horizontal position.

Replace the end cover, with the lower worm bearing cup, thrust washer and gasket. Assemble and tighten the end cover bolts and lock washers.

Assemble the upper bearing spring seat and spring, upper bearing washer and cotter pin, and then the steering wheel. Adjust the worm bearings as described in a preceding paragraph.

Rotate the steering wheel until the nut is approximately in the center of its travel. Make sure that the center tooth of the gear will enter the center tooth space of the nut, and push the side cover and gasket into place. Assemble and tighten the side cover bolts and lock washers.

LAVINE

This gear has two adjustments: 1—Drive block adjustment for eliminating steering wheel play. 2—Worm bearing adjustment for eliminating worm shaft end play. Proceed with the adjustment as follows:

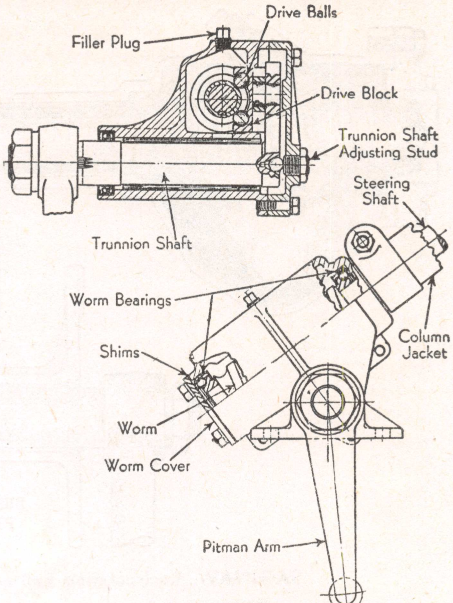
DRIVE BLOCK, ADJUST

Disconnect the drag link from the pitman arm. Loosen the lock nut from the adjustment screw at the engine side of the gear housing. Turn the adjusting screw to the right until all excess steering wheel play has been removed. Rotate the steering wheel to the right and left extremes to see that the operation is free at all points. If not, it will be necessary to loosen the adjustment slightly. Tighten the lock nut and make sure that the adjusting screw has not been moved after the lock nut is secured.

WORM SHAFT END PLAY, ADJUST

With the drag link disconnected, grasp the steering wheel rim firmly, and raise it up and down. If end play is felt, remove the four cover screws from the bottom of the gear housing. Remove sufficient shims to eliminate the end play and replace the cover. After the cover has been tightened in position, rotate the gear to the right and left extremes to see that no drag exists on the worm shaft bearings.

When properly adjusted, the gear should be without backlash in the straight ahead position, and should have free movement over the complete travel of its range.



LAVINE

DELCO SHOCK ABSORBERS

An inoperative shock absorber, or one requiring fluid, does not control the body movement of the vehicle properly, which results in continuous up and down movement, or short, jerky movements which diminish the riding qualities of the car with its attendant passenger discomfort.

Rear wheels bouncing over small bumps spin while in the air, causing the rubber to scuff off when they again contact the ground. There is also a loss of traction which affects gasoline economy.

Good steering is more or less dependent on the proper performance of the shock absorbers. Front wheel shimmy and wheel tramp are often traceable to shock absorbers that are incorrectly or unevenly adjusted, or improperly lubricated or inoperative. It is important that the shock absorbers be checked and properly serviced when found to be out of order.

Shock absorbers should dampen the jar a front wheel receives upon hitting a sharp bump. Inoperative absorbers permit this jar to be transmitted to the steering wheel, which results in steering wheel whip or "fight."

EMPTY OR LOW FLUID

To check the unit for low fluid, determine if there is a uniform resistance through the complete stroke of the absorber movement. A quick check can be made by bouncing each corner of the vehicle up and down. If the unit is in need of service, the vehicle will continue to bounce after the weight exerted to bounce the vehicle is released.

If this check does not indicate a need for service, a more positive check can be made by disconnecting and moving the absorber or its arm through the complete stroke.

The fluid level should be checked about twice a year to make sure that they are controlling the car movement properly. If the fluid is allowed to become low, air pockets may form in the working chambers and destroy the action of the shock absorbers.

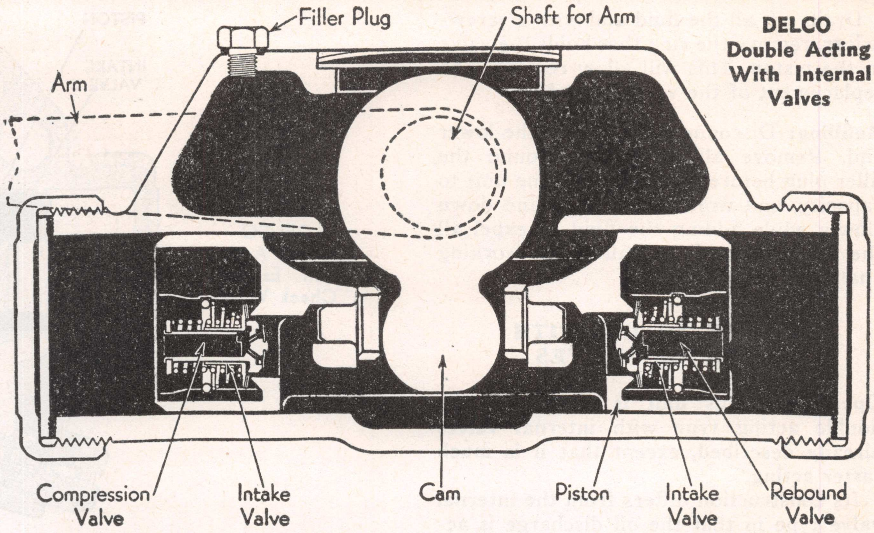
FLUID LEAKAGE

Leakage of the fluid can be determined by the presence of excessive fluid around the outside of the shock absorber body. To locate the leak, clean off the entire outside of the body thoroughly and fill the unit to its proper level.

Drive over a rough road for a short distance, and then inspect the gaskets, especially the end cap gasket on double acting units at the inner side, and the filler plug.

A slight leak at the seal on single and double acting units, where the shock absorber arm goes through the housing, just after the shock absorber has been filled is of little consequence, and is due to initial expansion.

However, if there is a leak at any of the end caps or valves, new gaskets should be installed, and the unit should be cleaned and tested again.



DELCO Double Acting With Internal Valves

The slightest leak at the end cap will empty the shock absorber within a few miles. Packing washers on units which have been operated with the fluid below the proper level, are apt to become worn, causing leaks around the shaft. Such leaks can only be corrected by replacing the shock absorber.

INOPERATIVE ABSORBERS

A broken or inoperative shock absorber can readily be detected by the lack of absorber resistance, or too much resistance. Check the resistance as described in checking for low fluid.

Too much resistance may be caused by broken internal parts, clogged valves or frozen pistons. No resistance may indicate a lack of fluid, dirt holding a valve open, a broken cam, or other broken internal parts. Check the absorber body to see that it is not cracked or broken.

NOISY OPERATION

Noisy operation is usually caused by looseness somewhere in the shock absorber linkage. However, when investigating the cause of this trouble, check and tighten the entire shock absorber mechanism. Check the shock absorber brackets to make sure they are tight, and see that the shock absorber is not striking or rubbing on the frame or other parts of the body or axle.

Check the rubber mounting bushings and replace if worn. Also make sure that the shock absorber arm is tight on its splined shaft.

Noise which is attributed to the shock absorbers, may be caused by worn or broken links or bushings, absorbers empty or low on fluid, stabilizer links and bushings, loose brake rods, loose tools, broken internal shock absorber parts, spring shackles or spring covers, loose metal parts such as fenders or bumpers, and loose shock absorber mountings.

If it is definitely determined that the shock absorber is at fault, it must be disassembled and the necessary parts replaced. If the necessary equipment is not available for making repairs efficiently, they may be exchanged for rebuilt units. This is especially important in servicing direct acting units.

RIDING COMPLAINTS

In handling riding complaints, do not make any valve changes before checking the amount of fluid in the shock absorbers. Also check the tire pressure, and see that the springs and spring bolts are properly lubricated and work freely.

DELCO
DOUBLE ACTING WITH INTERNAL VALVES

Operation: As the shock absorber arm moves downward, due to the vehicle spring rebound movement, fluid pressure opens the rebound relief valve by compressing the valve spring which limits the maximum rebound resistance of the shock absorber.

At the same time, the compression intake valve opens, due to the partial vacuum created in the compression cylinder, filling this cylinder with fluid.

As the shock absorber arm moves slowly upward, fluid is forced through the compression relief valve orifice to the fluid reservoir. During this operation, fluid flows through the rebound intake valve to the rebound cylinder. The size of the relief valve and spring, control the amount of fluid flow.

For rapid arm movement, sufficient fluid pressure is built up in the compression cylinder, to lift the compression relief valve from its seat by compressing a spring, which limits the maximum compression resistance of the absorber.

Service: An adjustment in the control of the shock absorber can only be made by changing the compression and rebound valves, as they control the flow of the fluid.

The shock absorbers must be removed and disassembled to make this change. To disassemble the unit, remove the end caps from the housing, using a special tool for this purpose, otherwise the end caps may become distorted and may impair the efficiency of the unit.

Drain out all the fluid and with a screwdriver, remove the ring that holds the valve in the piston. This will allow removal and replacement of the valve assembly.

Refilling: Disconnect the link at the lower end. Remove all dirt from around the filler plug before removing. Fill the unit to capacity, and work the arm up and down slowly while adding the fluid to expel all the air in the unit and allow the working chambers to be filled.

DOUBLE ACTING WITH EXTERNAL VALVES

Operation: This unit is similar to the double acting type with internal valves already described, except that it is much faster acting.

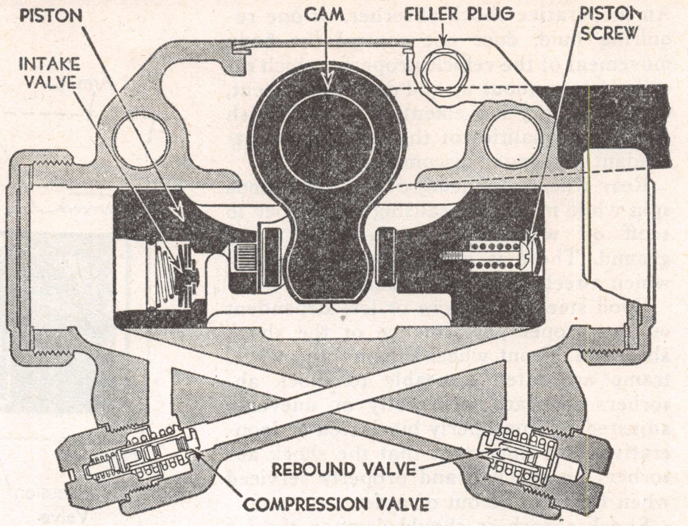
Its construction differs from the internal valve type in that the oil discharge is accomplished by means of two drilled passages from one end of the shock absorber body to the other.

The compression and rebound valves are located in the ends of these passages rather than in the pistons. These valves act as main control valves only.

An intake valve is provided in each piston, and its only function is to replenish fluid lost by piston leakage as the cylinder is filled under pressure from the valve discharge of the opposite cylinder.

On vehicles where the rear shock absorber is mounted underneath the axle, the shock absorber arm moves downward on compression, while on vehicles where the unit is mounted above the rear axle, the arm moves downward on the rebound, which is the case for the front units.

Service: An adjustment in the control can be made by changing the compression and rebound valves after removing the screws in which they are mounted. When reinstalling the valve cap screws, use new gaskets and if the new valves are of a different code, use new screws or re-stamp the original, which will prevent confusion when it becomes necessary to change the valves again. Be sure to refill the absorber after the unit is assembled.



DELCO Double Acting with External Check Valves

Refilling: This procedure is the same as already described for the double acting internal valve type.

DOUBLE ACTING WITH PARALLEL CYLINDERS

Operation: Upon compression of the vehicle springs, fluid is forced out of the lower (compression) cylinder through the compression valve directly into the upper (rebound) cylinder.

When the vehicle springs rebound, fluid is forced out of the upper cylinder through the rebound valve into the lower cylinder.

This method of discharging fluid always assures a full cylinder of fluid for either compression or rebound, and effectively controls the up and down movement of the springs.

Service: The only service that can be made on this unit is to change the compression and rebound valves. To do this, all that is necessary is to remove the screws in which they are mounted.

Refilling: Disconnect the link at the lower end and remove the filler plug. Fill the unit to capacity, and work the arm up and down while adding fluid. Replace the plug and connect the link.

SINGE ACTING WITH EXTERNAL RELIEF VALVE

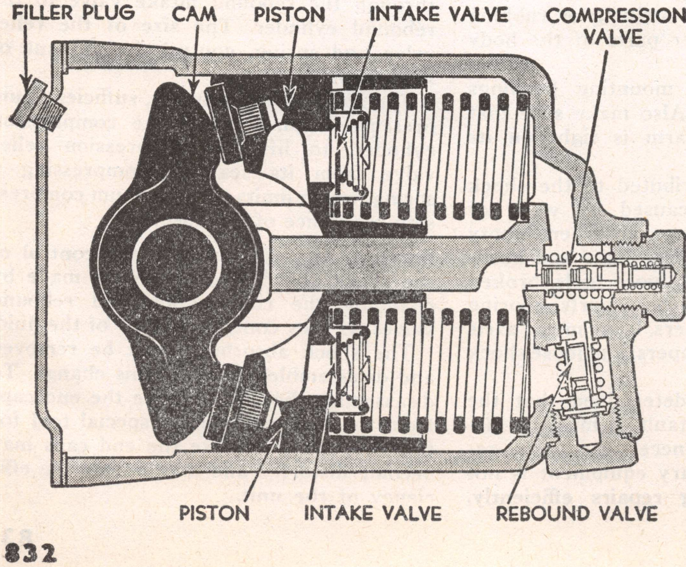
Operation: This type absorber provides control of the rebound only. The method is similar to the double acting type. The control valve is in the body of the shock absorber, and the intake valve is located inside the head of the piston.

Refilling: If the unit being serviced is not provided with a filler plug, it will be quicker and easier to replace the cover with one having a filler hole and plug, which can be obtained especially for the purpose.

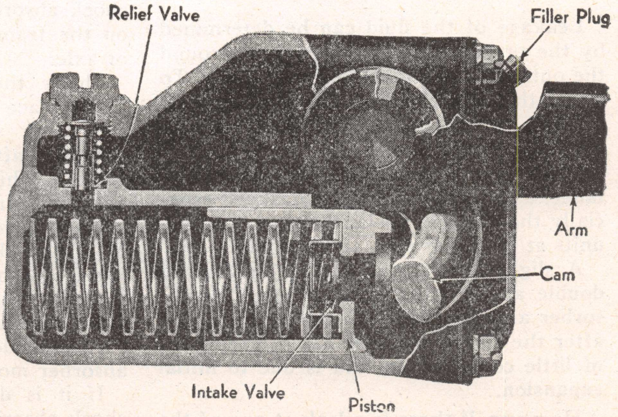
To make this change, clean all dirt away from the shock absorber cover and the vehicle frame with a wire brush, so that the dirt will not get into the absorber when the cover is removed. Do not disconnect the link until the cover with the filler plug hole has been installed.

Use an offset screwdriver to remove the cover screws. Pry off the cover and allow the old fluid to drain out. Scrape off the old gasket, and install the new cover and gasket, tightening the cover screws securely.

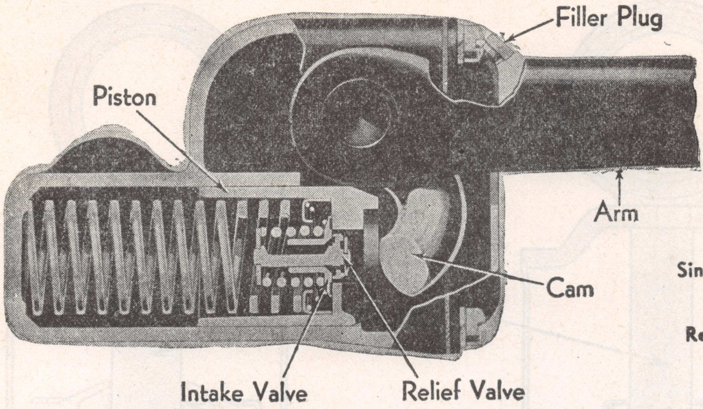
Disconnect the link at the lower end.



DELCO Double Acting With Parallel Cylinders



DELCO Single Acting with External Relief Valve



DELCO Single Acting with Internal Relief Valve

and refill the shock absorber through the filler hole, and work the arm up and down slowly while filling.

If this new cover is not convenient to obtain, the unit may be filled by removing the relief valve retaining screw.

SINGLE ACTING WITH INTERNAL RELIEF VALVE

The unit is the same as the single acting external relief valve type except the intake and relief valves are in a single assembly in the piston, which necessitates the disassembly of the unit to change the control.

Refilling: Disconnect the link at the lower end, and remove the filler plug. Fill the unit to capacity, and work the arm up and down slowly while filling.

DIRECT ACTING

Operation: When the vehicle spring is being compressed, the piston moves toward the lower end of the cylinder. Fluid is forced through the holes in the piston, lifting the valve plate, and enters the upper cylinder.

The volume of fluid thus displaced by the piston rod is forced out of the lower chamber through the valve orifice, through the opening into the surrounding reservoir.

As this opening is below the level of the fluid in the reservoir, no emulsion of fluid and air can be formed. The resistance to the vehicle spring travel is determined by the orifice in the valve, and in the strength of the valve discs.

When the vehicle spring rebounds, the resistance is instantly effective. As the piston is pulled up, the fluid in the upper chamber is forced though the slot in the valve plate, through the holes in the piston at its upper end, against the orifice plate.

As the pressure increases, fluid is forced through the orifice, compresses the rebound valve spring, and lifts the orifice plate from the valve seat, letting fluid pass into the lower chamber.

Since the piston rod is moving out of the inner chamber, the added displacement is compensated by a return flow of fluid drawn into the lower chamber from the surrounding reservoir, through the intake relief valve. The valve plate is lifted off its seat in this operation, allowing the fluid to fill the inner chamber

Absorbers Without Filler Plugs, Refill: It is of extreme importance that the absorber be refilled with the exact quantity of fluid recommended. Consult the Delco Direct Acting Capacity table for the unit being serviced.

When assembling the unit, see that the valve parts are installed perfectly flat, and they must be free from nicks and burrs. All parts must be thoroughly cleaned.

To disassemble the unit, clamp its lower end in a vise and pull out the absorber to its fully extended position. Do not clamp on the tube. Insert the lugs of a spanner wrench through the small holes in the dust shield so that they engage the slots in the piston rod guide inside of the absorber.

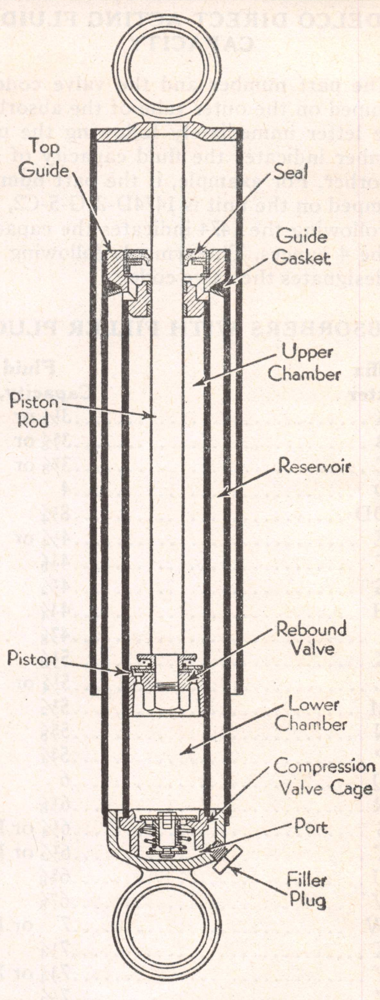
After disassembling the dust shield and reservoir tube from the pressure tube, tap out the compression valve assembly, while keeping the pressure tube extended. The compression valve is a press fit in the end of the pressure tube.

Empty the old fluid out of both the pressure tube and the reservoir tube. Place the dust shield and pressure tube in a vise. Fill a measuring cup with the exact quantity of fluid required (see capacity table) and pour the fluid into the pressure tube until it is filled.

Replace the compression valve in the end of the pressure tube, keeping the pressure tube extended. Pour the balance of the fluid from the measuring cup into the reservoir tube, with the reservoir tube in an upright position.

Place the reservoir tube in a vise and assemble the dust shield and pressure tube to the reservoir tube, keeping the pressure tube extended. Be sure to use a new rod guide retainer gasket. This gasket fits around the inside of the reservoir tube, and should be soaked in the fluid before assembling. Tighten both halves of the absorber with the spanner wrench securely.

Absorbers With Filler Plugs, Refill: Consult the Delco Direct Acting Capacity table for the exact quantity of fluid for the unit being serviced. Be sure that all the old fluid is drained out before refilling, as an excessive amount of fluid will damage the shock absorber.



DELCO Direct Acting With Filler Plug

Before removing the unit from the vehicle, note the position of the filler plug, which should be at the bottom and to the rear.

After removing the unit, clean all dirt from around the filler plug; pull out the shock absorber to its fully extended position and remove the filler plug.

Pump the piston back and forth until the absorber is completely empty of fluid. Clamp the fluid plug base end in a vise, with the filler hole up. Be sure that the absorber is in a horizontal position, or on a slant with the end which is not clamped in a lower position.

Use a special funnel which screws into the filler plug hole. Refer to the capacity table for the fluid capacity of the unit being serviced, and pour this exact amount into a measuring cup. Pour the fluid from the measuring cup into the funnel, and pull out the absorber to its fully extended position. Work the absorber back and forth until all fluid is worked into the unit, and replace the filler plug.

Before mounting the absorber on the vehicle, place the absorber in a vise in an upright position (same as when mounted on the vehicle) and work the unit up and down to expel any air pockets which may be present in the unit.

DELCO DIRECT ACTING FLUID CAPACITY

The part number and the valve code is stamped on the outer tube of the absorber. The letter immediately following the part number indicates the fluid capacity of the absorber. For example, if the part number stamped on the unit is 1474D-2-G-5-C2, the D following the 1474 indicates the capacity to be 4 ounces. The symbols following the D designates the valve code.

ABSORBERS WITH FILLER PLUGS

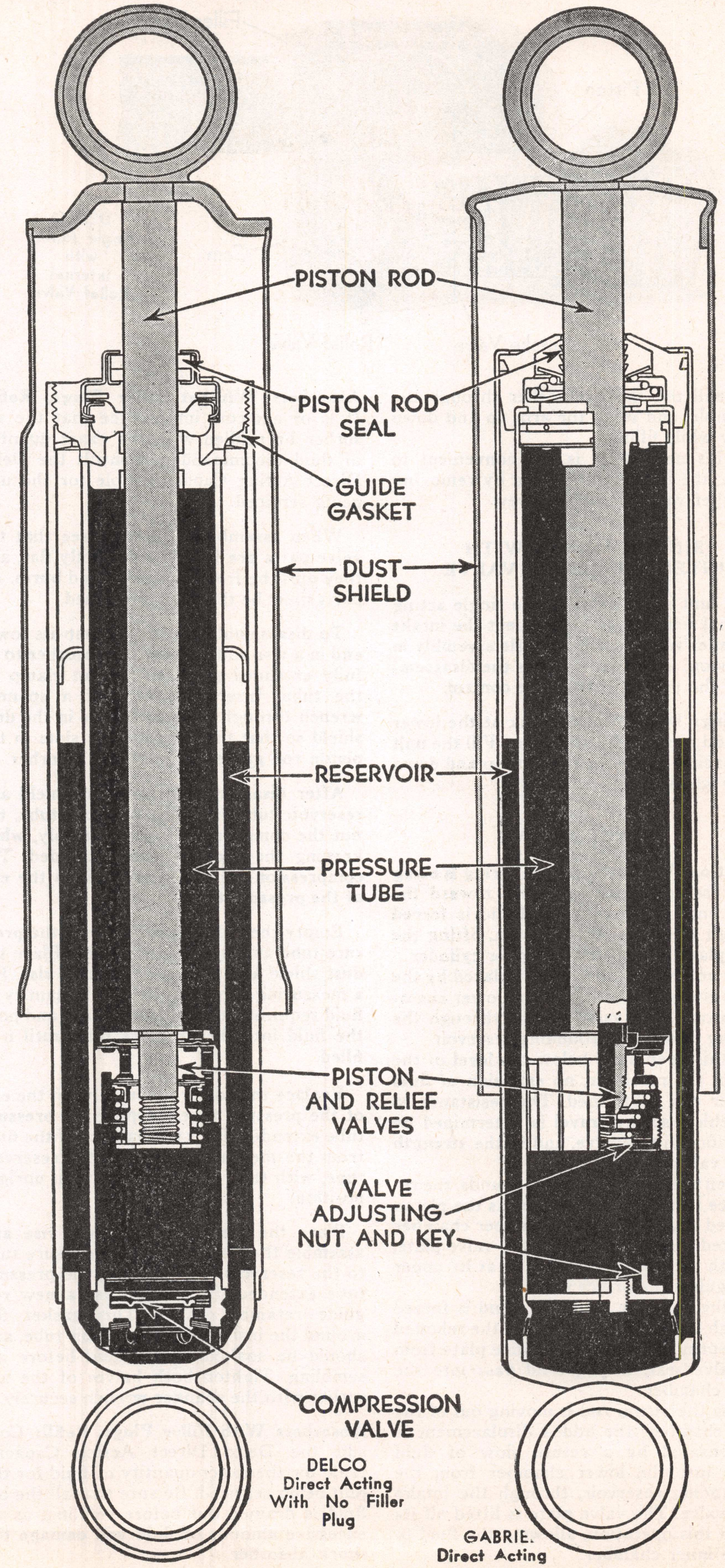
Suffix Letter	Fluid Capacity, oz.
*A	3½ or 4¾
*B	3⅝ or 5¼
*C	3⅞ or 5¼
D	4
DD	8¼
*E	4¼ or 6¾
F	4⅜
G	4½
H	4¾
J	4⅞
K	5⅛
**L	5¼ or 8¾
M	5½
N	5⅝
P	5¾
Q	6
R	6⅛
**S	6¼ or 10½
**T	6½ or 11⅛
U	6⅝
V	6⅞
**W	7 or 12
X	7¼
**Y	7¾ or 12⅝
Z	7½

*If the absorber has a hex head filler plug, it is a Spicer unit; use largest capacity shown.

**If the absorber is the large type (outer tube 2⅝" diameter) use largest capacity shown.

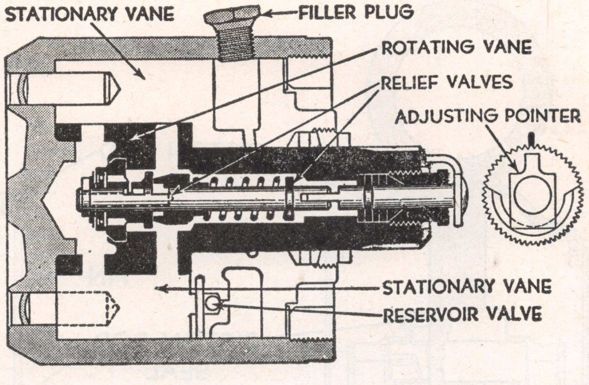
ABSORBERS WITHOUT FILLER PLUGS

Suffix Letter	Fluid Capacity, oz.
A	3½
AA	7½
B	3⅝
BB	7¾
C	3¾
CC	8
D	4
DD	8⅛
E	4⅛
EE	8¼
F	4¼
FF	8⅜
G	4½
H	4⅝
J	4⅞
K	5
L	5⅛
M	5⅜
N	5½
P	5⅝
Q	5⅞
R	6
S	6¼


PISTON ROD
PISTON ROD SEAL
GUIDE GASKET
DUST SHIELD
RESERVOIR
PRESSURE TUBE
PISTON AND RELIEF VALVES
VALVE ADJUSTING NUT AND KEY
COMPRESSION VALVE

DELCO Direct Acting With No Filler Plug

GABRIEL Direct Acting



HOUDAILLE
With External
Adjustment

T	6⅜
U	6½
V	6¾
W	7
X	7⅛
Y	7¼
Z	7⅜

The fluid capacity of the Delco direct acting shock absorbers can also be determined by measuring the collapsed length of the unit. These measurements are given in the following tables.

EYE TYPE ABSORBERS

The collapsed length of the eye type shock absorbers should be measured from the center line of the upper eye to the center line of the lower eye.

Collapsed Length, inch	Fluid Capacity, oz.
8	3½
8¼	3½
8½	3⅝
8¾	3⅞
** 9	4 or 6¾
9¼	4¼
9½	4⅜
9¾	4⅝
10	4¾
*10¼	5 or 4⅜
**10½	5⅛ or 8¾
10 11/16	5⅛
10¾	5½
11	5½
11¼	5⅝
11 5/16	5¼
11 7/16	5¾
11½	5⅞
*11¾	6 or 5¼
**12	6⅛ or 10½
12¼	6⅜
12 7/16	6¼
12½	6⅝
12¾	6¾
12 11/16	6½
**13	6⅞ or 12
13¼	7⅛
**13½	7¼ or 12⅝
13¾	7⅜
13 15/16	7⅜
14 3/16	7½
14 7/16	7¾
14 11/16	8
14 15/16	8⅛
15 3/16	8¼
15 7/16	8⅜

* If absorber has hex head filler plug, it is a Spicer unit. Use smallest capacity shown.

** If absorber is large type (2⅝" diameter) use largest capacity shown.

BAYONET TYPE ABSORBERS

The collapsed length of the bayonet type shock absorbers should be measured from the base of the stem (at the shoulder) to the base of the other stem (at the shoulder). If the unit is equipped with one stem and an eye, take the measurement from the centerline of the eye to the base of the stem (at the shoulder).

Collapsed Length, inch	Fluid Capacity, oz.
7¼	3½
7½	3⅝
7¾	3⅝
8	3⅞
8¼	4
8½	4¼
8¾	4⅜
9	4½
9¼	4¾
9½	5
9¾	5⅛
10	5⅜
10¼	5⅝
10½	5¾
10¾	5⅞
11	6
11 1/16	6¼
11¼	6⅛
11 7/16	6⅛
11½	6¼
11¾	6½
12	6⅝
12¼	6⅞
12½	7
12¾	7¼
13	7⅜
13¼	7½
13½	7¾
13¾	8
14	8⅛
14¼	8¼
14½	8⅜

GABRIEL

DIRECT ACTING

This unit is similar to the Delco direct acting shock absorber already described, but the fluid is sealed within the unit, there being no filler plug and the unit itself cannot be disassembled. The fluid capacity is about 8½ ounces.

There is an adjustment for control however, and normally, for average requirements, this adjustment is set at one turn open. If any change of adjustment is desired, make certain that the tires are inflated to the recommended pressure, and that the springs and shackles are lubricated and in good condition.

To make the adjustment, press the upper and lower cylinders together as far as they will go. If the unit is on the vehicle, disconnect the lower mounting, otherwise a complete collapse cannot be obtained.

When the unit is fully collapsed, keep the cylinders pressed together and turn slowly by hand to the right until the adjusting nut key can be felt slipping into the valve adjusting nut. Continue turning to the right until you feel a stop. This will probably require one turn, but never more than two turns.

The adjustable valve is now closed. Turn toward the left to open the valve. For a very firm to firm control, turn from ¼ to 1 turn from the closed position. For average control, 1 to 1½ turns from the closed position, and for a soft ride, from 1½ to 2 turns open.

NOTE—When performing this operation, use the hands only and do not force beyond the closed position. The adjustment valve should be left at least ¼ turn open. If fully closed, would give a very firm ride and damage the mountings. Do not try to force the stop positions.

HOUDAILLE

The working chambers of the Houdaille shock absorbers consist of a forged steel housing filled with fluid and divided into two equal sections by a stationary partition.

In each section, a wing on the shaft, connected to the shock absorber arm, oscillates with the vehicle spring.

In the partition, there is a check valve on either side of the shaft which permits the flow of fluid through the partition when the vehicle spring is compressed.

As soon as the rebound stroke begins, pressure of the fluid closes the check valves so that the only return for the fluid to its normal chamber on the other side of the partition is through drilled holes in the shaft.

A needle valve in the center of the shaft controls the size of the openings in the shaft, which regulates the resistance on the rebound stroke.

To obtain maximum performance, the working chambers must be completely filled with fluid, and must also be free from dirt so that the valves can open and close as required.

Unless the air, resulting from rapid operation, is eliminated from the working chambers, an emulsion is produced which destroys the operation of the unit.

Air is eliminated by means of an air vent, small enough, so that the air can escape, while the fluid can only escape when under pressure.

Two replenishing valves at the bottom of the housing keep the working chambers always filled with fluid, providing there is fluid in the working chamber. These valves close when the fluid in the working chamber is under compression.

A by-pass, cut in the wall of the housing at the neutral position of the wings, allows the vehicle springs to ride free on small or gentle bumps.

EXTERNAL ADJUSTMENT TYPE

The reservoir should be filled to the level of the bottom of the filler plug hole.

The adjusting pointer is set at the factory to meet the demands for average driving conditions. This position is indicated by a punch mark on the end of the shaft between the shoulder stops.

The resistance of the shock absorber can be adjusted by turning the pointer between the two shoulders. Turning the pointer clockwise increases the resistance until, when it contacts the shoulder, the valve is shut.

When the pointer is turned counterclockwise, the resistance is reduced until the pointer contacts the shoulder, when the valve is fully opened.

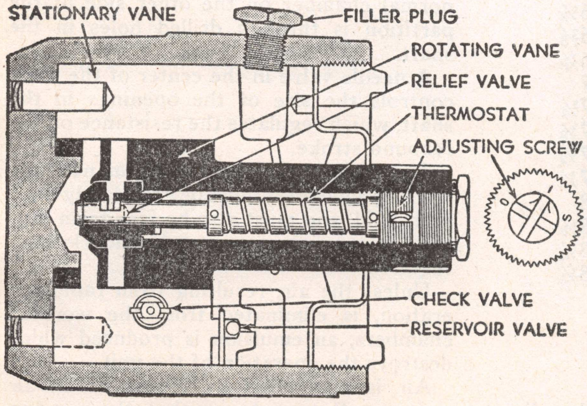
A slight movement of the pointer produces considerable change in the resistance, and therefore, it should not be moved more than 1/16" to ⅛" at a time.

INTERNAL ADJUSTMENT WITH THERMOSTATIC CONTROL

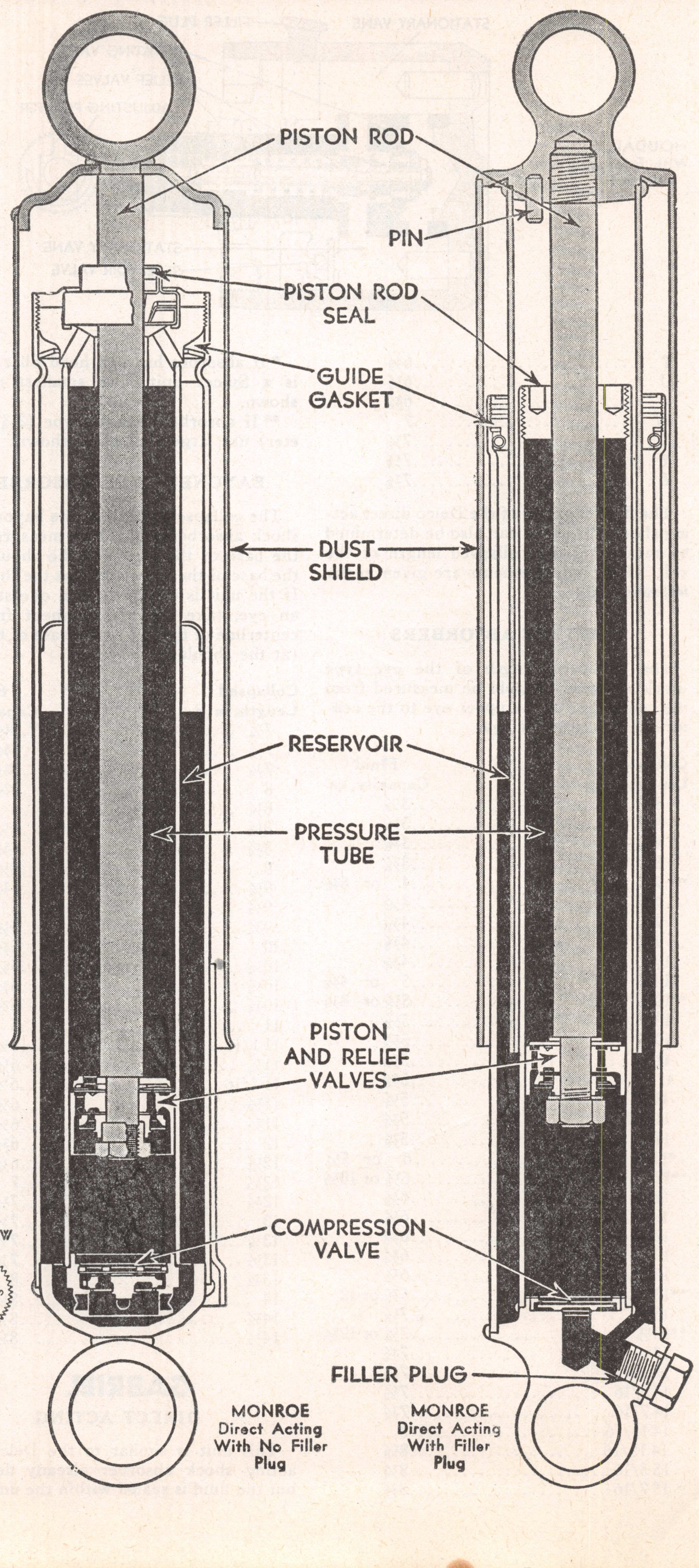
This unit is the same as described for the external adjustment type except that a thermostatic valve is fitted which automatically controls the absorber for uniform operation through all temperature changes. In addition, as the fluid passes through the orifice in the moving wing, it strikes the flat portion of the valve.

When the vehicle is driven on smooth roads, the valve retains its position as set by the thermostat.

When the vehicle is driven on rough roads, the impact of the fluid on the flat portion of the valve, closes the valve in proportion to the pressure of the fluid, to give an automatic ride control.


STATIONARY VANE
FILLER PLUG
ROTATING VANE
RELIEF VALVE
THERMOSTAT
ADJUSTING SCREW
O
S
CHECK VALVE
RESERVOIR VALVE

HOUDAILLE With Internal Adjustment and Thermostatic Control


PISTON ROD
PIN
PISTON ROD SEAL
GUIDE GASKET
DUST SHIELD
RESERVOIR
PRESSURE TUBE
PISTON AND RELIEF VALVES
COMPRESSION VALVE
FILLER PLUG

MONROE Direct Acting With No Filler Plug

MONROE Direct Acting With Filler Plug

Adjustment: The adjusting head is set for average driving conditions but can be adjusted to meet some special requirements.

To make an adjustment, remove the valve cap nut from the end of the shaft. This will expose the adjusting screw and the letters indicating the position of the valve.

The head of the adjusting screw has two slots; the deep slot with the arrowed indicator is used to stake the valve to the shaft through the means of a small shim inserted in the slot. The wide slot is the one which should be used when making an adjustment.

Unless the shock absorber has already been adjusted, the arrow will be directly in line with the punch mark located between the letters O and S on the end of the shaft. The letter O indicates that the valve is open, with the unit giving its least resistance. The letter S indicates that the valve is open, with the unit giving its greatest resistance.

A special tool is available which will fit the wide slot and permit adjusting the valve without damaging the soft brass head. Two wire horns extend from the shank of the tool to indicate the position of the arrowed slot while making an adjustment.

The full range of adjustment lies between the letters O and S, and the valve should never be turned beyond these points.

Turning the valve clockwise increases the resistance of the shock absorber, and counter-clockwise, decreases the resistance. Adjustments beyond the S mark will cause excessive pressures and leakage.

A slight movement of the valve produces considerable change in resistance, and therefore, the valve should not be moved more than 1/16" to ⅛" at a time.

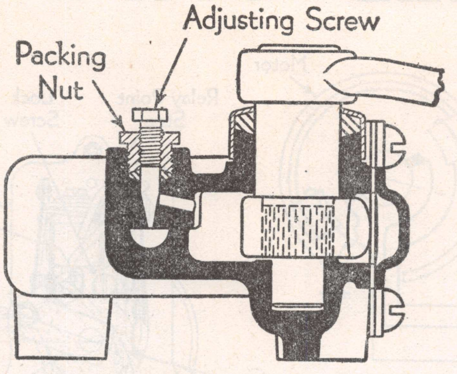
Refilling: The reservoir should be filled to a level just below the bottom of the filler plug hole.

MONROE

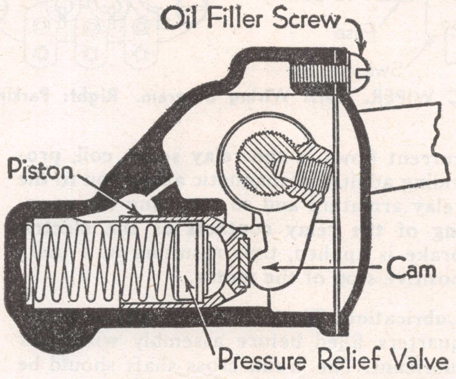
SINGLE ACTING

This shock absorber has an adjustable needle valve to regulate the flow of oil from the cylinder to the supply chamber as the cam on the shock absorber arm forces the piston into the cylinder on the spring rebound stroke.

Before making an adjustment, the unit should be completely filled with oil. The top cover fastening screw must be removed to fill the unit with oil and the oil poured in until it reaches the level of the screw hole.



MONROE SINGLE ACTING



MONROE SINGLE ACTING

To make an adjustment, turn the adjusting screw up tight and then back it off to give the desired ride. Never adjust it closer than 1/6 turn off its seat.

If there is a leak around the adjusting screw or adjusting screw packing nut, first turn the adjusting screw up tight to find out the present setting and then turn it back two full turns. Tighten the packing nut and reset the adjusting screw in its original position. Cover leaks generally can be stopped by tightening the cover screws. If this does not stop the leak, install a new cover gasket.

The shock absorbers should be inspected and refilled every 5,000 miles by removing the upper cover screw and filling the housing to overflowing at this screw hole. Move the arm up and down to make sure that the housing is completely filled and all air expelled.

There are no points of adjustment and if a change in the ride is required, the valve and piston assembly must be changed. The pressure at which the valve opens is determined by the weight of the spring steel disc which is permanently assembled to the piston. By replacing the piston assembly with one having a spring disc of a different weight, the ride control can be changed. Three assemblies are available, standard control, heavy control and light control. The assemblies used in front and rear units are not interchangeable. The shock absorber must be disassembled to replace a piston assembly.

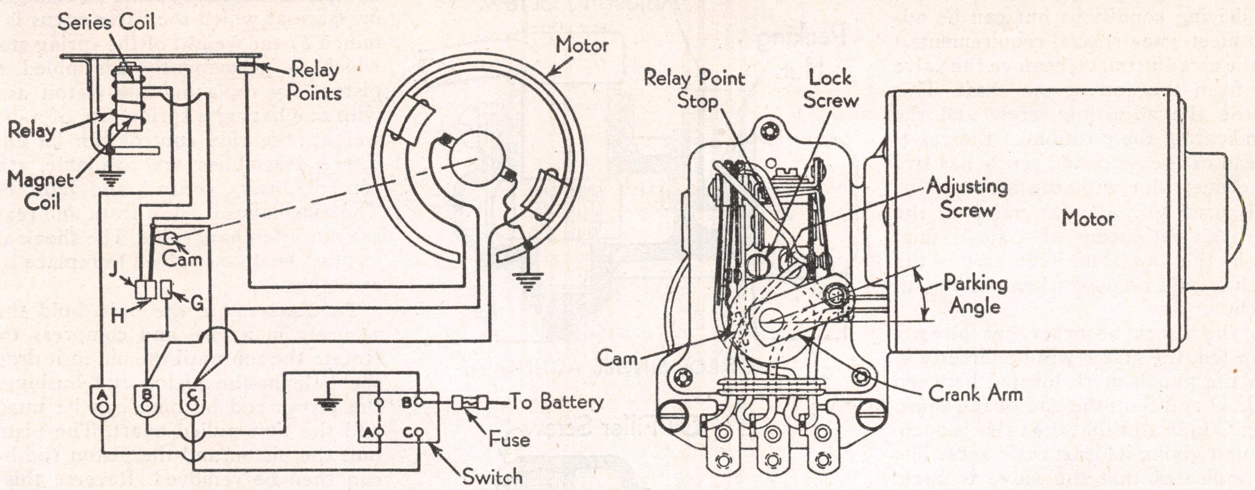
To disassemble the unit, hold the base securely in a vise and compress the top. Rotate the top until the pin in it drops into the hole in the piston rod bushing. Now the piston rod bushing can be unscrewed and the unit pulled apart. The piston rod nut, the piston and the piston rod bushing can then be removed. Reverse this order to assemble. Make sure that the piston rod bushing is assembled with the hole pointing toward the top. The nut at the bottom of the piston rod should be securely tightened and staked.

If leaks occur at the filler plug, it is merely necessary to replace the filler plug gasket or tighten the plug securely. The reserve chamber is permanently assembled and if leakage develops there, the unit should be replaced.

The shock absorbers should be removed, cleaned, inspected and refilled every 5,000 miles or at least twice a year. The shock absorber must be removed for refilling. Clean all dirt from around the filler plug and remove the filler plug. Pump all old fluid out of the unit. Clamp the base in a vise with the filler hole up. Compress the unit and screw the special filler cup, which is available from Monroe, into the filler plug hole. Pour the exact amount of fluid specified into the unit and pull the shock absorber to its extended position, drawing in the fluid. After all the fluid has been drawn in, force all air out by compressing the unit until the fluid level comes to the top of the filler plug hole. Replace the filler plug, using a new gasket. When installing the rear units on the vehicle, make sure that the gravel shield welded to the lower tube is toward the front of the vehicle.

DIRECT ACTING

The operation, service and refilling instructions are the same as described for the Delco Direct Acting units.



AUTO-LITE ELECTRIC WIPER. **Left: Wiring diagram. Right: Parking angle adjustment**

AUTO-LITE ELECTRIC

This wiper is a two-pole shunt-wound, electric motor, with two wiper arm pivots and the necessary linkage to connect the pivots to the motor. Its operation is controlled by a dash mounted switch and a fuse is installed in the circuit between the switch B terminal and the battery.

Some units use a 14-ampere fuse while a 20-ampere fuse is used on others. A fuse substitute or a fuse of a higher capacity from that specified should never be used. In some cases, this fuse is in the line between the switch B terminal and the ignition switch. In others, it is built into the switch.

In each pivot assembly is a friction clutch which allows the motor to operate without moving the arm in the event that movement of the arm is affected by heavy sleet, snow, etc. This clutch also permits the arm to be moved so that the windshield glass may be cleaned. The design of the clutch is such that a pull of from two to three pounds applied at the end of the wiper arm will allow it to slip.

It is essential that the motor, linkage and drive pivots be assembled so that they will operate freely, otherwise noisy operation or even failure will result.

Electrical Circuit: When the switch is turned on, the connection between the B and C terminals in the switch is closed, allowing current to flow through the motor armature and the relay magnet coil, closing the relay points and passing current through the motor field circuit, thus allowing the motor to start. When the switch is turned off, the motor will continue to run until the parking position is reached. This action takes place because the cam is not touching the armature controlling contact H and the current continues to flow to the motor until the cam opens the contacts G and H and in so doing closes contacts H and J. The closing of these contacts grounds the armature circuit and with current momentarily still flowing in the field circuit, acts as a dynamic brake to park the wiper arms. For an instant after contacts H and J close, current flows in the relay series coil, providing additional magnetic attraction to the relay armature and so retarding the opening of the relay contacts as the electric brake is applied, thus resulting in a more positive stop of the motor.

Lubrication: The gear box should be three-quarters filled before assembly with gear lubricant. The crank cross shaft should be greased along its entire length with this same lubricant before assembly in the housing. Care must be exercised that no grease or oil is allowed to get on the commutator or any of the contact points.

Test Data: The field current draw is 1.5 to 1.7 amperes at 6 volts. Amperage draw, running light, 3 to 4.5 amperes at 5.8 volts. Motor to start under load at 4.0 volts. Relay point gap should be .020" to .025" and is adjusted by bending the relay point stop. Never bend the relay armature hinge lug. Relay points close at 4 volts maximum. With the points closed the armature is to be seated flat against the top of the core. The relay points open at 0.2 volt minimum to 0.5 maximum. The relay shunt coil should have a resistance of 21 to 25 ohms at 80 degrees. The resistance of the series coil should be 0.035 ohm at 80 degrees.

Bearings: After the motor is completely assembled and before it is run, the frame should be given several sharp blows with a rawhide hammer to align properly the commutator end and drive end bearings with the armature shaft. If it is necessary to install thrust washers to reduce the end play of the armature to eliminate noise due to excessive end motion, it must not be reduced to less than 1/32 inch. This can be measured by removing the gear case cover and moving the crank arm back and forth.

The parking position is controlled by the relationship between the cam on the crank arm and the armature on which the contact H is mounted. It can be adjusted by loosening the lock screw and turning the adjusting screw until the angle is correct. When correctly adjusted there must be a gap of .025" minimum between contact points G and H with the unit stopped in the parked position. The contact pressure of these points at this position should be 2 ounces minimum. Under load the parking angle should be 21 degrees.

TROUBLE SHOOTING

Trouble: Motor will not start.

Cause: Blown fuse.

Remedy: If the relay points are dirty, clean them with carbon tetrachloride on a narrow strip of clean linen tape. After cleaning the points, draw a dry piece of tape between the points to remove any residue that may be on the contact surface. The points can also be cleaned with a file. After filing the points should be cleaned with carbon tetrachloride.

If the connections are poorly soldered they should be cleaned and resoldered.

If the wiper ground strap is loose, its screws should be tightened.

If the battery is discharged so that its voltage is too low to operate the relay, the battery should be recharged or replaced.

If the field or armature connections are grounded where the wires pass through the drive end head into the frame and field, a sleeve should be placed around these wires to protect them from sharp edge of die casting.

If the pivot clutch is inoperative, it should be replaced.

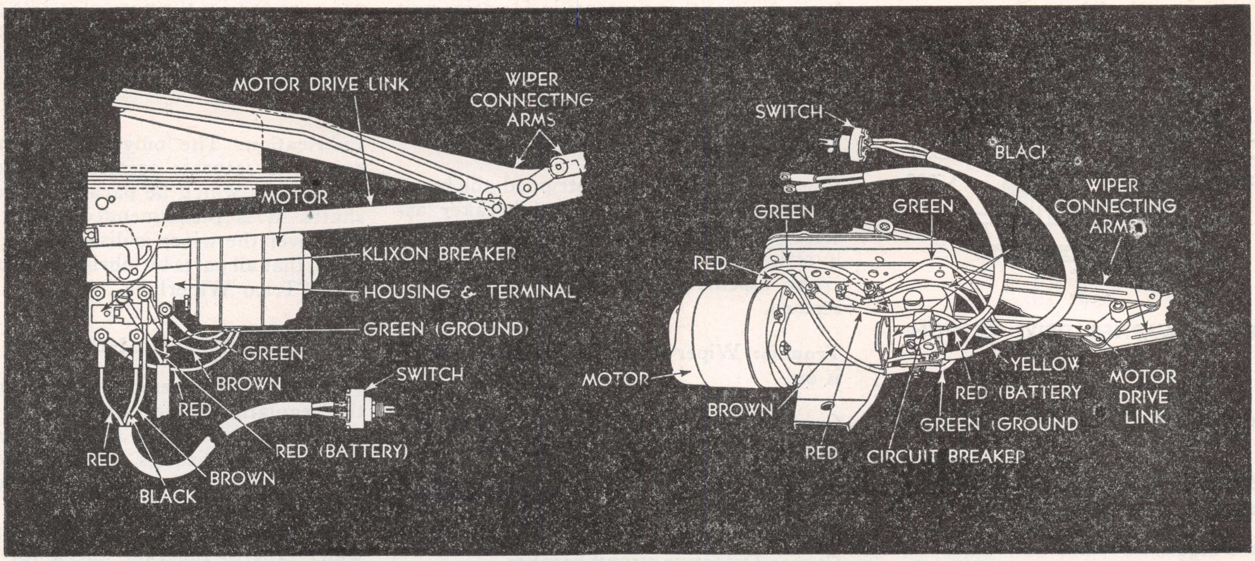
If the pivot shaft is frozen due to a bend or improper lubrication, the pivot assembly should be replaced.

Cause: Loose connections in the external circuit.

Remedy: Check and tighten the wiring between the ignition switch and the wiper control switch and also between the control switch and the wiper motor.

Cause: Crankshaft not free.

Remedy: Replace the drive end head, being sure that the crank cross shaft is greased for its entire length before assembling in the housing. Care must be used to see that all soldered connections are clean and tight.



STEWART-WARNER TWO-SPEED ELECTRIC WIPER. **Showing two applications.**

Cause: Linkage not free.

Remedy: Check linkage to be sure it is operating freely.

Trouble: Motor will not stop.

Cause: Incorrect relay operation.

Remedy: On units manufactured before December 1, 1938, the complete motor should be replaced. On units manufactured after that date, code letter S12, check the relay to be sure it is operating within specifications. If it is not correct, the relay should be replaced or adjusted. When replacing a relay be sure that the single lead which emerges on the lower side of the relay is connected to the A terminal and the two leads on the other side of the winding are connected as shown.

Cause: Loose connections at the control switch.

Remedy: Tighten either the connection at the switch A terminal or at the switch ground connection.

Cause: Parking mechanism out of adjustment.

Remedy: Adjust the parking mechanism so that it operates according to specifications.

Trouble: Overtravel of the right-hand wiper arm.

Cause: Movement of the right-hand pivot assembly in its mounting.

Remedy: Install a new right-hand pivot and pivot support assembly.

Cause: Excessive clearance in the bearings of the right-hand pivot assembly.

Remedy: Install a new right-hand pivot assembly: If the vehicle does not have welded supports on the body or the pivot support assembly, assemble a late type pivot support assembly.

Cause: Insufficient tension of the wiper arm and blade against the glass.

Remedy: Increase the spring tension to 5 to 6 ounces by bending the lower spring holding lug. This tension to be measured with the wiper blade and arm assembled on the vehicle and the reading taken as the blade leaves the glass.

Cause: Excessive side play between the wiper arm and blade.

Remedy: Press the two blades holding fingers on the wiper arm together to provide a press fit between the wiper arm and the blade. To facilitate the assembly of these two parts it is also necessary to bend the ends of the fingers as shown in the illustration.

STEWART-WARNER ELECTRIC

This wiper has two speeds. The wiper motor is connected through the ignition switch so that the ignition must be on for the wiper motor to operate. When the wiper switch is in its first "on" position the wiper is in high speed, and when it is in its second "on" position the wiper is in its low speed. The ignition switch must be on before the wiper will operate. Power is transmitted from the wiper motor to the wiper arms by means of a worm gear, fibre driven gear, crank, linkage and the transmission to which the wiper arms are attached.

When the wiper switch is turned off, the motor continues to operate until the blades are parked at the bottom of their stroke. When turned off, the wiper automatically goes into high speed to finish the stroke to the parked position. Parking is accomplished by automatic parking mechanism inside the drive unit which conducts current until the blades are parked. The parking mechanism declutches from the motor simultaneously with cutting off current from the motor, allowing the motor to coast to a stop.

To adjust the parking position of the blade, turn on ignition and the wiper switch. Then turn off the wiper switch, allowing the blades to park before turning off the ignition switch. Loosen the wiper arm nut several turns and loosen the arm on the shaft. Move the wiper blade to its proper parking position and tighten the slotted head nut securely.

Lubrication: The motor bearings require no lubrication and the drive and driven gears are lubricated for life when assembled. After a year or more of use, a few drops of oil should be put on the felt washers at the various linkage bearings. When replacing the bracket, driven gear and crank assembly, place a small amount of graphite grease on the fibre driven gear. Do not over-lubricate, causing grease to run out.

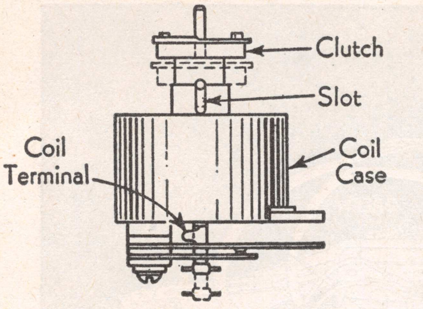
In order to replace any of the wiper parts located under the cowl except the wires, it is advisable to remove the entire wiper from the vehicle.

To remove the entire wiper from the vehicle, pull off the control switch knob and remove the switch mounting nut. Disconnect the red and the green wires at the switch. Remove the wiper arms by taking out the slotted head nuts. Remove the octagon nut and lift off the fibre washer, spacer and rubber gasket. Remove the nut holding the unit to the mounting stud. This allows all the wiper parts under the cowl to be removed as an assembly, provided nothing else, such as a glove compartment, radio or heater, is in the way.

To replace the circuit breaker, disconnect the red, green and brown wires at the circuit breaker. Unsolder the short black wire between the motor and the circuit breaker at the circuit breaker. Remove the nut at the bottom of the circuit breaker Install a new circuit breaker by reversing this procedure.

TROUBLE SHOOTING

Trouble: Wiper does not change speed when turned from first to second "on" positions or wiper runs excessively fast.



STEWART-WARNER DRIVE CLUTCH

Cause: Loose or broken resistor connections.

Remedy: Check resistor connections without removing wiper from vehicle.

Cause: Defective switch.

Remedy: Disconnect four wires leading to switch and connect new switch and cable assembly to the wiper. Then test to see if wiper changes speed when new switch is operated.

Cause: Burned out resistor.

Remedy: Entire wiper assembly must be removed from the vehicle and resistor replaced. Remove the entire drive unit from the bracket by taking out two screws. Unsolder the lead wires at either end of the resistor. Solder a new resistor in place. Attach the drive unit to the bracket with two screws and lock washers. Be sure that the small washer is over the driven gear shaft and that the gasket is in place.

Trouble: Wiper motor runs when switch is on but wiper crank does not operate.

Cause: Defect in motor drive shaft, springs or drive clutch.

Remedy: Remove the entire wiper from the vehicle, disconnect the motor from the drive unit housing and remove all parts inside drive unit. Examine the motor drive shaft, springs and drive clutch and replace any defective parts. Make sure that the arm on the drive clutch is not worn and swings freely on its pivot. Also examine the ears of the clutch member attached to the coil assembly.

Cause: Defective or worn coil, shaft and contact assembly.

Remedy: Test the coil by connecting one terminal of a regular 6-volt storage battery to the case of the coil and the other battery terminal to the coil terminal onto which the wire is soldered. The clutch member of the coil should be drawn down to position shown by the dotted lines when this is done. Hold the coil assembly in the position shown with the cross pin of the clutch member in its slot when making this test. If the clutch member does not move, replace the entire coil, shaft and contact assembly.

Cause: Contacts inside drive unit housing dirty or bent.

Remedy: See that contacts inside drive unit housing are clean, that terminals of connecting leaf springs on end of coil are clean and are not bent out of position. These springs are normally parallel with coil face.

Cause: Stripped drive or driven gear.

Remedy: If drive gear is stripped, the housing, drive gear, resistor and breaker assembly must be replaced. If the driven gear is stripped, the bracket, driven gear and crank assembly must be replaced as described.

Trouble: Wiper does not run when switch is on.

Cause: Loose connections at ignition and wiper switch which must be fixed.

Remedy: Check all wire terminals to make sure that connections are tight.

Cause: Defective circuit breaker.

Remedy: Check circuit breaker by shorting across terminals B and C. If wiper operates when this is done, the trouble is in the circuit breaker and it must be replaced.

Cause: Defective switch and cable assembly.

Remedy: Connect new switch and cable assembly to wiper and test. If wiper operates, switch and cable assembly must be replaced.

Cause: Defective motor.

Remedy: Test motor by connecting the red and the green motor lead wires to one terminal of a 6-volt storage battery, and the brown lead to the other battery terminal. If the motor does not run, replace with a new unit. If the motor operates, check for dead spots in the motor. To do this, detach the motor from the housing. Place a screwdriver in the slot in the motor drive shaft and, while the motor is connected to the battery, allow the drive shaft to revolve very slowly until it has made at least one complete revolution. If a dead spot is found, a new motor must be installed.

TRICO FOLBERTH

PRESSURE WIPER

With this type wiper, the most important consideration is to see that the air supply is kept free from excess oil, water, dirt, grit or other foreign matter. A clean air supply insures against rust, gumming or premature wearing of the piston or valve parts. Most vehicles are equipped with air strainers as part of the compressor system. However, if the air compressor system is not equipped with an air strainer or filter in the air line, the installation of one will insure dependable operation of this type wiper.

NOTE—Failure of this type wiper is often traceable to forcing the wiper arm against pressure or past the normal stroke position. When the arm is forced against pressure, a strain is placed on the valve mechanism which will very likely cause damage to these parts.

Lubrication: The only lubrication necessary is to saturate occasionally the oil retainer felts which lie parallel to the wiper shafts. It is recommended however, that whenever the wiper is disassembled for repairs, that all parts be lubricated thoroughly with "Trico Wiperlube."

TROUBLE SHOOTING

Check the air pressure at the wiper with the regulating valve turned on. If there is no pressure, check the air line for obstructions, plugged fittings, kinked tubing, scaling or flaking rubber hose, oil soaked hose or loose connections and leaks.

If the air line is satisfactory and the wiper fails to function, check for the following causes:

Wiper works slowly or uneven: A—Shaft binding in the bearings. B—Wiper arm or blade binding. C—Wiper not mounted squarely on the windshield.

Wiper runs slowly or no power: A—Leather diaphragm leaking. B—Defective valve.

Wiper operation jerky: Bent connecting rod.

Wiper works only in one direction: A—Broken connecting rod. B—Valves bent, gummy or sticking.

Wiper will not operate: A—No air pressure. B—Clogged line. C—Valve broken or defective. D—Broken gear sector or rack. E—Valve stuck or piston gummed or dirty.

WIPER, OVERHAUL

NOTE—For all internal repairs it is necessary to remove head assembly "A" Fig. 1. If necessary to take motor apart, all parts should be carefully checked for wear and lubricated before assembly. Worn parts should be replaced.

Valve Head, Remove: Remove 6 screws, turn handle "B" so as to bring gear rack assembly "C" as near as possible to the head. Lift head and unhook connector rod assembly "H" Fig. 2. To replace head, move gear rack assembly "C" (use handle) as near to the opening as possible. Raise connecting rod "H" and hook under wire "D" Fig. 1, making sure that air passage in head is directly opposite air tube in cylinder. Then move rack assembly slightly away from end to provide clearance for assembly head. Use new gasket "E" when replacing head.

Valves and Head, Repair (Use Trico Parts Package No. 1079): Remove head as outlined above and cut wire "N" Fig. 3 holding valves and levers. Remove wire and levers and replace valves "O." Valves must now be seated. (Use Trico Tool No. 3544-1). Insert new wire "N" in valves. (Do not flatten ends). Lay valve head in vise and place fork of tool around valve so that it rests

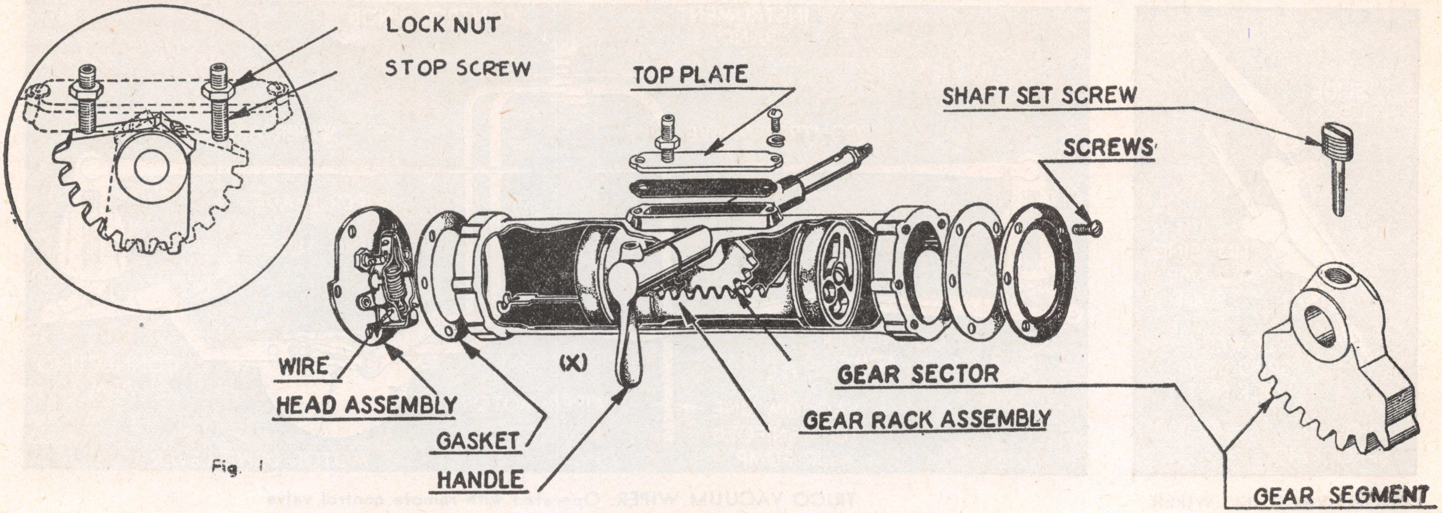


Fig. 1

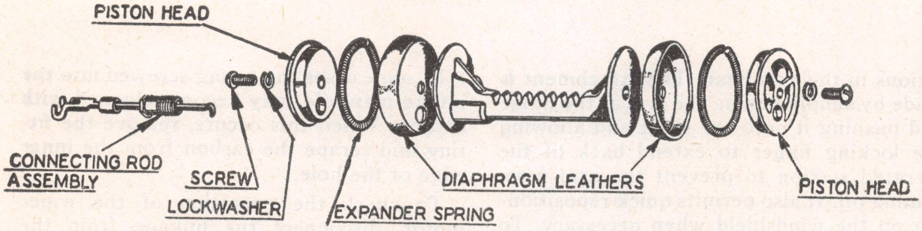


Fig. 2

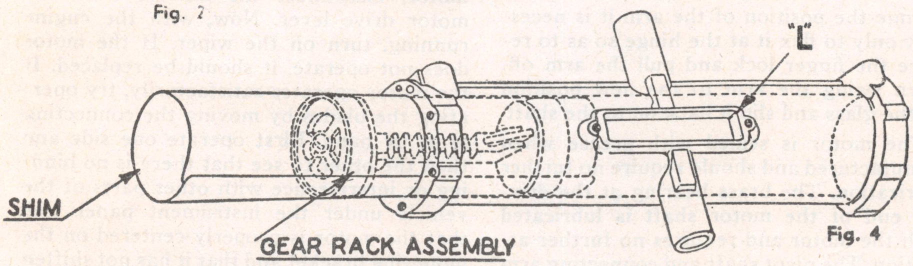


Fig. 4

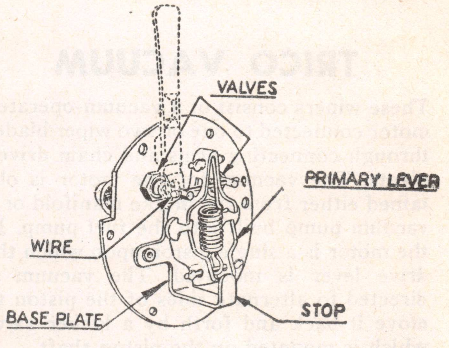


Fig. 3

TRICO FOLBERTH PRESSURE WIPER

on top of wire and tap lightly with a hammer. Now slip tool under the wire so that anvil rests on the surface of the head proper and tap tool lightly at a point back of the anvil. This will cause the end of the tool to rise, seating the valve in that direction. Follow same procedure for the other valve.

CAUTION—Do not strike valve proper. Remove wire, replace levers, slip wire through valve and flatten end to hold in place.

Now work primary lever "P" back and forth. Make sure that valves click (or seat) when primary lever is midway between stop "R" and base plate "S"; otherwise the levers may strike the plate or stop before the valve reverses. Adjustment can be made by moving base plate toward casting by tapping it lightly, or away from casting by inserting a screw driver between the plate and casting. Place a small amount of grease on all moving parts and replace head.

Diaphragm Leathers, Replace (See Fig. 2): Remove head as outlined above. Then remove top plate "F" Fig. 1, by removing two screws. Then remove shaft set screw "G," pull out shaft and remove gear sector. Gear rack assembly can now be withdrawn from cylinder.

Dismantle assembly, replace damaged or worn leathers or other defective parts. Clean all parts thoroughly; lubricate leathers and cylinder wall with "Trico Wiperlube" (a special formula grease designed for this purpose.) Reassemble, making sure that all parts are placed in their relative positions as shown on Fig. 2. When replacing expander spring, loop ends together so that the spring will be approximately 1/16" larger in diameter than the piston head "K." (This will insure proper pressure against the walls of the leather.)

CAUTION—Do not try to reassemble gear rack assembly into cylinder without the use of shim as follows: To slip gear rack assembly into cylinder, wrap entire rack in steel shim as shown in Fig. 4. Insert rack and shim into cylinder far enough to pass opposite end of opening "L". Hold shim and push rack down as far as it will go. Now hold rack at this point with screw driver and withdraw shim, Then grease end of cylinder before replacing head.

Shaft Replace: Move rack to center of cylinder and insert gear sector "M" Fig. 1, making sure that the teeth match those in the rack. The last tooth in the sector should go into the last tooth of rack at either end. Before inserting sector, place a little grease on the teeth, then insert shaft through housing sector and replace set screw.

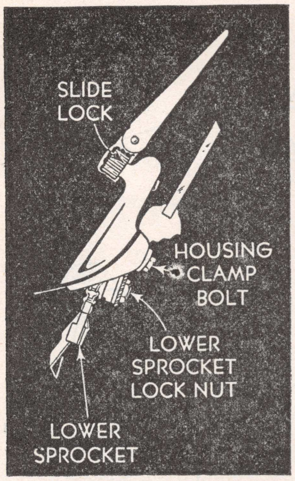
CAUTION—Run set screw down tight.

Connecting Rod Assembly, Replace: Remove head as outlined above. Move gear rack assembly as close to opening as possible. Unscrew connecting arm "H" Fig. 2. Replace connecting rod assembly and tighten securely.

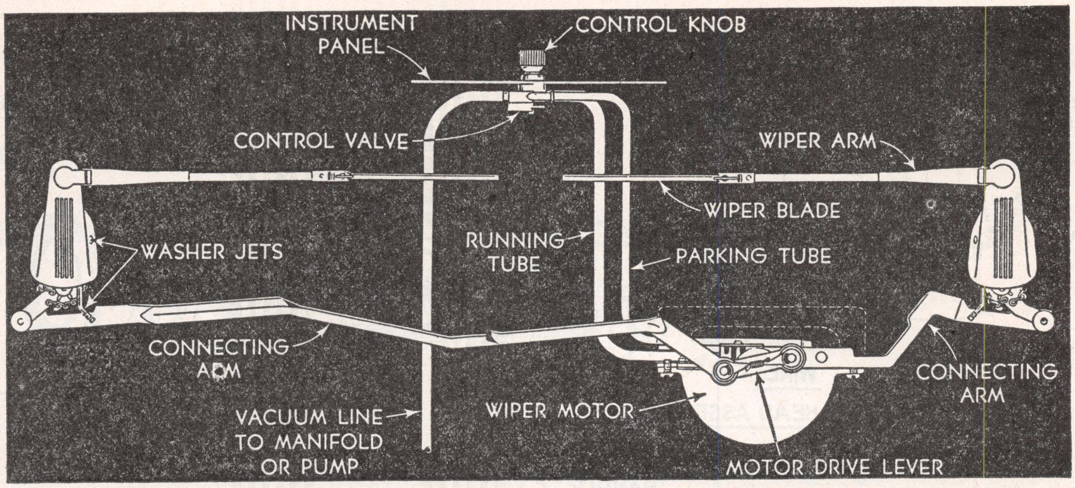
NOTE—When replacing this part do not substitute. Obtain exact duplicate by ordering F-415 and specifying the degree of stroke marked on the motor.

Broken Gear Segment, Replace: Remove top plate and gear segment as outlined in Item No. 3, and replace as outlined in Item No. 4.

Stop Screws, Adjust: Turn wiper on and let operate at slowest possible speed. Loosen lock nut "T" Fig. 1 and run down stop screw "U" until wiper is stopped by screw. Now back out screw just enough to permit wiper to operate. With stop screw in this position, run down and tighten lock nut. Repeat operation on other stop screw. These instructions must be carefully followed otherwise screws will be improperly set.



TRICO VACUUM WIPER. Showing side view of housing



TRICO VACUUM WIPER. Operated with remote control valve

TRICO VACUUM

These wipers consist of a vacuum-operated motor connected to one or two wiper blades through connecting arms and chain driven pivots. The vacuum for the motor is obtained either from the intake manifold or a vacuum pump built into the fuel pump. In the motor is a single piston upon which the drive lever is mounted. The vacuum is directed to alternate sides of the piston to move it back and forth by a kicker valve which is mounted on the piston shaft.

A new remote control valve used on late production units, utilizes three tube outlets. One tube leads to the intake manifold and the other two to the wiper motor. The tubes to the wiper are two sizes. The larger tube for use when running and the smaller tube for use when parked. To operate this wiper, the control is turned in exactly the same manner as the direct type used on other models. Movement of the knob regulates the flow of air to the wiper and provides for a wider range of speed adjustment than obtained in some direct or straight mechanical types. It also permits positioning of the control several inches or feet away from the wiper motor without sacrificing the positive blade parking feature. This positive parking is accomplished by means of a differential valve built into the motor cover. When the control valve is turned to the "off" position, it changes the course of the vacuum from the running line to the parking line and causes the differential valve of the motor to close off the running port, thus placing full vacuum on the parking piston.

Some remote control governors include a built-in governor which provides for more uniform speed of the wiper. With the type, the valve stem is pulled out to turn on the wiper, pushed in to shut it to parking position and turned to regulate the speed.

The Snap-On-Type of wiper arm attachment insures positive positioning on the shaft and simplifies the installation. On earlier wipers the arm was held to the shaft by means of a nut. The new design embodies a serrated shaft with matching serrations in the arm head. The attachment is made by simply flexing the arm at the hinge and pushing it onto the shaft and allowing the locking finger to extend back of the serrated section to prevent the arm from coming off. It also permits quick repositioning on the windshield when necessary. To change the position of the arm it is necessary only to flex it at the hinge so as to release the finger lock and pull the arm off. Then swing the arm to the new position on the glass and slip it back on to the shaft.

The motor is sealed with grease when manufactured and should require no further lubrication. The brass bearing at the driving end of the motor shaft is lubricated with the motor and requires no further attention. The pivot shaft and connecting arm joints are fitted with oiled felts. To oil felts, remove wiper arms and blades and inject a little oil around each shaft at the joints.

Service: To check the vacuum line for leakage, disconnect the fitting at the manifold, slip the hose from the wiper and stop up one end of the tube by holding the thumb over it. Blow cigaret smoke into the other end of the tube. Smoke will appear at any point in the hose where there is leakage. If the hose is in good condition, see that all connections are tight. Inspect the line to make sure that the tube is not pinched or kinked and that it is not plugged. Oil soaked, porous or hose which is defective from any other cause should be replaced. The hose should be kept away from the exhaust manifold or excessive heat from any other source. See that the tubing does not come in contact with moving parts of the engine or the wiper, for it might cause wear or an unpleasant rattle.

If the vacuum line is connected to a vacuum pump, test for a leaky diaphragm. With the engine running, slip the hose from the wiper motor and place your thumb over the end of the hose. If the diaphragm is okeh, a steady suction will be felt. If a pulsation is felt or if there is no suction at all, and the line is not plugged or does not leak, it indicates a leaky pump diaphragm which should be replaced.

In some cases the fitting screwed into the intake manifold may become clogged with carbon. When this occurs, remove the fitting and scrape the carbon from the inner edge of the hole.

To check the operation of the wiper motor, disconnect the linkage from the motor drive lever. Now, with the engine running, turn on the wiper. If the motor does not operate, it should be replaced. If the motor operates satisfactorily, try operating the blades by moving the connecting arms by hand. First operate one side and then the other to see that there is no binding or interference with other parts of the vehicle under the instrument panel. See that the motor is properly centered on the mounting bracket and that it has not shifted to an angle which might put a bind on the connecting arm where it attaches to the motor drive lever. The driven end of the connecting arm is fitted with a ball joint which helps to compensate for any misalignment in the installation but the end which is attached to the stud on the motor lever is snug fitting and any undue twist or bend here may cause a bind which will slow down the motor.

The chain drive transmission housing clamping bolt must be tightened firmly to prevent any looseness or rocking of the casting during wiper operation. This will also insure against possible leakage around the gasket. To test the chain for looseness, stop the engine while the wiper is running. Then move the blades by hand to their vertical position on the windshield. Hold the connecting arm under the cowl firmly and move the wiper arm from side to side slightly. If correct, the end of the blade should not travel more than approximately 1½ inches before power is transmitted to the connecting arm. If the wiper arm can be moved more than this, it indicates that the chain is loose. The chain can be tightened by loosening the lower sprocket lock nut. Then pull down the lower sprocket, and while holding it taut, tighten the lock nut securely. In some cases it may be necessary to remove the linkage from the vehicle to do this.

The early type of Snap-On-Arm included a separate wirelock. When this type is used, see that the end of the wire is hooked firmly over the back of the driving burr. See that the arm travel does not permit pounding of the blade against the windshield at either side. If the blades do not park properly, or if the cleaning arc is not central, remove the wiper arms from their shafts. With the engine running, turn off the wiper to bring the shafts into their parked position. Then, place arms in their parked position on the windshield and slip them over the shafts as already described. If the blade has excessive travel after doing this it indicates that the wiper motor is off center. To correct this condition, the motor mounting screws should be loosened and the motor shifted slightly to the right or left until the blade is equalized on both sides of the windshield. Then tighten the mounting screws securely. Further reduction of the blade sweep can be accomplished by changing the valve kicker in the motor. Also see that the arm clip is not bent and that the blade flops back and forth at each stroke of the arm so that the arm will pull, not push, the wiper blade.

TRICO VISIONALL

AIR PRESSURE WIPER

The air supply must be kept free from water, dirt, grit or excessive grease or oil. A strainer or filter is recommended to be placed between the wiper and the supply tank.

SERVICE INSTRUCTIONS

1. Check the air supply line for plugged or kinked tubing, leaks, oil soaked rubber hose or clogged fittings.
2. Check Visionall motor for air leaks. With the air valve open, listen for escaping air. Make sure the motor is oiled thoroughly.
3. To oil the motor, use a light gum free oil. Trico recommends their Zero Mix Oil No. 2. Remove the oil screw at the inlet and inject oil through the hole while moving the cylinder in the normal operating manner. Allow the valve to trip at the end of each stroke. Do not force the cylinder against pressure. Allow excessive oil to remain in the motor to soften the leathers and saturate the felts. Place a few drops of oil on the roller bearings (B, Fig. 2). If the cylinder and tubes (C, Fig. 2) are excessively dirty or gritty, remove the entire motor from the windshield for a thorough cleaning.

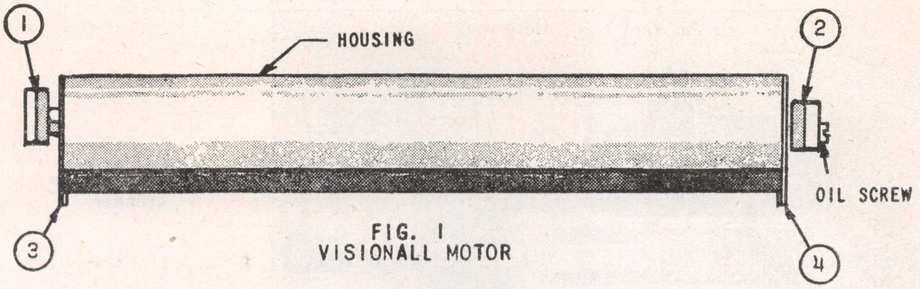
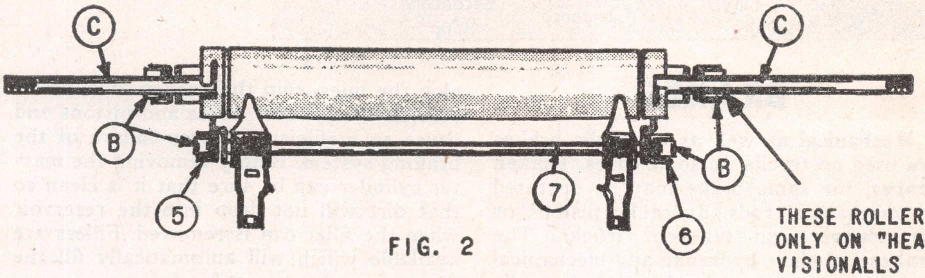


FIG. 1
VISIONALL MOTOR



THESE ROLLERS APPEA
ONLY ON "HEAVY DUTY
VISIONALLS

FIG. 2

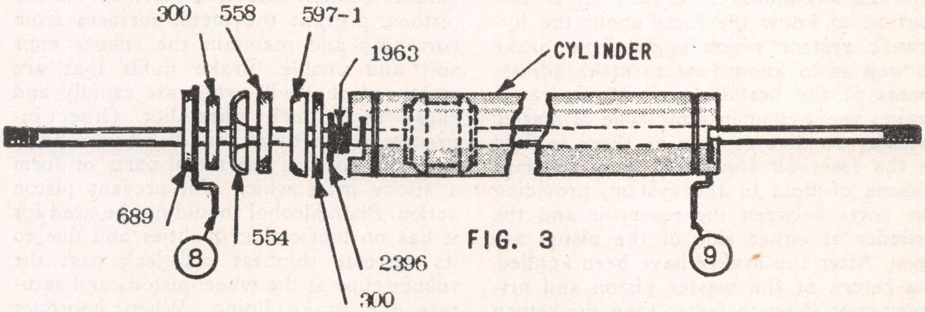
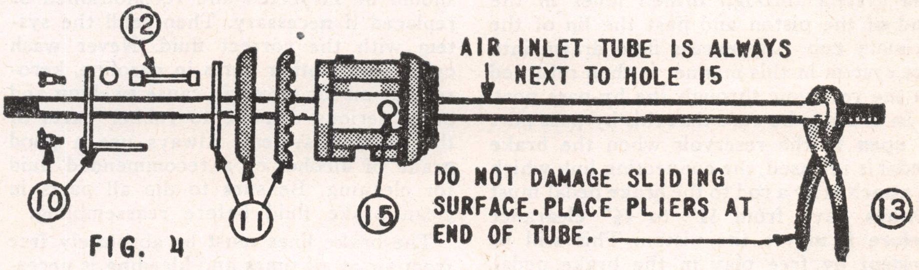


FIG. 3



AIR INLET TUBE IS ALWAYS NEXT TO HOLE 15

DO NOT DAMAGE SLIDING SURFACE. PLACE PLIERS AT END OF TUBE.

FIG. 4

TRICO VISIONALL (4 views)

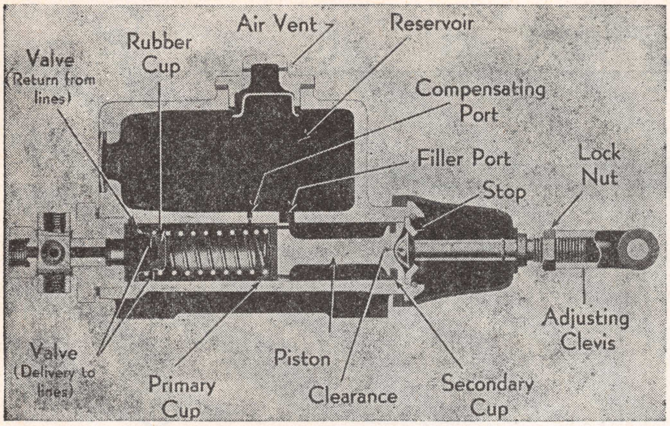
REPAIRS

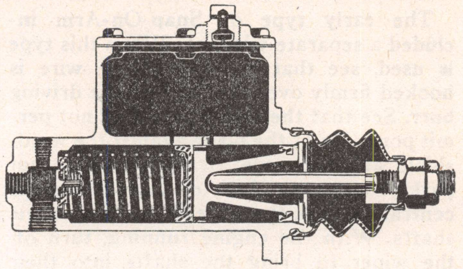
1. Unscrew the end fittings (1 and 2, Fig. 1) and remove the end plates (3 and 4, Fig. 1), being sure they are marked to assure correct assembly.
2. Unscrew the end rollers (5 and 6, Fig. 2) and remove the wiper arm carrier assembly (7, Fig. 2).
3. Remove the end plates (8 and 9, Fig. 3) by turning them slightly to withdraw them from the slots. This will permit the removal of the piston assembly together with the end bearings, packing, springs and felts.
4. The end bearings may be released by sliding the tube back and forth in the cylinder. Be sure to make note of the correct position of bearings, leathers, felts, etc.

CAUTION—The slide plate, leather and expander are secured by two screws (10, Fig. 4). Do not remove the tubes unless the piston is damaged. However, the tubes may be unscrewed by carefully holding with pliers near the outer threads. Assemble the tube with the breather hole (15, Fig. 4) toward the air inlet tube.

When assembling, replace with new leathers and expanders which are available in a repair parts kit. To insert the piston into the cylinder, wrap brass shimming or paper around the leathers to form a sleeve, which will avoid damage to the leathers. Be sure the cupped leathers are assembled without kinks. Special assembly tools are available for this operation which will assure correct assembly into the cylinder.

BRAKES





Hydraulic master cylinder.

BRAKES

Mechanical as well as hydraulic brakes are used on trucks. In some cases, Timken brakes, the same brake may be operated by mechanical rods, hydraulic pistons or air plungers on different trucks. The brakes and their hydraulic and mechanical controls are covered in this chapter while the vacuum power units and air brake units are in separate chapters.

As the majority of cars are fitted with hydraulically-operated brakes it is important to know the facts about the hydraulic system which applies the brake as well as to know how to make adjustments at the brake shoes. All hydraulic brakes use a compensating type of master cylinder so that as long as there is fluid in the reservoir there will be a constant volume of fluid in the system, providing the ports between the reservoir and the cylinder at either side of the piston are open. After the brakes have been applied, the return of the master piston and primary cups is much faster than the return of fluid into the master cylinder. A momentary vacuum is created in the cylinder barrel and additional fluid is drawn into the system through drilled holes in the end of the piston and past the lip of the primary cup. Any excess fluid drawn into the system in this manner is then returned to the reservoir through the by-pass port.

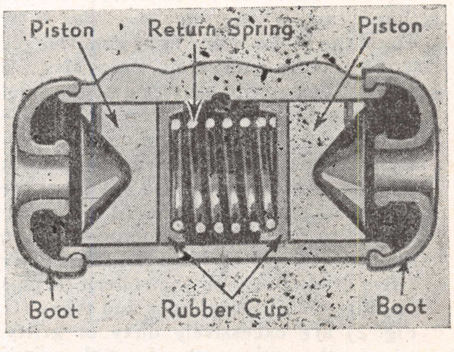
In order to be sure that this by-pass port is open to the reservoir when the brake pedal is released, the connecting link which is attached by a rod to the brake pedal must always have from ¼" to ⅜" clearance before it moves the piston. This will be evident by free play in the brake pedal. If this free play is not present the compensating action of the master cylinder will be destroyed and the brakes will drag. The reservoir over the master cylinder must be kept at least half full of fluid at all times to prevent air from entering the system.

The fluid in the master cylinder reservoir should be checked every 2,500 miles and also when the brakes are adjusted. It should be slightly below the bottom of the filler hole. If the fluid level is allowed to get low it will be necessary to bleed the system. Absolute cleanliness is necessary when serving the hydraulic system because any foreign matter in the system will tend to clog the lines, ruin the rubber cups, pit or scratch the cylinder bores and pistons and cause an inefficient or even failure of the braking system. Before removing the master cylinder cap be sure that it is clean so that dirt will not drop into the reservoir when the filler cap is removed. Fillers are available which will automatically fill the reservoir to its correct level.

Great care must be used in the selection of the brake fluid for it must not be materially affected by either high or low temperatures and it must be a lubricant for the pistons, prevent the metal surfaces from corroding and maintain the rubber cups soft and pliable. Brake fluids that are mostly alcohol will evaporate rapidly and cause vapor lock when hot. Other ingredients sometimes found in brake fluids rust and corrode the metal parts or form a sticky mass which will prevent piston action. Plain alcohol should not be used for it has no lubricating qualities and due to its extreme thinness will leak past the rubber cups at the wheel pistons and saturate the brake lining. When improper brake fluids are found in the system, the entire brake system should be drained and than flushed. The pistons and rubber parts should be inspected and reconditioned or replaced if necessary. Then refill the system with the correct fluid. Never wash cylinders or other parts in gasoline, kerosene or oil for they will cause swelling and other serious damage to rubber parts of the braking system. Always use a good grade of alcohol or a recommended fluid for cleaning. Be sure to dip all parts in clean brake fluid before reassembling.

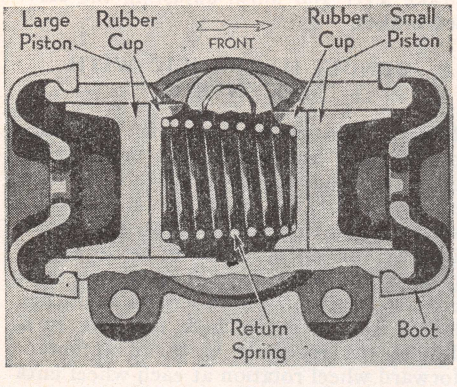
The brake lines must be absolutely free from air at all times and bleeding is necessary whenever a line has been disconnected or when a leak has allowed air to enter the system. A leak in the system is usually evident by a spongy brake pedal for air trapped in the system is compressible and does not permit the full brake pedal pressure to be transmitted to the brake shoes. If the main line from the master cylinder is disconnected or air enters the system because of the lack of fluid in the reservoir then it will be necessary to bleed all four wheel cylinders. If a line is disconnected at any wheel cylinder or a piston is forced out of a wheel cylinder, then that wheel cylinder only need be bled. If all the lines must be bled it is good practice to bleed the longest line first. During the bleeding operation the master cylinder must be kept at least half full of brake fluid. Fillers are available which automatically maintain the correct fluid level in the master cylinder during the bleeding operation. Do not attempt to bleed the system or depress the brake pedal while the brake drums are removed.

To bleed the system, fill the reservoir with fluid or insert a filler in the filler hole. Remove the bleeder valve screw at the wheel cylinder and attach a drain tube to the bleeder valve, allowing the tube to hang in a clean quart jar. With a wrench, unscrew the bleeder valve ½ to ¾ turn and then depress the brake pedal a full stroke and allow it to return slowly. Keep the end of the drain tube below the surface of the fluid in jar and continue operating the pedal in this manner until the liquid which is being drained into the jar is free from air bubbles and the stream is a solid mass. The bleeding operation requires approximately ½ pint of fluid for each wheel. Now tighten the bleeder valve and remove the drain hose. Replace and tighten the screw at the end of the bleeder valve. Fluid which is withdrawn in bleeding should not be used again.



Double acting wheel cylinder, both pistons the same diameter.

There are two basic types of shoe designs. One is the Lockheed in which the shoe heels are pivoted on the backing plate. The other is the so-called self-energizing type such as Bendix and Huck wherein the shoe heels are linked to each other. With Lockheed brakes, piston diameters in any one wheel may be the same size, or the front piston may be larger than the rear or vice versa, all depending on viewpoint of the individual car engineering department. With either self-energizing or Lockheed shoes the piston areas in the



Double acting wheel cylinder, larger piston at rear.

front wheels are likely to be greater than those in the rears. Hence a brief analysis of the whys and wherefores regarding variations in shoe design and piston sizes may not be amiss.

To begin at the very beginning, it should be noted that there is a certain amount of self-energizing action in the forward shoes of Lockheed brakes owing to the fact that when the shoe is applied the frictional pull of the drum on the shoe swings the shoe more tightly against the drum. Just the opposite effect is obtained at the rearward shoe. Hence, if the designer wishes to make the latter do its full share of the work, the rearward piston is made larger in diameter than the forward piston.

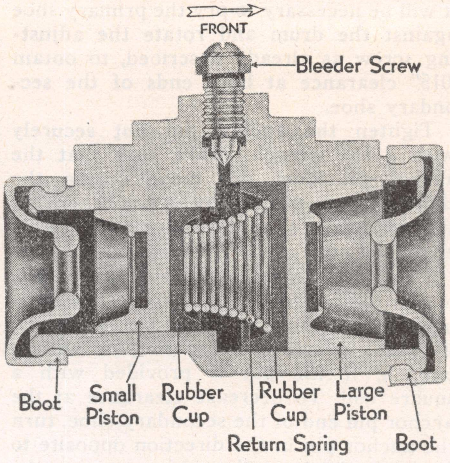
On the other hand, some designers do just the opposite, making the forward piston larger in diameter than the rearward one, their object being to reduce pedal pressure. In other words the larger share of the braking effort at any one wheel is applied to the shoe which has a natural self-energizing action.

In Bendix and Chevrolet brakes the heels of the two shoes are linked together to provide extra self-energizing action with corresponding reduction in pedal pressure, resulting from the fact that the forward shoe forces the heel of the rearward shoe against the drum.

Whenever brakes are applied, the car tries to keep on going thus, in effect, shifting weight from the rear wheels to the front with the result that the front tires are capable of exerting a greater retarding force than the rears. To take advantage of this fact, piston areas on front wheels are frequently made larger than on rears.

LINING INSPECTION

Before making a brake adjustment check the lining for wear and loose rivets and correct if necessary. Also inspect for metal or foreign particles imbedded in the surface and remove them, if found. Shoes having lining soaked with lubricant or hydraulic brake fluid should be relined. Lubricant leakage at the front or rear wheel bearings should be corrected by replacing lubricant seals. Brake fluid leaks at the wheel cylinders should be corrected by replacing or reconditioning the cylinders. If shoes are removed, use a clamp on the wheel cylinder to prevent the pistons from being forced out of their cylinders either through natural back pressure in the hydraulic system combined with the spring pressure between the rubber cups or by an accidental movement of the brake pedal. If this should happen it will result in loss of fluid and will also allow air to enter the hydraulic system, necessitating bleeding the system. Inspect each drum braking surface and rebore the drum if necessary. Remove only sufficient metal to provide a smooth surface. If excess material is removed, the drum may be weakened to the extent that erratic braking and rapid lining wear may result.



Double acting wheel cylinder, larger piston at front.

BRAKE PEDAL ADJUSTMENT FOR HYDRAULIC BRAKES

Before making a brake adjustment check the brake pedal. To insure full return of the master cylinder piston to its stop there must be play in the push rod. Unless this occurs the compensating port in the master cylinder will not be open to the reservoir. This may cause the brakes to drag and also result in continuous operation of the stop light. The compensating port can be covered by the piston primary cup when in a released position only as a result of incorrect master cylinder assembly, the use of wrong parts or because the brake pedal does not have floor board clearance so that the piston push rod can not return to its free position.

On most vehicles this play is measured at the pedal and there should be ¼" to ½" free travel of the brake pedal before the pressure stroke starts. To adjust this play, loosen the master cylinder push rod lock nut and turn the rod in or out until it has clearance where it seats in the master piston. Then tighten the lock nut. On Chevrolet trucks loosen the check nut on the eccentric bolt at the rear of the master cylinder and turn the eccentric to adjust this clearance. When clearance is correct, tighten the lock nut.

BRAKE ADJUSTMENTS

Brake adjustments can be divided into two classes, a minor adjustment to compensate for lining wear. which also restores the correct brake pedal reserve, provided the brake system is in good condition and a major adjustment which should be made after relining the brakes, when the anchors have been disturbed, after turning down the brake drums or when a minor adjustment fails to give satisfactory results. Brakes should be adjusted if the pedal travels to within 2 inches of the floor.

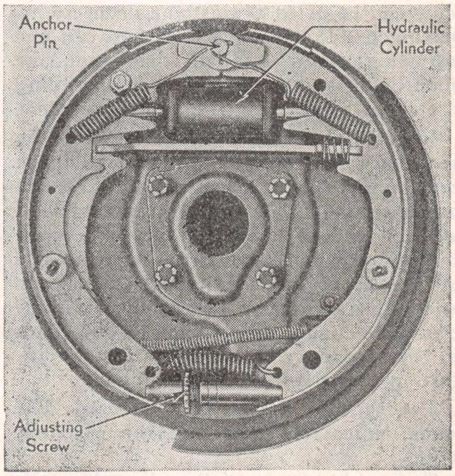
In addition to service at the brake shoes, the hydraulic system must also receive some attention although if the correct fluid is used in the system and its level is maintained at the proper height, little attention is required.

Before making a brake adjustment it is important that wheel bearings be checked for proper adjustment and that the brake backing plates are not loose. It is impossible to adjust brakes properly when backing plates are loose or when the wheel bearing adjustment is faulty.

BENDIX

HYDRAULIC WITHOUT ECCENTRIC

Minor Adjustment—Jack up all four wheels and take up end play in the wheel bearings if the hand brake operates on the rear service shoes, set the hand brake lever in its fully released position. Now check the cables to the rear brakes to make sure that they are not so short that the shoes are partially applied when the brake lever is in its released position. If this should occur it will be necessary to adjust the hand brakes.



Bendix hydraulic brake with no eccentric adjustment.

Check the pedal adjustment to make sure that the pedal travels about ½ inch before the master cylinder link end play has been taken up and the master cylinder piston starts to move. Lubricate the pedal linkage.

Check the anchor pin with a 16" wrench to make sure it is tight. If the anchor pin nut is found loose a major adjustment will be necessary. If the anchor pin is tight, remove the adjusting hole cover from the brake backing plate. Expand the brake shoes by turning the adjusting screw, moving the handle of the screw driver or adjusting tool toward the axle until the brake drum can just be turned by hand. Then back off the adjusting screw, moving the handle of the tool away from the axle, approximately 14 notches. Make this adjustment at all four wheels.

The brake drum should then turn freely. If there is a heavy drag between the shoes and drum, reset anchor pin.

Major Adjustment—After the wheels are jacked up, remove the hub and drum assemblies for inspection of the drums, lining and brake assembly mechanism.

Check the linings for wear and loose rivets and correct if necessary. Also, inspect the linings for metal or foreign particles imbedded in the surface and remove any, if found. Linings that are soaked with lubricant or hydraulic brake fluid should be replaced. Any brake fluid leaks at the wheel cylinders should be corrected by replacing or reconditioning the cylinders.

Disconnect the hand brake cable at the forward end. When newly lined shoes are installed, it will be necessary to back off the adjusting screw to provide clearance for drum installation. After the rear shoes are in place, attach the cable end to the rear brake lever. Do not connect the front end of the cable. After installing the hub and drum assemblies, insert a pry between the lining of the secondary shoe and drum, through the drum feeler gauge hole, and move the drum shoe assembly until the primary shoe is against the opposite side of the drum. With drums having saw slots for feeler gauge holes, the primary shoe can be pried against the drum by inserting a .015" feeler gauge between the adjusting screw end of the secondary shoe lining and drum, and then spreading the shoes by rotating the adjusting screw.

Insert a .015" feeler gauge between the secondary shoe lining and drum and check the lining to drum clearance at each end of the secondary shoe. A clearance of .015" at each end of the secondary shoe with the primary shoe against the opposite side of the drum indicates good anchor pin and adjusting screw positioning. If .015" clearance cannot be obtained at both ends of the secondary shoe by rotating the adjusting screw, adjust the anchor pin.

Two types of anchor pins are used: The radial adjustable type and the eccentric type.

To position the radially adjustable type anchor pin, loosen the anchor pin nut just enough to permit moving the pin by tapping the nut with a soft hammer. Do not back the nut off too much as this will result in moving the shoes out of position when retightening the nut. To reduce clearance between the lining and the drum at the anchor end of the secondary shoe, move the anchor pin away from the center of the axle or spindle. To reduce clearance at the adjusting screw end, move the anchor pin toward the center of the axle or spindle. After moving the anchor pin, it will be necessary to pry the primary shoe against the drum and rotate the adjusting screw as already described, to obtain .015" clearance at both ends of the secondary shoe.

Tighten the anchor pin nut securely with a 16" wrench. Make sure that the anchor pin does not move during the tightening operation by again checking the secondary shoe clearance after tightening the nut.

To adjust the eccentric type anchor pin, loosen the nut just enough to permit turning the pin with an offset screw driver, if it has a screw driver slot, or with a wrench, if the pin is provided with a square end. To decrease clearance at the anchor pin end of the secondary shoe, turn the anchor pin in the direction opposite to forward wheel rotation. After moving the anchor pin, it will be necessary to pry the primary shoe against the drum and to readjust the adjusting screw as described for a minor adjustment to obtain .015" clearance at both ends of the secondary shoe. Tighten the anchor pin nut securely with a 16" wrench while holding the anchor pin to prevent it from turning during the tightening operation. After tightening the nut, again check the secondary shoe clearance to be certain the anchor pin has not moved.

At the rear wheels tighten only the adjusting screws until the wheels can hardly be turned by hand. Be sure that the parking brake lever is applied approximately one notch from the fully released position. Adjust the parking brake cable so that all cable slack is removed when the cable is connected. Back off the adjusting screw at the rear wheels approximately 14 notches. Replace the adjusting screw hole covers in backing plates and feeler gauge hole covers in the drum at all four wheels.

Hand Brake Adjustment—The hand brake operates the rear service shoes through mechanical linkage. When making a minor or a major adjustment the hand brake linkage should be adjusted when the shoes are expanded tight against the drum by the adjusting screw. To remove slack from the hand brake lever to the equalizer cable, remove the clevis pin or the lock nut from the rear of the cable. Then turn the clevis until the clevis pin will just slip into place without binding. Do not turn the cable. Replace the clevis pin. If separate cables operate each rear brake, adjust the length of each cable by turning its clevis until all slack is removed from the cable and the clevis pin can be slipped easily into place. If a single cable is used to operate both rear brakes, loosen the cable clamp screws at the spreader and apply the hand brake lever. This will permit the cable to slide in the spreader until tension is equal on both brakes. In some cases it may be necessary to open the clamp on the spreader with a screw driver to allow the cable to slide in the spreader. With the hand brake lever still on, tighten the cable clamp screws in the spreader. It may then be necessary to make another adjustment on the hand brake to equalizer cable. Release the hand brake lever and finish adjusting the service brakes.

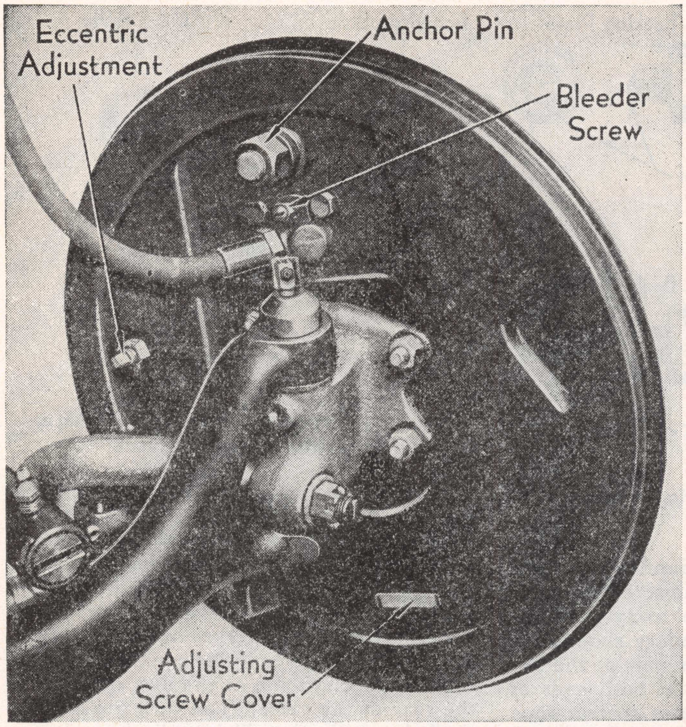
BENDIX HYDRAULIC WITH ECCENTRIC

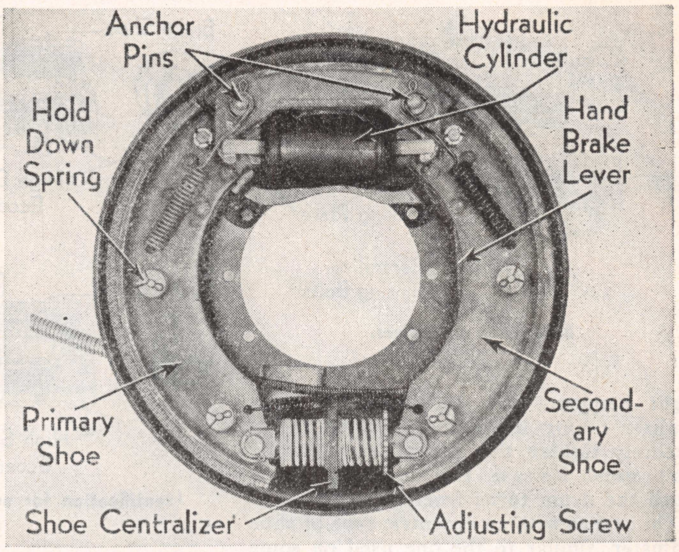
Minor Adjustment—Disconnect the hand brake cable and adjust the brake pedal operating rod to allow ¼" to ½" free movement of the brake pedal before it starts the piston on its pressure stroke. Inspect the anchor pin to be sure that it is tight. Remove the inspection hole covers from the brake drums and then loosen the eccentric lock nut one turn. Rotate the eccentric in the direction of forward wheel rotation at each wheel until there is a heavy drag on the drum. Then rotate the eccentric slowly in the opposite direction until the drum is free of drag. If a feeler gauge is used, the eccentric should be turned in the direction of forward wheel rotation until the gauge is just snug between the lining and the drum near the adjuster end of the secondary shoe, the one against which the eccentric operates. Then tighten the eccentric lock nut. The clearance at both ends of the secondary shoe should now be the same. Should there be a difference greater than .003" or should the anchor end have more clearance than the adjusting end it indicates that the anchor pin must be adjusted and a major adjustment is necessary.

Remove the adjusting hole covers on all four wheels. Insert a brake adjusting tool or a thin screw driver through the adjusting hole at the bottom of the backing plate until it contacts the notched adjusting screw. Turn the adjusting screw downward at all wheels until the brake shoes have been expanded so that there is a heavy drag on the brake drum. If the hand brake operates on the rear service shoes, adjust the hand brake cable and reconnect the hand brake lever. Now back off the adjusting screw until all brake drag is removed. Be sure to back off the same number of notches at both rear brakes so that the hand brakes will be balanced. A .010" feeler gauge can be inserted between the lining and the drum or the adjusting screw can be loosened about 20 notches to give the correct clearance. Replace the adjusting screw hole covers.

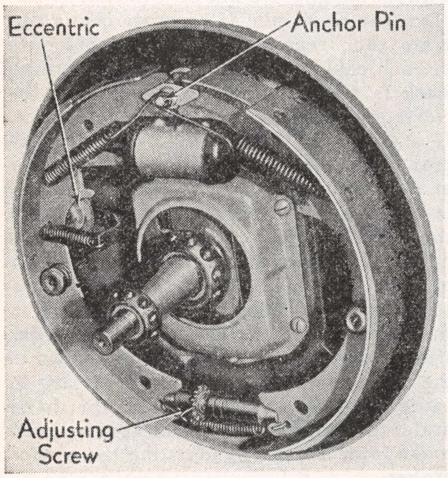
Major Adjustment—Jack up all four wheels and remove the hub and drum assemblies for inspection of drums, lining and brake mechanism. If the lining is still serviceable reinstall the brake drums but otherwise replace the lining before putting the drums in place. Check the brake pedal for clearance and adjust if necessary. After all necessary corrections have been made, remove the adjusting hole covers in the brake backing plate and the inspection hole covers in the brake drum, if this has not been done previously. Loosen the hand brake cables by backing off the nut at the equalizer or removing the clevis pin.

Two types of anchor pins are used, sliding and eccentric. The eccentric type





Bendix commercial hydraulic brake with two anchor pins



Bendix hydraulic brake with eccentric adjustment.

is identified by the slot at the nut end of the pin. The high end at one side of the slot indicates the high side of the eccentric section of the pin.

To adjust the sliding type of anchor pin, loosen the anchor pin nut one full turn and also loosen the eccentric lock nut. Rotate the eccentric in the direction of forward wheel rotation to decrease the adjusting end clearance and in the opposite direction to increase clearance and tap anchor pin lightly with a soft hammer away from the center of the axle to decrease anchor end clearance and in the opposite direction to increase clearance. After the specified clearance of .010″ at both anchor end and adjusting end of the secondary shoe, the one against which the eccentric operates, has been obtained, tighten the anchor pin nut as tight as possible with a 16″ wrench. Tighten the eccentric lock nut.

When the eccentric type of anchor pin is fitted, loosen the anchor pin nut one full turn and also loosen the eccentric lock nut. Adjust the anchor pin and eccentric to provide the clearance of .010″ at each end of the secondary shoe, the one against which the eccentric operates. Rotate both in the direction of forward wheel rotation to decrease clearance and in the opposite direction to increase clearance.

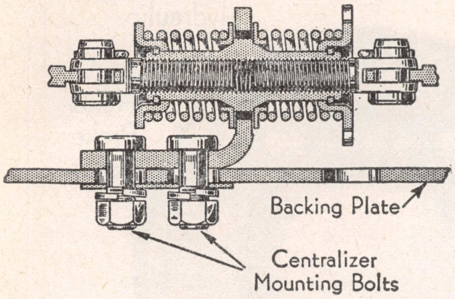
When the correct shoe position has been obtained, hold the anchor pin to prevent its turning and tighten the anchor pin nut as tight as possible with a 16″ wrench. Tighten the eccentric lock nut. Recheck the clearance to insure that tightening the anchor pin nut and eccentric lock nut has not disturbed the lining to drum clearance. Expand the brake shoes tightly against the brake drum. Then turn the adjusting screw as described for a minor adjustment. Replace the wheels and replace the adjusting hole covers.

Hand Brake Adjustment—The hand brake operates the rear service shoes through mechanical linkage. When making a minor or a major adjustment the hand brake linkage should be adjusted when the shoes are expanded tight against the drum by the adjusting screw. To remove slack from the hand brake lever to the equalizer cable, remove the clevis pin or the lock nut from the rear of the cable. Then turn the clevis until the clevis pin will just slip into place without binding. Do not turn the cable. Replace the clevis pin. If separate cables operate each rear brake, adjust the length of each cable by turning its clevis until all slack is removed from the cable and the clevis pin can be slipped easily into place. If a single cable is used to operate both rear brakes, loosen the cable clamp screws at the spreader and apply the hand brake lever. This will permit the cable to slide in the spreader until tension is equal on both brakes. In some cases it may be necessary to open the clamp on the spreader with a screw driver to allow the cable to slide in the spreader. With the hand brake lever still on, tighten the cable clamp screws in the spreader. It may then be necessary to make another adjustment on the hand brake to equalize cable. Release the hand brake lever and finish adjusting the service brakes.

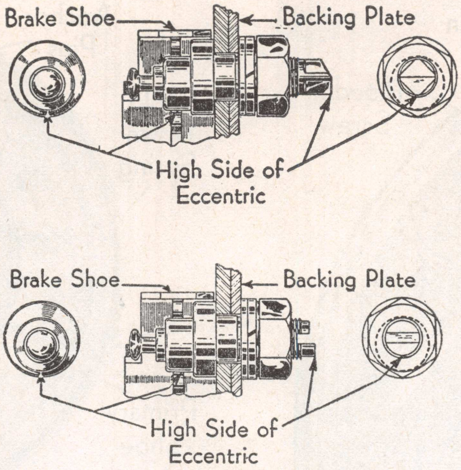
BENDIX HYDRAULIC WITH SINGLE ANCHOR

Minor Adjustment—If the hand brake operates on the rear service shoes, set the hand brake lever in its fully released position and check the pedal adjustment to make sure that the pedal pad travels approximately ½″ before the master cylinder piston starts to move. Then check the anchor bolt nut at each wheel with a 16″ wrench to make sure they are tight. If an anchor bolt is found loose, a major adjustment will be necessary. Remove the adjusting hole cover from the backing plate. Turn the adjusting screw, moving the handle of the tool or screw driver toward the axle, until the brake shoes are expanded tightly against the drum.

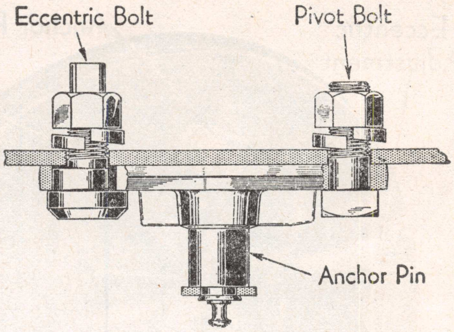
Back off the adjusting screw, moving the handle of the tool away from the axle, until the brake drum turns freely. If there is insufficient pedal reserve after completing a minor adjustment at all wheels, adjust the shoe centralizer at all wheels. Loosen the shoe centralizer mounting bolt nuts, until they are just free of lockwasher tension so the centralizer can float freely. Expand the adjusting screw until the brake shoes are tight against the drum. Tap the backing plate near the centralizer with a



Brake shoe centralizer.



Identification for eccentric pin position.



Anchor pin adjustment.

light hammer blow to insure the centralizer taking its correct position. Then securely tighten the centralizer mounting bolt nuts. Release the adjusting screw until the drum turns freely.

On brakes with an eccentric type of shoe adjuster, similar to the one used on some Bendix passenger car brakes instead of the centralizer, loosen the eccentric lock nut just enough to permit turning the eccentric. Rotate the eccentric in the direction of forward wheel rotation until there is a heavy drag when the wheel is revolved. Then slowly rotate the eccentric in the opposite direction until the wheel just turns free of lining drag. Tighten the eccentric lock nut while holding the eccentric securely with a wrench to prevent changing the adjustment during the tightening operation.

Now expand the shoes by rotating the adjusting screw until the shoes are tight against the drum. Then back off the adjusting screw until the brake drum is just free of lining drag. Replace the adjusting hole covers in the backing plate and lower the vehicle.

Major Adjustment—With the four wheels jacked up, remove the hub and drum assemblies for inspection of drums, linings and brake operating mechanism. When connecting the shoe centralizer to new or relined shoes, be sure that the adjusting screw notched wheel is at the right hand shoe when the shoes are assembled to each brake backing plate. Release the adjusting screw several notches to provide clearance for installing the drum. After the rear shoes are in place, attach the cable end to the rear brake lever on vehicles having wheel parking brakes. When installing new shoes it may be necessary to turn the eccentric anchor pin to allow shoe clearance for drum installation.

After installing the hub and drum on each wheel, remove the brake adjusting hole cover in the backing plate and the feeler gauge hole cover in the brake drum or covers in the backing plate rim. Be sure that the shoe centralizer mounting bolt nuts, are just free of lockwasher tension so that the centralizer can float freely. Turn the adjusting screw, moving the handle of the tool or screw driver toward the axle until the brake shoes are expanded tightly against the drum. Then tap the backing plate near the centralizer with a light hammer to insure centralizer taking its correct position between the shoe ends. Tighten the centralizer mounting bolt nuts. Then back off the adjusting screw, by moving the handle of the tool away from the axle, and check the secondary shoe lining to drum clearance at both ends of the lining. A clearance of .010" at both ends of the secondary shoe indicates correct shoe positioning. If these clearances are not within .003" of being the same, it is necessary to correct the shoe position by adjusting the anchor pin.

To adjust the anchor pin, loosen each anchor bolt nut about one turn. Turn the eccentric bolt, in the direction required to secure the correct secondary shoe position. It may be necessary to turn the adjusting screw when resetting the anchor pin to obtain .010" clearance at both ends of the secondary shoe. Tighten the anchor pin bolt nuts securely with a 16" wrench while carefully holding the anchor pin eccentric bolt with a wrench to prevent it from turning during the tightening operation. After tightening the anchor pin bolt nuts, again check the secondary shoe clearance to make certain that the anchor position has not changed in the nut tightening operation.

Reset the shoe centralizer as already described and then release the adjusting screws at each front wheel until the drums turn freely. Adjust the hand brake cables while the rear brakes are still expanded. To adjust the brake cables, pull the hand brake lever back from the release stop to the first notch of the ratchet sector. Then pull the brake cable toward the cross shaft lever with about a twenty pound pull. Adjust the clevis so that the clevis pin can just be inserted and then lock the clevis jam nut and install the cotter pin. Release the hand brake lever. Release the adjusting screw the same number of notches at each rear wheel, until the drums turn freely. Replace the adjusting screw hole covers in the backing plates and also the feeler gauge hole covers. Lower the vehicle and road test the car.

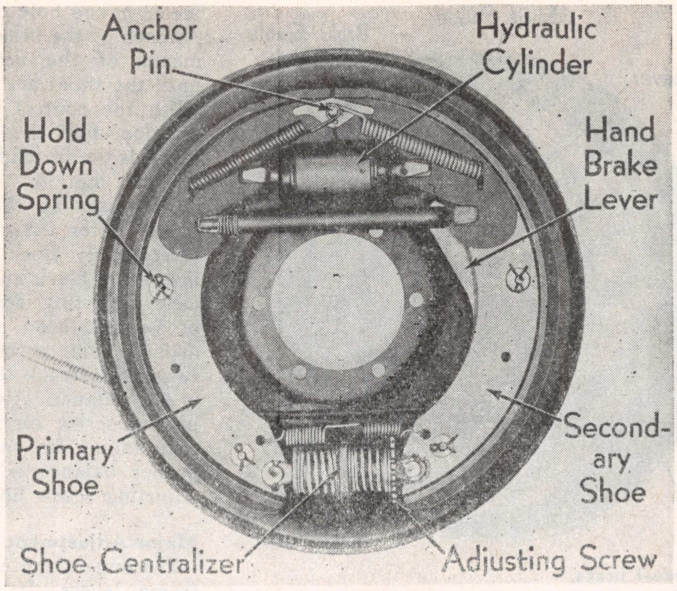
In heavy tractor, road machinery and similar equipment provided with brake feeler gauge holes in the brake backing plates, it is recommended that the shoe position be determined with the weight of the vehicle on the wheels or track.

Hand Brake Adjustment—The hand brake operates the rear service shoes through mechanical linkage. When making a minor or a major adjustment the hand brake linkage should be adjusted when the shoes are expanded tight against the drum by the adjusting screw. To remove slack from the hand brake lever to the equalizer cable, remove the clevis pin or the lock nut from the rear of the cable. Then turn the clevis until the clevis pin will just slip into place without binding. Do not turn the cable. Replace the clevis pin. If separate cables operate each rear brake, adjust the length of each cable by turning its clevis until all slack is removed from the cable and the clevis pin can be slipped easily into place. If a single cable is used to operate both rear brakes, loosen the cable clamp screws at the spreader and apply the hand brake lever. This will permit the cable to slide in the spreader until tension is equal on both brakes. In some cases it may be necessary to open the clamp on the spreader with a screw driver to allow the cable to slide in the spreader. With the hand brake lever still on, tighten the cable clamp screws in the spreader. It may then be necessary to make another adjustment on the hand brake to equalizer cable. Release the hand brake lever and finish adjusting the service brakes.

BENDIX HYDRAULIC WITH DOUBLE ANCHOR

Minor Adjustment—If the hand brake operates on the rear service shoes, set the hand brake lever in its fully released position and check the pedal adjustment to make sure that the pedal pad travels approximately ½" before the master cylinder piston starts to move. Then check the anchor bolt nut at each wheel with a 16" wrench to make sure they are tight. If an anchor bolt is found loose, a major adjustment will be necessary. Remove the adjusting hole cover from the backing plate. Turn the adjusting screw, moving the handle of the tool or screw driver toward the axle, until the brake shoes are expanded tightly against the drum.

Back off the adjusting screw, moving the handle of the tool away from the axle, until the brake drum turns freely. If there is insufficient pedal reserve after



Bendix commercial hydraulic brake with single anchor pin.

completing a minor adjustment at all wheels, adjust the shoe centralizer at all wheels. Loosen the shoe centralizer mounting bolt nuts, until they are just free of lockwasher tension so the centralizer can float freely. Expand the adjusting screw until the brake shoes are tight against the drum. Tap the backing plate near the centralizer with a light hammer blow to insure the centralizer taking its correct position. Then securely tighten the centralizer mounting bolt nuts. Release the adjusting screw until the drum turns freely.

On brakes with an eccentric type of shoe adjuster, similar to the one used on some Bendix passenger car brakes instead of the centralizer, loosen the eccentric lock nut just enough to permit turning the eccentric. Rotate the eccentric in the direction of forward wheel rotation until there is a heavy drag when the wheel is revolved. Then slowly rotate the eccentric in the opposite direction until the wheel just turns free of lining drag. Tighten the eccentric lock nut while holding the eccentric securely with a wrench to prevent changing the adjustment during the tightening operation.

Now expand the shoes by rotating the adjusting screw until the shoes are tight against the drum. Then back off the adjusting screw until the brake drum is just free of lining drag. Replace the adjusting hole covers in the backing plate and lower the vehicle.

Major Adjustment—With the four wheels jacked up, remove the hub and drum assemblies for inspection of drums, linings and brake operating mechanism. If new shoes are installed, be sure to set the anchor pins with their arrows pointing toward each other. The nut at the end of each anchor pin is marked with an arrow to indicate the high side of the eccentric part of the anchor. When connecting the centralizer mechanism to a pair of relined shoes, be sure the adjusting screw notched wheel is at the right hand shoe when the shoes are assembled to each brake backing plate. Release the adjusting screw several notches to provide clearance for drum installation. After the rear shoes are in place, attach the cable to the rear end brake lever when the hand brake operates on the rear wheels.

After installing the hub and drum assemblies, remove the brake adjusting hole cover in the backing plate and the feeler gauge hole cover in the brake drum or in the backing plate rim. Be sure that the shoe centralizer nuts are just free of lockwasher tension so that the centralizer can float freely. Turn the adjusting screw, moving the handle of the tool or screw driver toward the axle, until the brake shoes are expanded tightly against the drum. Then tap the backing plate near the centralizer with a light hammer to insure the centralizer taking the correct position between the shoe ends. Tighten the centralizer nuts.

Back off the adjusting screw, moving the handle of the tool away from the axle, and check the secondary shoe lining to drum clearance at both ends of the lining. A clearance of .008" at the anchor pin end and clearance of .020" at the adjusting screw end of each shoe indicates correct shoe position. If these clearances are not within .003", it is necessary to correct the shoe position by adjusting the anchor pin.

To adjust the anchor pins, loosen each anchor nut about one turn. Turning the arrow point, on the nut end of the anchor, away from the center of the axles moves the anchor end of the shoe lining toward the drum and decreases lining to drum clearance. To increase clearance, turn the anchor in the opposite direction. Each shoe is adjusted independently of the other.

It will be necessary to readjust the adjusting screw each time the anchor pin is moved, to maintain the proper clearance at each end of the shoe. Now repeat the shoe positioning operations at the primary shoe.

Tighten the anchor nuts securely with a 16" wrench while carefully holding the eccentric anchor pin with another wrench to prevent it from turning during the tightening operation. After tightening the nuts, recheck the clearance at each end of both shoes to make certain the anchor pins have not moved. Then reset the centralizer and release the adjusting screws at each front wheel until the drums turn freely.

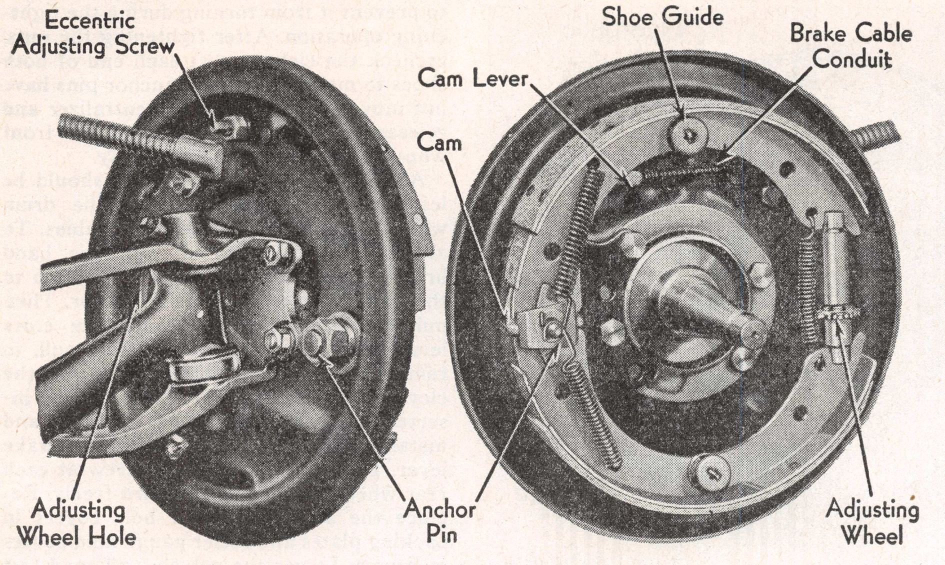
At the rear wheels the shoes should be left expanded tightly against the drum while adjusting the hand brake cables. To adjust the brake cables, pull the hand brake lever back from the release stop to the first notch of the ratchet sector. Then pull the brake cables toward the cross lever, with about a twenty pound pull, to remove all slack or lost motion. Adjust the clevises so that the clevis pins can be inserted easily. Lock the clevis jam nuts and install cotter pins. Release the hand brake lever. Release the adjusting screw at each rear wheel until the drums turn freely. Replace the adjusting screw hole covers in backing plates and feeler gauge hold covers in drums. Lower the vehicle and road test the brakes.

Hand Brake Adjustment—The hand brake operates the rear service shoes through mechanical linkage. When making a minor or a major adjustment the hand brake linkage should be adjusted when the shoes are expanded tight against the drum by the adjusting screw. To remove slack from the hand brake lever to the equalizer cable, remove the clevis pin or the lock nut from the rear of the cable. Then turn the clevis until the clevis pin will just slip into place without binding. Do not turn the cable. Replace the clevis pin. If separate cables operate each rear brake, adjust the length of each cable by turning its clevis until all slack is removed from the cable and the clevis pin can be slipped easily into place. If a single cable is used to operate both rear brakes, loosen the cable clamp screws at the spreader and apply the hand brake lever. This will permit the cable to slide in the spreader until tension is equal on both brakes. In some cases it may be necessary to open the clamp on the spreader with a screw driver to allow the cable to slide in the spreader. With the hand brake lever still on, tighten the cable clamp screws in the spreader. It may then be necessary to make another adjustment on the hand brake to equalizer cable. Release the hand brake lever and finish adjusting the service brakes.

BENDIX MECHANICAL

There are two adjustments on this type of brake to compensate for brake lining wear: The eccentric adjustment which centralizes the brake shoes in the brake drum and the adjusting screw which takes up clearance between the brake lining surface and the brake drum to compensate for lining wear. Two types of anchor pins are used on these brakes; a sliding type on brakes of 16" diameter or less and the eccentric type of anchor pins on brakes 17" in diameter and greater.

Minor Adjustment—Jack up all wheels clear of the floor. Disconnect the cables or rods at the frame levers. Loosen the



Bendix mechanical brake.

eccentric lock nut and rotate the eccentric in the direction of forward wheel rotation, until there is a brake drag, then rotate the eccentric very slowly in the opposite direction until the drum is free of brake drag. Tighten the eccentric lock nut. Be sure the eccentric does not turn as the nut is tightened. Uncover the adjusting screw hole and rotate the notched adjusting screw toward the drum with a special tool or screw driver, moving the outer end of the tool toward the center of the wheel, until the shoes are tight against the drum.

With the control system in the released position, pull the cables or rods toward the frame levers to remove all slack and lost motion at the cam levers. Adjust the clevises so that the clevis pins will barely enter clevises and levers easily. Lock the clevis jam nuts and insert clevis pin cotter pins. At each wheel, back off the notched adjusting screw until the brake does not drag.

Lower the truck and test for brake balance on a brake tester or on the road. Always loosen the adjusting screw on tight brakes rather than to tighten the adjusting screw on loose brakes. This is a safeguard against the vehicle going into service with one or more brakes too tight. Replace the adjusting screw hole cover at each backing plate.

Major Adjustment with Sliding Anchors—Disconnect the cable or rod ends at the frame levers. If necessary, adjust that portion of the brake control system, ahead of the cables or rods, to secure its correct released position. Leave the cable or rod ends disconnected.

At all wheels loosen the anchor pin nuts free of lock washer tension. Remove the adjusting screw hole cover plate from the backing plate. Rotate the adjusting screw until both shoes are tight against the drum. Then tighten the anchor nuts and back off one turn. Release the adjusting screw 16 notches.

Loosen the shoe eccentric lock nut and rotate the eccentric in the direction of forward wheel rotation until there is a brake drag, then back off the eccentric until the drum is free of brake drag. Remove the feeler gauge hole cover from the drum, if one is provided. Check the lining to drum clearance with a feeler gauge. The shoe against which the shoe eccentric adjustment operates should be adjusted first. A check showing .008″ lining to drum clearance at the anchor end and .014″ lining to drum clearance at the adjusting screw end of the shoe indicates a properly positioned shoe. The .008″ and .014″ clearances can be obtained by tapping the shoe anchor towards or away from the axle and manipulating the shoe eccentric adjustment. Tapping the anchor towards the axle increases the drum at the anchor end, decreases the lining to drum clearance at the adjusting screw end. Tapping the anchor away from the axle produces the opposite conditions. Rotating the shoe eccentric in the direction of forward wheel rotation moves the shoe against which the eccentric operates towards the drum and the opposite shoe away from the drum. Rotating the eccentric in the opposite direction causes the shoe against which the eccentric operates to move away from the drum and the opposite shoe towards the drum.

After the .008″ and .014″ clearances have been obtained at the shoe having the eccentric against it tighten the anchor nut down tight using a special wrench or a wrench 16″ long.

The opposite shoe position can be obtained by tapping the anchor of this shoe towards or away from the axle and rotating the adjusting screw either on or off. Rotating the adjusting screw does not affect the position of the shoe against which the shoe eccentric operates, until the adjusting screw moves the opposite shoe against the drum, unless the spacer pin washer is too tight against the shoe web.

After the .008″ and .014″ clearance at the anchor and adjusting ends of the opposite shoe lining have been obtained, tighten the anchor nut. Replace the drum feeler gauge hole cover, if one was fitted. At each of the brakes, spread the shoes by means of the notched adjusting screw until the shoes are tight against the drum. With the control system in the released position, pull the cables or rods tightly towards the frame lever to remove all slack and lost motion at the cam levers. Adjust the clevises so that the clevis pins will barely enter the clevises and cross shaft levers easily. Lock the clevis jam nuts and insert the clevis pin cotter pins. Back off each adjusting screw 8 notches. If the brake has been properly adjusted, the drum will now be free of brake drag. Lower the truck to the floor and test for brake balance. Always back off the adjusting screw on the tight wheel rather than taking up on the loose wheel, until proper balance is obtained. Replace the adjusting screw hole covers.

Major Adjustment with Eccentric Anchors—Disconnect the cable or rod ends at the frame levers. If necessary, adjust that portion of the brake control system ahead of the cables or rods to secure its correct return position. Leave the cable or rod ends disconnected.

Note that the nut end of each anchor pin is longer to one side of the screw driver slot. This long end corresponds to the high side of the eccentric section of the anchor pin at the shoe web. Loosen the anchor lock nuts and rotate the anchors with a suitable tool so that the long side of the anchor ends face each other. Tighten the anchor nuts so that the anchors can just be rotated. Move the adjusting screw hole cover on the backing plate to one side and rotate the adjusting screw through the hole in the backing plate with a special tool or screw driver, until a slight brake drag occurs.

Loosen the lock nut on the shoe eccentric adjustment one turn and rotate the eccentric in the direction of forward wheel rotation until brake drag occurs. Then release the adjustment very slowly until the drum is free of brake drag.

Remove the feeler gauge hole cover plate from the drum, if one is provided. Check the shoe lining to drum clearance with a feeler gauge inserted through the feeler gauge hole in the drum. The shoe against which the shoe eccentric operates should be adjusted first. A check showing .008″ lining to drum clearance at the anchor end and .014″ lining to drum clearance at the adjusting end of this shoe indicates a properly positioned shoe. The .008″ and .014″ clearances can be obtained by rotating the anchor and manipulating the shoe eccentric adjustment. Rotating the anchor pin so that the long end moves toward the axle increases the clearance between the lining and the drum at the anchor end and decreases the clearance at the adjusting end. Rotating the anchor so the long end moves away from the axle causes the opposite condition. When the .008″ and .014″ clearances have been obtained, tighten the anchor nut with a wrench with a 22″ handle, taking care not to change the position of the anchor.

Tighten the eccentric lock nut taking care not to change the eccentric position.

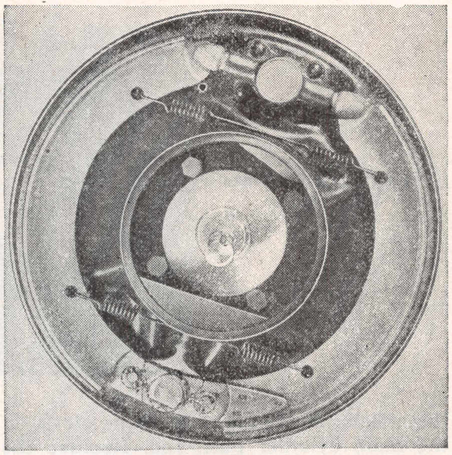
The opposite shoe position can be obtained by rotating the shoe anchor and turning the adjusting screw until the .008" and .014" anchor and adjusting end clearances are obtained. Tighten the anchor nut, taking care not to change the position of the anchor.

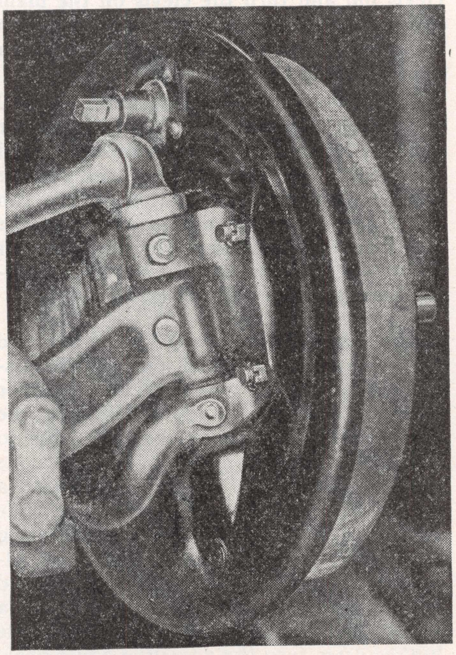
Rotating the adjusting screw does not change the position of the shoe against which the shoe eccentric operates, until the adjusting screw moves the opposite shoe against the drum, unless the spacer pin washer is too tight against the shoe web.

Replace the drum feeler gauge hole cover, if one was fitted. At each of the brakes, spread the shoes by means of the notched adjusting screw until the shoes are tight against the drum. With the control system in the released position, pull the cables or rods tightly towards the frame lever to remove all slack and lost motion at the cam levers. Adjust the clevises so that the clevis pins will barely enter the clevises and cross shaft levers easily. Lock the clevis jam nuts and insert the clevis pin cotter pins. Back off each adjusting screw 8 notches. If the brake has been properly adjusted, the drum will now be free of brake drag. Lower the truck to the floor and test for brake balance. Always back off the adjusting screw on the tight wheel rather than taking up on the loose wheel, until proper balance is obtained. Replace the adjusting screw hole covers.

Cable Lubrication—Cable and conduit assemblies should be lubricated with special cable lubricant every 5,000 miles. Lubricate through the lubrication fittings on the conduits, if they are so equipped, being careful that excess lubricant is not forced into the brake assembly. If conduits are not equipped with lubrication fittings, unfasten the conduit abutment brackets, clean the exposed portion of the cable, and slide the conduit toward the cross shaft exposing that portion of the cable which is sheathed by conduit. Then clean the exposed portion of the cable and lubricate freely. When cables are only slightly longer than the conduit, it is necessary to remove the entire assembly before lubrication. When conduits are reinstalled, the ends must be firmly bottomed in their abutment brackets.

Assembling the Adjusting Screw and Pivot Nuts to Newly Lined Shoes—Place the shoes on a bench so that the anchor pin holes in the shoes are away from you. Lubricate the pivot nuts and the threads on the adjusting screw with Lubriplate. Pick up the pivot nut that has a cotter pin hole in one end and insert this pivot nut in the shoe at your left with the cotter pin hole end, up. Then insert the other pivot nut, the one having an undercut shoulder, in the shoe at your right with the shoulder end, up. Now thread the adjusting screw into both pivot nuts to full travel of threads, left hand thread at left, right hand thread at right, always.





Ford mechanical brake.

Assemble the adjusting screw lock plate and insert and spread the cotter pin. Before mounting the relined shoes to the backing plate clean the exposed portion of the cable, then, pull the cable back and forth in the conduit and spread lubricant on the cable. Also use cable lubricant on the cable ramp over which the cable passes to the inside brake lever. Also lubricate where the pivot nuts bear against the backing plate; where the shoe webs bear against the steady rest pins and at the end of the eccentric adjustment; where the cable hooks onto the lever; on the cam between the cam plates where the ends of the shoes enter the cam and also the cam pin on the inside lever. Use only reasonable amounts of lubricant for excessive lubricant may work onto the lining and cause erratic brake action.

Assemble the shoes onto the backing plate. Assemble the anchor pin strut and insert cotter pins and spread the cotter pins on the sliding type on anchor pin. Curl the cotter pin ends around the anchor pins on the eccentric type of anchor pin. Put lubricant on the rounded edge, next to the shoe web, side of the spacer pin washer. Assemble the spacer pin washers and nuts. Then adjust the nuts loosely. Assemble the primary shoe return spring and the primary and secondary springs. Now tighten the spacer pin castle nuts just so the spacer pin washers can be turned with your fingers. Insert the cotter pins and spread.

Loosen the eccentric lock nut and rotate the shoe eccentric until the shoe is bearing against the lowest point of the eccentric. This operation also shows if the shoes have free movement. If the shoes do not have free movement, check each one of the spacer pin washers and correct if necessary, to insure their not being too tight.

FORD

MECHANICAL

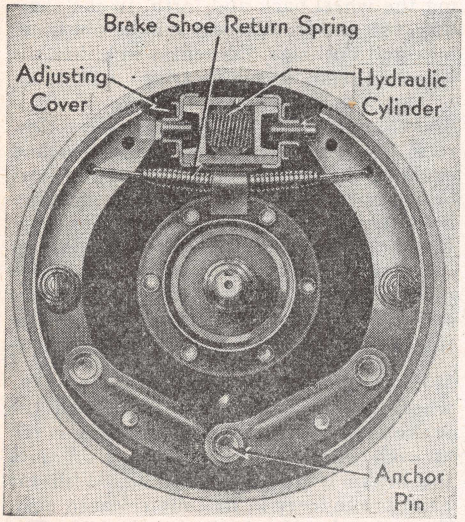
Test the front wheel bearings by rocking the wheel back and forth. In the same way, test the front wheel spindle pin bearings and bushings. Looseness in either the wheel or spindle pin bearings will cause or develop into brake chatter, which a brake adjustment will not remedy. Now rock the truck gently up and down and examine the spring shackle studs for wear or looseness. Examine the shock absorber links for twisted or worn rubber bushings. Examine the front radius rod mountings for looseness. Trouble at any of these points may affect the brake adjustment and prevent satisfactory operation. Be sure the brakes are cold before adjusting them.

1936: Remove the clevis pin from the wheel end of each brake rod. Turn the brake adjusting screw in until a drag is felt at each wheel and then back it off until the brake is just free of drag. With the hand brake lever in its fully released position, examine the brake cross shaft. The clevis pin for the rear brake rods should lie in a vertical line with the clevis pin for the front brakes. If the front and rear pins are not in a vertical line, adjust the pedal to cross shaft rod until they are correct.

Push the brake lever at each front wheel toward the brake cross shaft to take up play in the brake cam. Now adjust the length of the brake rods so that the clevis and brake lever holes line up. Then shorten the rods by half a turn of the clevis and insert the clevis and cotter pins. Set the hand brake lever in its second notch and test the brakes. All should be equal. If they are not equal, back off the tight brakes until all are equal. When all brakes are equal and with the hand brake lever still in its second notch, back off the adjusting screw at each rear wheel two notches.

1937-38: Remove the clevis pins from the front and rear brake cables at the cross shaft. The front brake cable operating lever should rest against the bottom of the cross shaft bracket. If not, the pedal to cross shaft rod clevis should be adjusted accordingly. Be sure that the hand brake is not so short that it holds the cross shaft out of position. Turn the adjusting screw in until the shoes are tight against the drums. Adjust each cable clevis so that the pin can be installed while a 25-pound pull is exerted on the cable. Back off the adjusting screw until the drag is removed. Apply the hand brake to its first notch and check the brakes for even drag. If the brakes are not even, back off the tight ones. On 1938 trucks the pedal to cross shaft rod should be adjusted so that the stop on the operating lever touches the frame cross member.

Normally the brake pedal rod is in the upper hole of its lever at the cross shaft but if a harder pedal is desired the rod should be moved down to the lower hole. The front brake operating lever should just touch the bracket when the brake pedal rod is correctly adjusted. The vertical pin in the cross shaft bracket controls end play of the cross shaft.



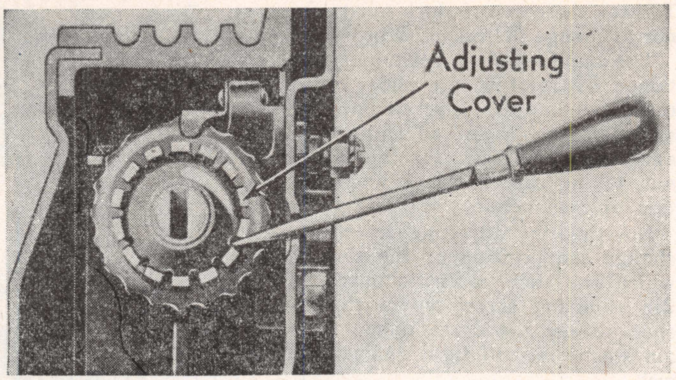
Huck hydraulic brake.

HUCK

HYDRAULIC

On 1936 to 1939 ½-ton trucks and ¾-ton trucks the adjusting holes for the front brakes are located in the brake drum under the wheel flange which necessitates the removal of the front wheels to make a brake adjustment. On 1936 to 1939 ¾-ton special trucks it is necessary to remove the rear wheels as well as the front wheels. On all other models the brake flange plates have openings with spring snap covers which can be reached without removing the wheels.

Toe-Board Clearance—Toe-board clearance very seldom needs to be adjusted. The pedal stop located in the brake master cylinder is permanent. Before attempting to adjust this stop, be certain that the pedal returns to the full released position freely, with no binding, and that the pedal retracting spring has not lost its tension.



Huck hydraulic brake adjustment.

To adjust toe-board clearance, loosen the check nut on the rear of the clevis on the main cylinder push rod. Remove the clevis pin and turn the clevis on the main cylinder push rod in the proper direction to secure ¼" toe-board clearance. Tighten the check nut against the clevis.

To adjust toe-board clearance on 1940 Chevrolet COE trucks or to fill the master cylinder it is necessary to remove the wood floor board in the left floor pan. As the hand brake lever is mounted on the cab sub frame it will be necessary to remove the front cowling assembly and the left front fender in order to reach its attaching bolts and the pull rod clevis pin.

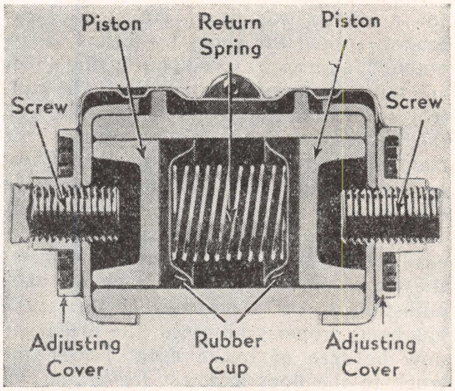
Brake Shoe Adjustment—On ½-ton and ¾-ton trucks, jack up all four wheels. Disconnect the hand brake cables at the idler lever to eliminate the possibility of the brake shoe dragging on the drum due to misadjustment of the hand brakes. Remove the adjusting hole covers and insert a screw driver through the adjusting hole and engage the teeth on the adjusting cover of the wheel cylinder. Turn the adjusting cover clockwise, looking at the end of the cylinder until the shoes cause a slight drag on the brake drum. When the brakes drag, turn the adjusting cover back, in the opposite direction, four notches. Repeat this operation on each shoe in each brake.

One and one half ton and COE trucks—Adjustment of front brakes is the same as already described except that the wheel cylinder adjusting covers are backed off five notches instead of four.

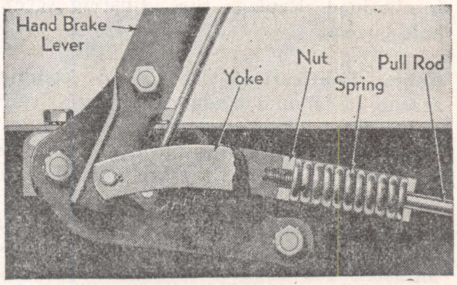
To adjust the rear brakes, use a ⅝" open end wrench to turn the adjusting pinion. Turn the adjusting pinion clockwise until the shoe causes a slight drag on the brake drum. Then turn the adjusting pinion ¾ turn in the opposite direction to provide running clearance.

The backing off of the adjusting cover the specified number of notches will be indicated by a faint click in the cover lock spring as it is turned. This backing off of the adjusting cover moves the brake shoe away from the drum.

Hand Brake Adjustment—The hand brake adjustment should be checked each time the service brakes are adjusted. The service brakes must be properly adjusted before adjusting hand brakes.



Huck hydraulic wheel cylinder.

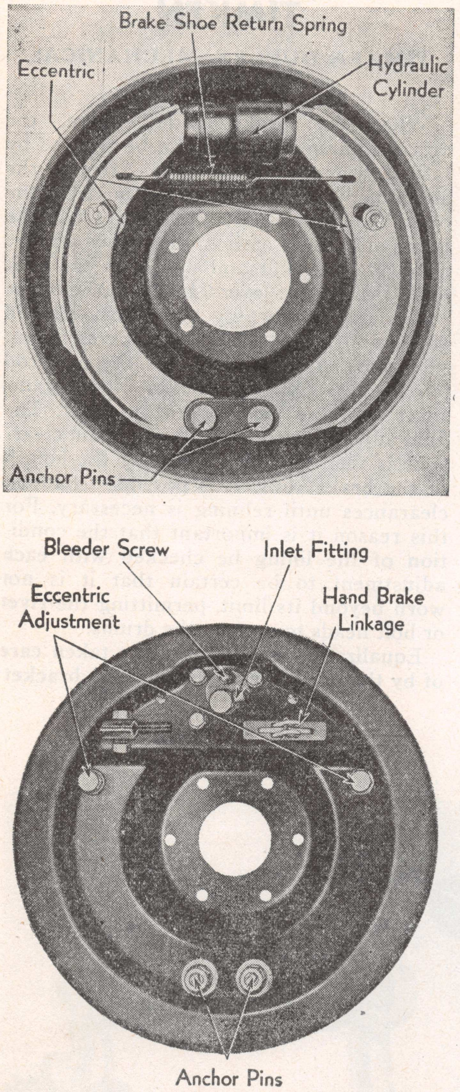


Chevrolet hand brake adjustment.

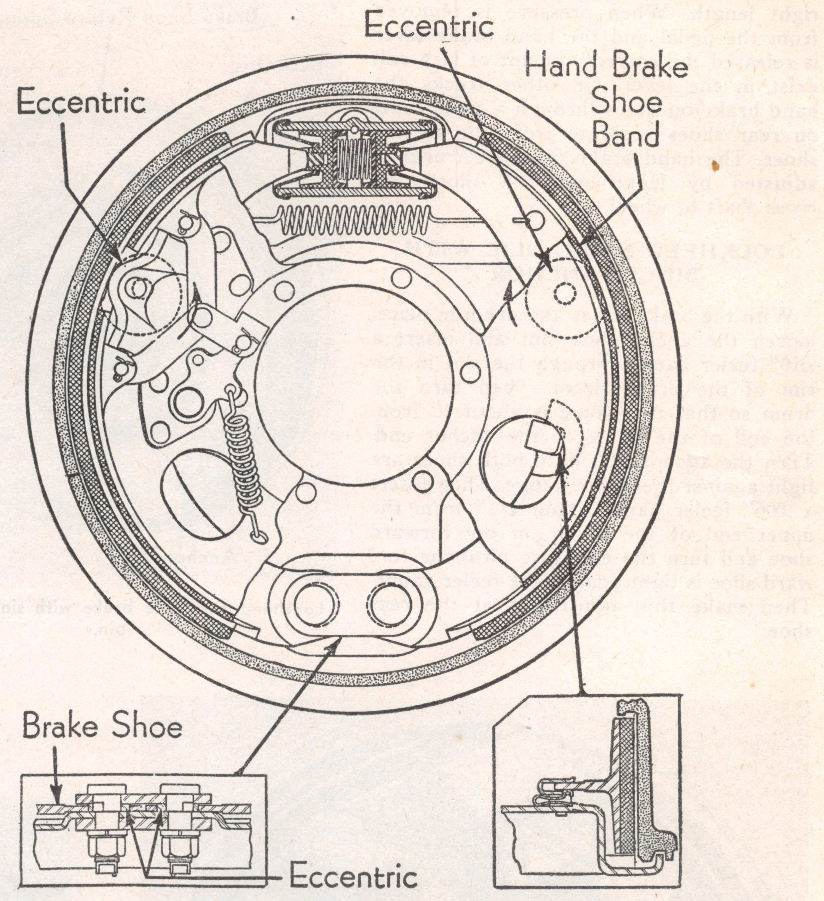
To make an adjustment, set the hand brake lever in its fully released position. Loosen the check nuts at the cable ends. Pull the cables out of the conduit by hand until a positive stop is felt. While holding the cable in this position, adjust the check nuts in the clevis plates. Then tighten the check nuts securely.

Hand Brake Toggle Adjustment—Whenever new rear brake shoes are installed on ½-ton and ¾-ton trucks, it is necessary to adjust the toggle lever with the hand brake extension link, by means of the eccentric bolt. This can only be done correctly after the service brake adjustment has been made and brake shoes are in a fully released position.

Remove the brake drum and loosen the eccentric bolt lock nut. Hold the toggle lever against the shoe and turn the eccentric bolt until there is only a slight clearance between the lever and the bot-



Lockheed hydraulic brake with two anchor pins.



1939 Ford truck hydraulic brake.

tom of the slot in the hand brake extension link. Tighten the eccentric bolt lock nut and again check for clearance. Replace the brake drum, adjust the hand brake cables and then road test the vehicle for performance.

LOCKHEED

HYDRAULIC WITH TWO ANCHORS AND DOUBLE ACTING PISTON

Minor Adjustment—To compensate for lining wear it is only necessary to adjust the brake shoe cam. Spring tension on the brake shoe cam automatically keeps it locked in any position. Turn the brake shoe cam adjusting nut, on the brake backing plate, for the forward shoe out at the top until the front shoe lining is against the drum and the wheel is locked. Then back off the nut until the wheel spins free. Now turn the cam adjusting nut for the rear shoe in the same manner.

Major Adjustment—Remove the wheels and brake drums or remove the inspection cover on the brake drum depending upon the construction of the brake. If a brake shoe gauge is available, place the gauge and proper adapter bushing on the spindle or axle shaft for the diameter of the drum. Place the gauge on the point marked "heel." If brake shoe gauge equipment is not available the shoe clearance can be checked by inserting a .010" feeler gauge between the lining and the drum about 1½" from the heel end of the lining. On some brakes, an arrow appears on the head of the anchor bolt. On these brakes the arrows must point toward each other before starting to adjust the shoes, otherwise the brake shoes will not be centralized when the adjustment is complete.

Loosen the anchor bolt lock nuts and if the bolts are marked with arrows, turn the bolts until the arrows are pointed directly at each other. Now turn the right hand anchor bolt counterclockwise and the left hand anchor bolt clockwise. Doing this will move the heel of each brake shoe downward and outward toward the drum. Continue to turn the anchor bolts until the heel of each brake shoe just comes in contact with heel adjusting finger on the gauge or with the feeler gauge. This will give the correct clearance at the drum.

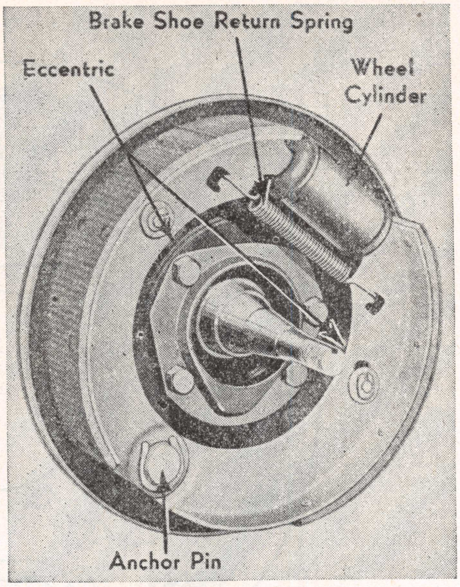
On Ford brakes it is recommended that when the anchor bolts are being adjusted that 25 to 35 pounds pressure be applied to the brake pedal and maintained through the adjustment of the anchor bolts. After the lock nuts are loosened the anchor bolts should be turned so that the marks on the tang are toward each other. Then turn the anchor bolt down until the shoe just touches the drum. Tighten the lock nut, making sure that the anchor bolt does not move. Release the pedal and check the wheel to make sure that it is free of drag. Then adjust the other anchor bolt in the same manner.

When the anchor bolts are correctly adjusted, move the gauge to the point marked "toe" and rotate the gauge marker to the top of the brake shoe or insert a .006" feeler gauge between the top of the shoe and the drum. Turn the adjusting cam until the toe of the brake shoe just comes in contact with the gauge. The toe of the shoe is then properly set and will have the correct clearance at the brake drum. Then adjust the other shoe of the pair in the same manner. After rechecking the clearance, tighten the anchor bolts and nuts securely.

Ford Hand Brake Adjustment—On the 1939 1-ton truck, set the hand brake lever in the first notch. Apply approximately 30 pounds pressure to the brake pedal, keeping this pressure applied throughout the operation. Pull up all slack in the cable and adjust the length of the conduit so that the cable is exactly the right length. When pressure is removed from the pedal and the hand brake lever is released the correct amount of lash will exist in the lever. On other trucks the hand brake operates through a cross shaft on rear shoes separate from the service shoes. The hand brake on these trucks is adjusted by lengthening or shortening cross shaft to wheel rods

LOCKHEED HYDRAULIC WITH SINGLE ANCHOR

With the brake shoes and drum in place, loosen the anchor bolt nut and insert a .010" feeler gauge through the slot in the rim of the brake drum. Then turn the drum so that the gauge is about 1" from the end of the lining at the anchor end. Turn the anchor bolt until both shoes are tight against the feeler gauge. Then insert a .006" feeler gauge about 1½" from the upper end of the lining on the forward shoe and turn the eccentric until the forward shoe is tight against the feeler gauge. Then make this adjustment at the rear shoe.



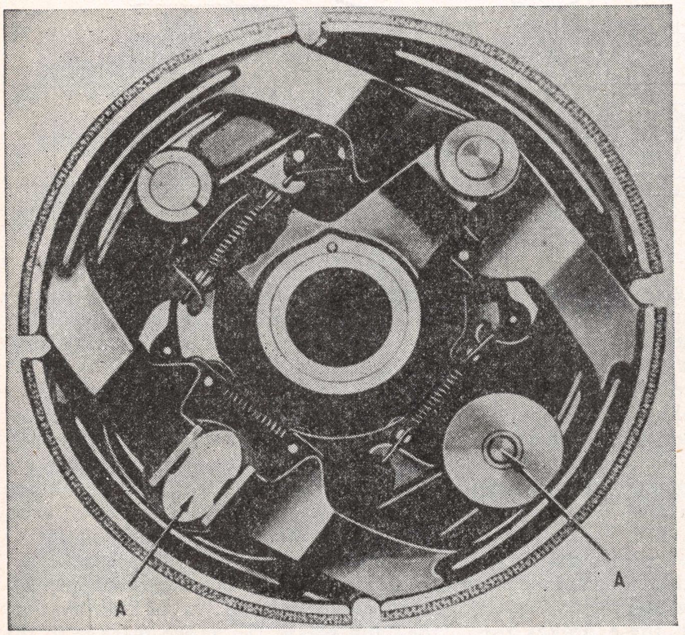
Lockheed hydraulic brake with single anchor pin.

TIMKEN

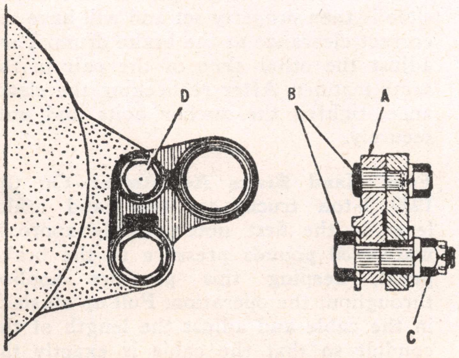
TIMKEN DUPLEX, MECHANICAL OPERATION

When the brake lining wears, the original lining clearance can be secured by taking up on the brake rods. After all the adjustment possible has been made in the brake rods, remove the levers from the inner or splined ends of the camshafts by removing the bolt and nut from the split hub of the brake levers. Increase the brake rod length by turning the adjustable rod yokes and move the levers back sufficient serrations to compensate for the new rod lengths. Lock the lever hubs on the camshaft with the locking bolt and nut. The final adjustment of the shoe to drum clearance is then made by adjusting the length of the brake rods. It is possible to adjust clearances until relining is necessary. For this reason it is important that the condition of the lining be checked with each adjustment to be certain that it is not worn beyond its limit, permitting the rivet or bolt heads to contact the drums.

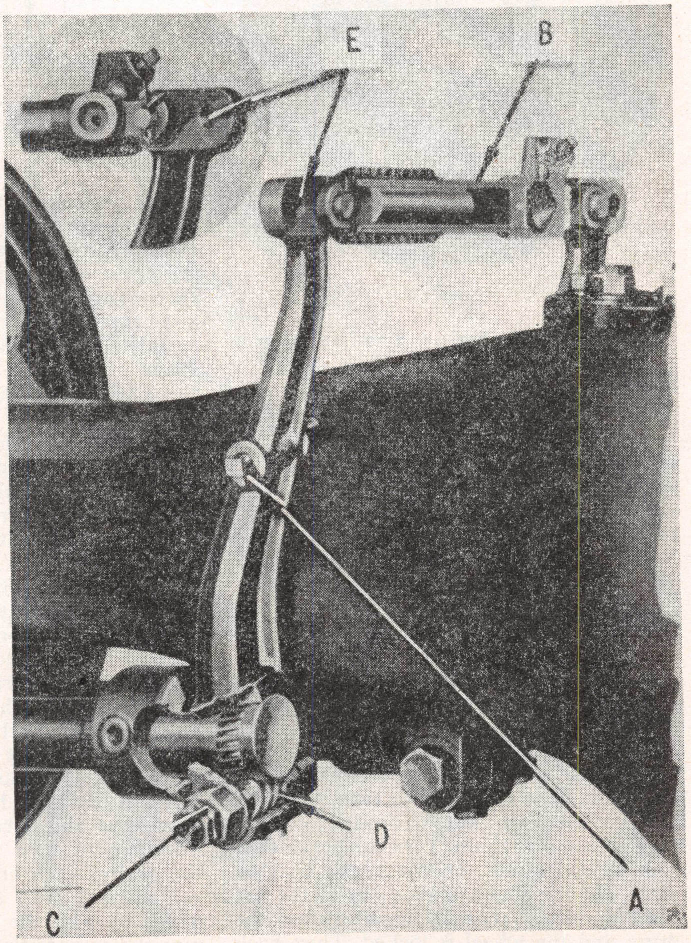
Equalization is automatically taken care of by the use of an adjustable cam bracket



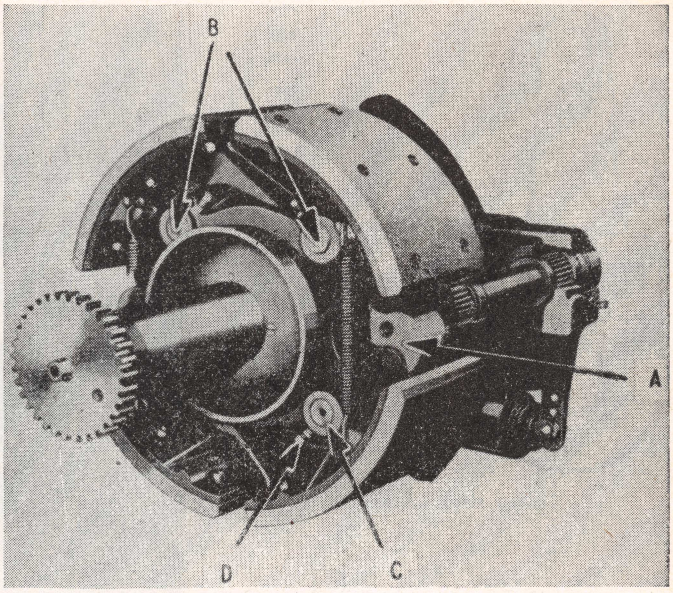
Timken duplex brake, mechanical operation
A—Camshaft.



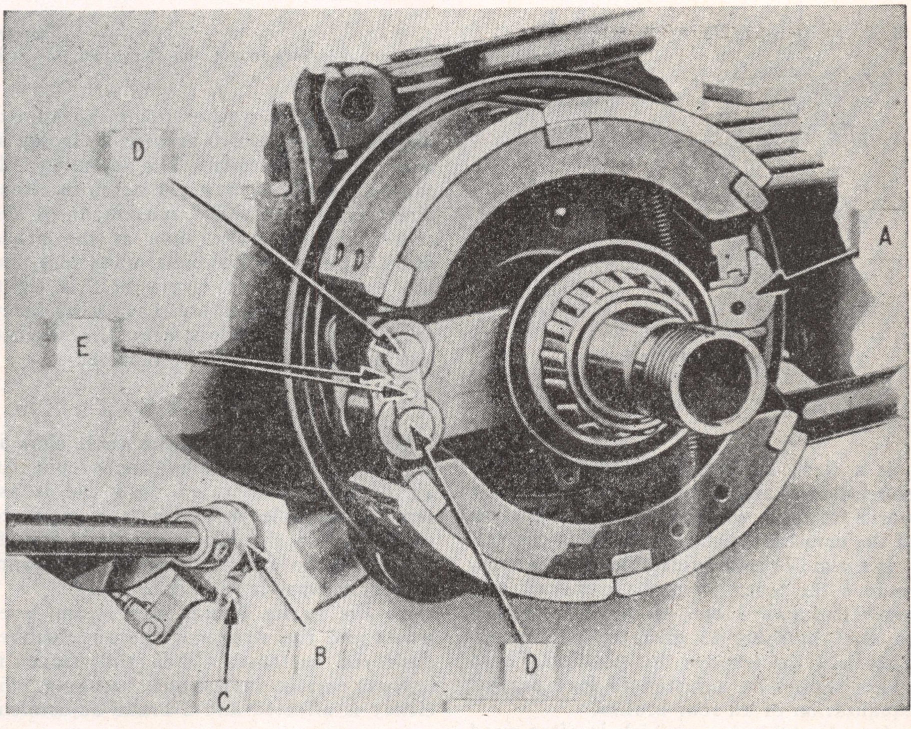
Adjustable bracket for Timken duplex brake.
A—Movable bracket. B—Bracket bolt. C—Lock nut. D—Pivot.



Timken duplex brake, hydraulic operation.
A—Stop screws. B—Operating cylinder. C—Release jam nut. D—Worm. E—Extra holes



Timken Type DW duplex brakes, air operated.
A—Constant lift camshaft. B—Anchor pin. C—Anchor pin boss. D—Lock screw.



Timken Type W brakes.
A—Constant lift camshaft. B—Slack adjuster. C—Worm. D—Anchor pin. E—Anchor pin lock plate

This bracket permits an adjustment of the cam to compensate for any unequal wear that may take place on opposite brake linings. The camshaft bushing is in a movable bracket, held in place on the brake spider by bolts. To secure proper equalization, first loosen the castelated nut, which will allow free movement of the camshaft bracket. Then have someone apply the brakes. This will allow the cam to move freely about its pivot and it will seek the proper position to insure equal pressure on all brake shoes. Tighten the bolt nuts while the brakes are still on and lock the cam in its proper position.

TIMKEN DUPLEX, HYDRAULIC OPERATION

This is the Timken Duplex brake already described, but equipped with hydraulic operated cylinders mounted between the brake levers.

To adjust the hydraulic controls, back off the stop screws on either side of the rear axle housing an equal amount until the piston bottoms in its operating cylinder. Then turn the stop screws in against the housing and expand the operating cylinder about 1/8". When making this adjustment, set each brake lever about the same distance from the center line of the axle housing. Then equalize the brake shoes by loosening the nuts on the bolts which hold the movable cam bracket to the brake spider. Then have someone apply the brakes. This causes all brake shoes to seek their proper position and insure equal pressure on all shoes. Tighten the bolt nuts while the brakes are still on which will lock the cam in its proper position.

Slack adjusters are built in each brake lever which provide means of setting the brakes to give the correct clearance. The brake springs should be attached at all times. To make an adjustment, release the jam nut and then by turning the worm in the slack adjuster, which is in mesh with the threaded portion of the camshaft, shoes can be set to give proper clearance. This clearance should be .015". When the clearance is correct, lock the slack adjuster worm by tightening the jam nut.

There are extra holes in the top of the brake levers to provide means of attaching brake rods from the hand brake lever.

TIMKEN DW DUPLEX, AIR OPERATED

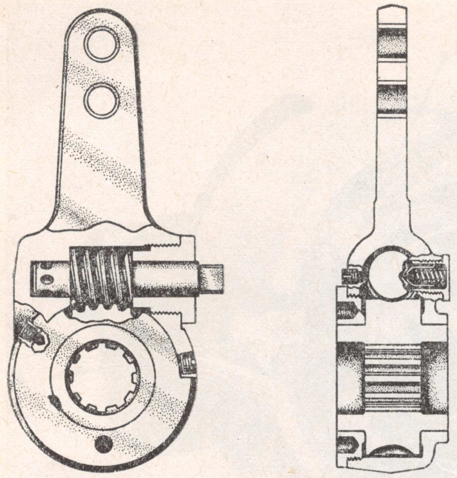
The shoes on these Duplex brakes are actuated by air cylinders through constant lift cams. Each shoe has a separate anchor pin which is locked in position with a plain washer, cap screw and cap screw lock on the front axle type. On the rear axle type the brake spider anchor pin bosses are drilled and tapped to accommodate a screw for locking the anchor pin in position. These pins are provided with tapped holes for lubrication fittings and should be lubricated to prevent any binding action. In the roller cam follower shoe, both the pin and roller require no lubrication.

Slack adjusters mounted on the inner end of the cam shaft are the only means of adjustment and should be adjusted to give perfect equalization to all four brakes. These adjusters are originally set so that the push rod travel at the ends of the levers is 7/8" when the brake is applied.

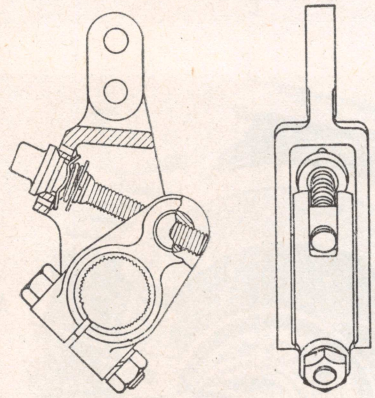
TIMKEN SERIES W

This two shoe brake has a thick brake liner bolted to the shoe and can be operated mechanically or with air. However, in the majority of cases the shoes are actuated by air through a constant lift cam. Slack adjusters or an adjustable lever compensate for brake lining wear. These levers or adjusters are originally adjusted to give 3/4" travel which increases with lining wear. When this travel reaches 1½" the levers or adjusters should be reset to give the original travel.

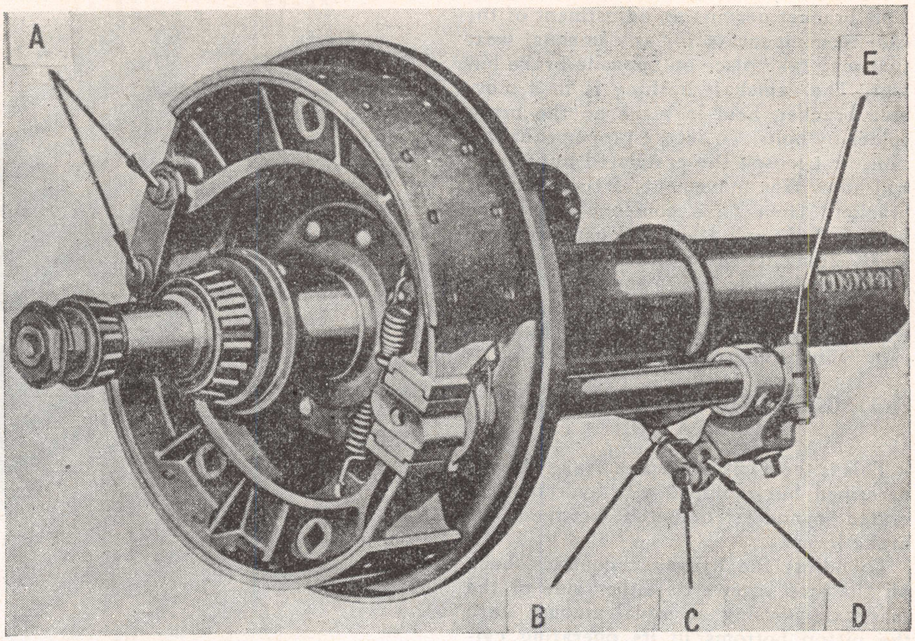
Each shoe has its own anchor pin which is locked in position with a lock plate and screw. These anchor pins are provided with tapped holes for lubrication fittings and should be lubricated to prevent any binding. The adjuster lever and the bearings at both ends of the camshaft should also be lubricated. Care must be used not to overlubricate these points at the spider or outer end.



Timken slack adjuster.



Timken adjustable lever.



Timken Type T brakes.
A—Anchor pin. B—Push rod. C—Clevis pin. D—Cam lever. E—Lever clamp bolt.

If a slack adjuster is fitted, loosen the bolt lock nut and turn the bolt, which is a worm in mesh with the threaded portion of the camshaft, until the travel is correct.

If a plain or non-adjustable lever is used, remove the lever from the camshaft and move it forward one or more serrations on the camshaft to give the ¾" travel. Then lock the lever in this position. These levers should be adjusted to give perfect equalization of all four brakes.

An adjustable lever which is often used on these brakes and also on Series T brakes provides a simple and dependable means of making an adjustment. This lever permits rotating the camshaft 45 degrees from its initial setting, which is usually sufficient to compensate for 3/16" wear of the brake lining. To make an adjustment for wear it is only necessary to remove the entire lever from the camshaft and to set the lever back four serrations or 40 degrees. The camshaft lever is clamped to the serrated end of the camshaft with a pin in the forked end of the lever, which is free to rotate. An idler lever straddles the camshaft but is not attached to it. An adjusting bolt which is locked in the idler lever is threaded into the camshaft lever pin. A spring mounted notched locking washer holds the adjusting bolt in position to prevent a change in brake shoe adjustment. The adjusting bolt can be rotated ¼ turn per notch in either direction, giving .0025" movement of the center of the brake shoe at the brake drum. After an adjustment, make sure that the camshaft lever clamp bolt is tight. Should the adjusting bolt have a tendency to vibrate out of adjustment, the notched locking washer should be replaced.

TIMKEN SERIES T

With this type of brake each shoe is mounted on an individual anchor pin. An air operated diaphragm push rod is assembled to a lever which is clamped to serrations on the inner end of the shaft operating the cam. When the diaphragm moves, it expands the brake shoes.

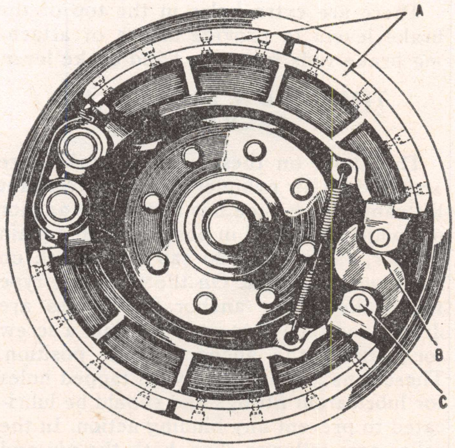
As the brake linings wear, cam lever travel and the stroke of the air chamber push rod increase. When this travel is beyond certain limitations, breaking efficiency is affected and a brake adjustment is necessary.

To make an adjustment, remove the clevis pin connecting the diaphragm push rod to the camshaft lever. Then remove the camshaft lever clamp bolt, and move the lever forward one or more serrations on the camshaft. Replace the bolt and lock the lever in its new position. Now connect the lever and push rod by replacing the clevis pin.

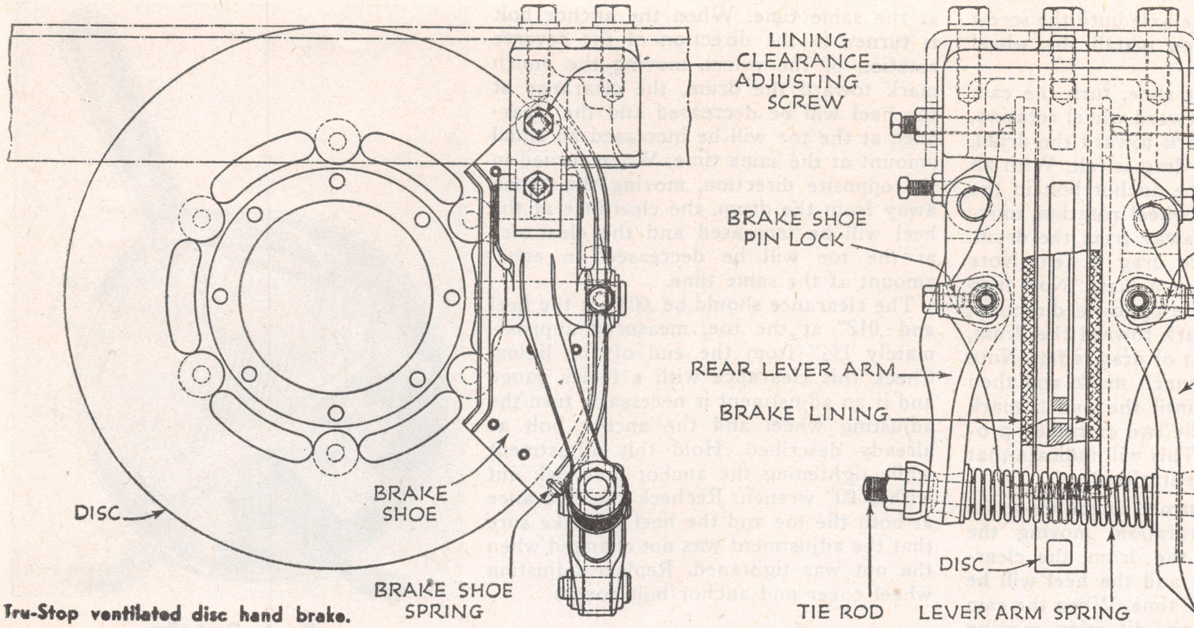
With the operating cam and lever in position, the brakes can now be adjusted. On all brakes except those which are 5" wide, the anchor pins are eccentric, and turning the pins moves the shoes away from or toward the drums. To adjust the position of the anchor pins, release the lock nut on the anchor pins and turn the pin until the clearance between the lining and the drum is about .015". When the clearance is correct, tighten the lock nuts. The anchor pins on shoes 5" wide are mounted the same as described for Timken W brakes.

TIMKEN SERIES P

Adjustments are the same as described for Series W. The roller cam followers and pin are nitrided, lubricoted parts, requiring no lubrication. The pin is locked in the brake shoe so that the roller turns about the pin. Each shoe has an anchor pin which is locked in the brake spider with a cap screw and has felt washers and retainers to seal the pin and bushing from dirt and grit. These pins require no lubrication except when the brake shoes are removed for inspection or relining at which time the pins should be cleaned and lubricated.



Timken Type P brakes.
A—Brake liner. B—Roller cam follower.
C—Roller pin.



Tru-Stop ventilated disc hand brake.

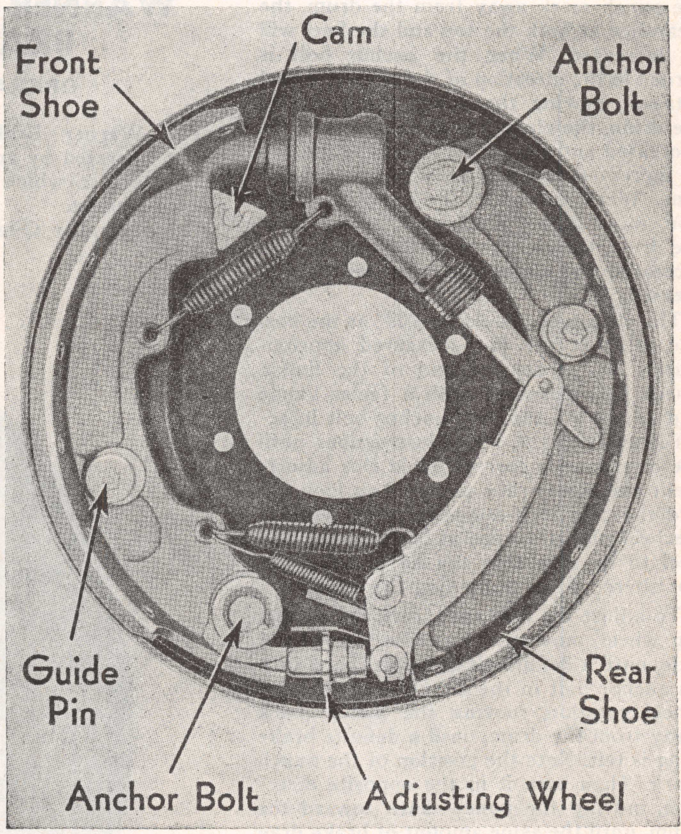
The camshaft is mounted in a needle bearing at the outer or brake spider end, and enclosed with a felt washer and retainer to keep dirt and grit from the bearing surfaces. The camshaft is grooved for a lock ring which holds it in position. Tapped holes are provided in the spider for lubrication fittings.

TRU-STOP

HAND BRAKE

Adjustment—To adjust this type of hand brake, disconnect the pull rod between the hand brake lever and the brake operating lever by removing the pin from the top of the operating lever. Tighten the nut at the rear of the lever arms tie rod so that the lever arm spring exerts enough pressure to bring the operating lever solidly against the front lever arm. Insert a 1/32" shim between the front shoe lining and the disc. Now tighten the tie rod nut so that there is 1/32" clearance between the rear lining and the disc. With the brake shoe spring in place, turn the disc adjusting screws until the linings are parallel with the disc. Remove the shim between the front shoe lining and the disc. With the hand brake lever in its released position, adjust the pull rod to its proper length.

Relining—To reline the shoes, remove the nuts from the brake tie rod. Remove the brake shoe spring. Apply the hand brake lever so that the rear lever arm can be swung back clear of the tie rod and spring. Remove the brake shoe pin locks and drop the shoes. Replace the relined shoes and adjust the brake as already described.



Wagner Hi-Tork hydraulic brake.

WAGNER HI-TORK

HYDRAULIC

Minor Adjustment—To make an adjustment for lining wear, loosen the front shoe cam lock nut and with a wrench, turn the cam in the direction of forward wheel rotation, moving the punch mark on the end of the cam toward the drum, until a definite drag is felt. Then back off the cam until the wheel is just free. Tighten the cam lock nut securely. Remove the adjusting wheel hole cover and insert a screw driver in the hole. Turn the adjusting wheel by moving the handle of the screw driver toward the axle until a definite brake drag is felt. Release the adjusting wheel by moving the handle of the screw driver away from the axle until the wheel is just free. Do not alter the position of the anchor bolts.

Major Adjustment—To replace the brake drum, if it has been removed, remove the adjusting wheel cover and the anchor bolt covers. Observe the position of the punch marks on the anchor bolts and also on the cam. Place these marks away from the shoes. This will indicate their full off position. Also rotate the adjusting wheel to its full off position by moving the handle of the tool away from the axle until the screw reaches its stop. Then install the wheel and drum assembly.

To adjust the front shoe, turn the cam in the direction of forward wheel rotation, moving the punch mark toward the drum, until a definite brake drag is felt. With an Allen wrench, turn the anchor bolt in the direction of forward wheel rotation, moving the punch mark away from the drum, until a definite brake drag is felt. Note the position of the punch mark. Now turn the anchor bolt in the opposite direction, moving the punch mark toward the drum, until the same amount of drag is felt. Note the position of the punch mark and then turn the bolt back until the punch mark is halfway between the two extremes, producing a free wheel. This will indicate that the shoe is roughly centralized.

When the cam is turned in the direction of forward wheel rotation, moving the punch mark toward the drum, the clearance at both the toe and the heel will be decreased at the same time. When the cam is turned in the opposite direction, moving the punch mark away from the drum, the clearance at both the toe and the heel will be increased. When the anchor bolt is turned in the direction of the reverse wheel rotation, moving the punch mark toward the drum, the clearance at the heel will be decreased and the clearance at the toe will be increased an equal amount at the same time. When turned in the opposite direction, moving the punch mark away from the drum, the clearance at the heel will be increased and clearance at toe will be decreased.

The clearance should be .008" at the heel and .012" at the toe, measured approximately 1½" from the end of the lining. Check this clearance with a feeler gauge and adjust the cam and anchor bolt in accordance with the above instructions until the clearance is correct. Hold this adjustment and tighten the anchor bolt lock nut and the cam lock nut with a 20" wrench. Recheck the clearance at both the toe and heel to be sure that the adjustment was not altered when tightening the nuts.

To adjust the rear shoe, turn the adjusting wheel, moving the handle toward the axle, until a definite drag is felt. Then turn its anchor bolt in the direction of forward wheel rotation, moving the punch mark away from the drum, until a definite brake drag is felt. Note the position of the punch mark. Then turn it in the opposite direction, moving the punch mark toward the drum, until the same amount of brake drag is felt. Note the position of the punch mark. Then turn the anchor bolt back until the punch mark is halfway between the two extremes, producing a free wheel. This will indicate that the shoe is roughly centralized.

When the adjusting wheel is turned with the handle of the tool moving toward the axle, the clearance at both toe and heel will be decreased at the same time. When the wheel is turned with the handle moving away from the axle, the clearance at both the toe and the heel will be increased at the same time. When the anchor bolt is turned in the direction of the reverse rotation of the wheel, moving the punch mark toward the drum, the clearance at the heel will be decreased and the clearance at the toe will be increased an equal amount at the same time. When turned in the opposite direction, moving the punch away from the drum, the clearance at the heel will be increased and the clearance at the toe will be decreased an equal amount at the same time.

The clearance should be .008" at the heel and .012" at the toe, measured approximately 1½" from the end of the lining. Check this clearance with a feeler gauge and if an adjustment is necessary, turn the adjusting wheel and the anchor bolt as already described. Hold this adjustment while tightening the anchor bolt lock nut with a 20" wrench. Recheck the clearance at both the toe and the heel to make sure that the adjustment was not changed when the nut was tightened. Replace adjusting wheel cover and anchor bolt covers.

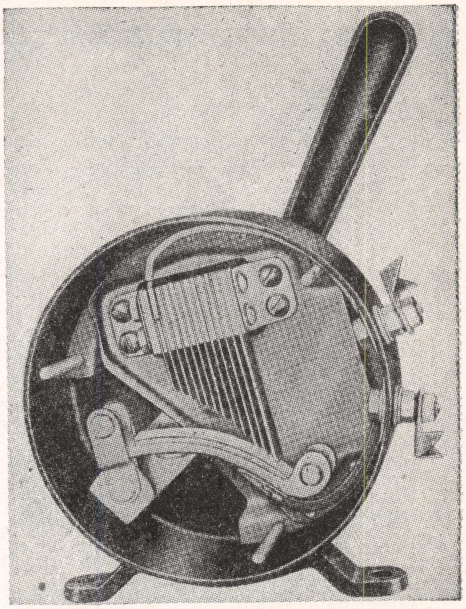


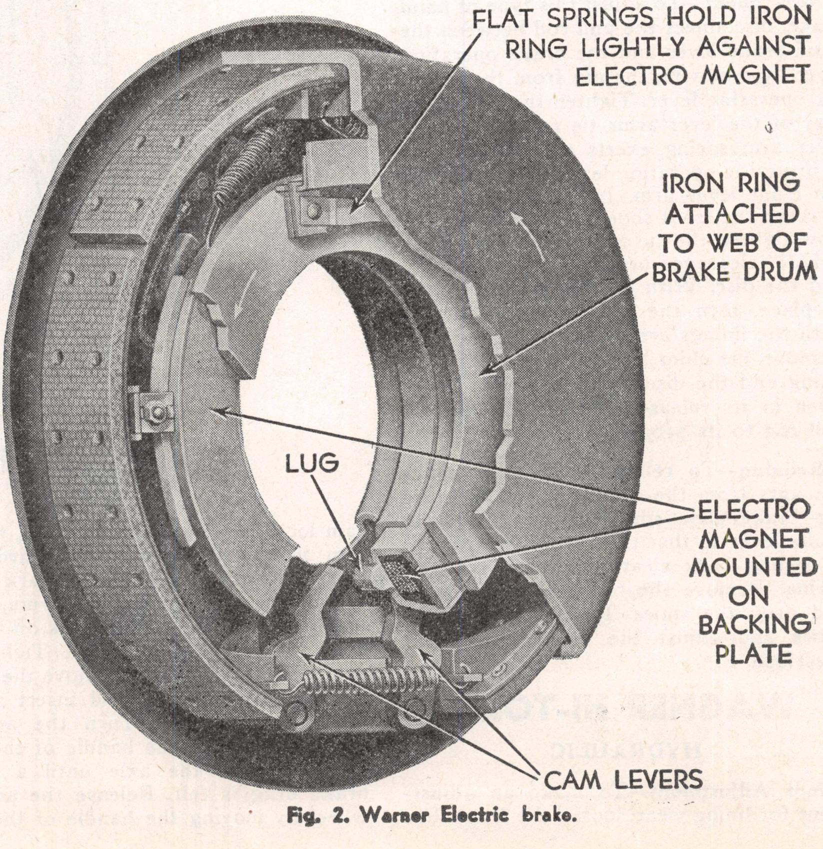
Fig. 1. Controller.

WARNER ELECTRIC BRAKES

OPERATION

The Warner Brake is a mechanical brake, operated by an electro-magnet and armature disc which is attracted by the electro-magnet.

The controller (Fig. 1) mounted on the steering post is operated by the driver manually. It may be mounted on the chassis and operate simultaneously with the brake pedal. By means of the controller the driver varies the electric current thus controlling the electro magnetic strength. The greater the magnetic strength the more severe the brakes will be applied.



FLAT SPRINGS HOLD IRON RING LIGHTLY AGAINST ELECTRO MAGNET
IRON RING ATTACHED TO WEB OF BRAKE DRUM
LUG
ELECTRO MAGNET MOUNTED ON BACKING PLATE
CAM LEVERS

Fig. 2. Warner Electric brake.

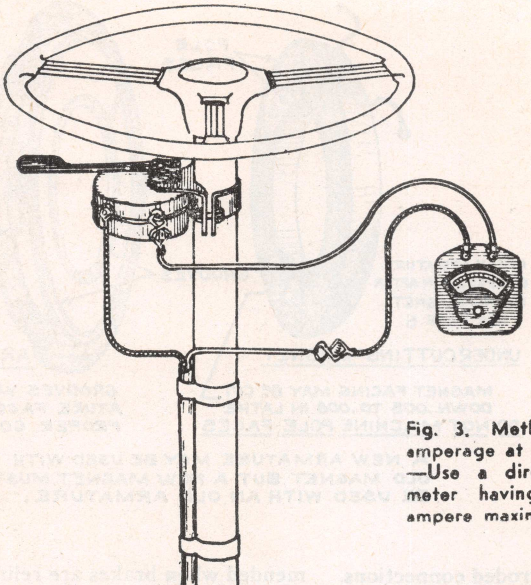


Fig. 3. Method of checking amperage at controller. NOTE—Use a direct current ammeter having a 10 or 15 ampere maximum scale.

The magnet (Fig. 2) is machined to run concentric to the axle and brake drum. It has a bronze bearing and is mounted upon the brake backing plate so as to allow it to turn the distance necessary to apply the brakes. It is held into a groove in the backing plate by small springs which return the magnet to the release position. As the controller is turned "ON", the electric current flows through the electro-magnet thus magnetizing the magnet and causing the revolving armature disc to cling to the magnet. The magnet then tends to revolve with the armature. The magnet and lug are integral, and shift together, moving the lever and cam. The cam presses against the end of brake band, thus applying the brakes. Moving the lever to "OFF" position breaks the circuit, the magnet then loses its magnetism, releases itself from the armature, and the springs return the magnet to its release position, thus releasing the brakes.

SERVICE

An electro-magnet's strength is in direct proportion to the flow of current in the magnetic windings. The braking power then is in proportion to the amount of current that is sent to the brakes through the controller. A poor contact, a loose connection or a broken wire will impair brake operation. A brake magnet should draw between 3 and 3.7 amperes or between 6 and 7.4 amperes for two brake magnets as measured at the controller (Fig. 3). If the current drain is low it is evidence of poor connections or an open circuit. Test current drain of each brake at the wheels (Fig. 4). If the current drain is greater than 3.7 amperes at either wheel or over 7.4 amperes at the controller, check for a short circuit or ground in the line. If the current drain is correct and the brakes do not function properly, it will be necessary to check the brake mechanism.

Remove the wheels and brake drums to check the brakes. If the lining is worn down near the rivets or covered with oil or grease, clean thoroughly and reline the brake bands with the correct lining as recommended by the brake manufacturer.

If a glazed or polished surface appears on the magnet facing it will be necessary to remove the magnet and take a small cut off the facing in a lathe—from .005 to .008 inch cut should suffice. Do not remove metal from pole faces of magnet.

An old armature will work with an undercut magnet. A new armature may be used with an old magnet but a new magnet must not be used with an old armature. Figure 6 shows the method of checking armature depression which should not be less than ⅛" nor more than 5/32". Due to wear and machining variations, this space may be under ⅛". If so, use armature spacers between drum and armature mounting ring as required.

GAUGE FOR MEASURING ARMATURE DEPRESSION

The armature should be depressed approximately 5/32" against the magnet when the brake drum is in position. This can be best measured with the special gauge designed for measuring and adjusting clearance.

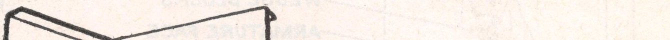
INSTRUCTIONS FOR USING GAUGE

1. Place short ends of gauge against magnet face.
2. Slide adjustable rod against bearing shoulder.
3. Tighten thumb screw in gauge.
4. Slide collar against frame.
5. Tighten thumb screw in collar.
6. Place inner bearing in hub.
7. At three places, wedge armature away from drum to its full travel.
8. Place long ends of gauge against armature face.
9. Loosen thumb screw in gauge.
10. Slide adjustable rod against wheel bearing.
11. Tighten thumb screw in gauge.

If "D" (Fig. 6) is under ⅛", then space out armature ring at "B". Variations from these dimensions must not exceed 1/64". If "D" is greater than 5/32", space bearing out at bearing shoulder "A". The distance "D" from collar to gauge is the armature depression after assembly. In assembling do not allow grease, however slight, to touch any part of the brake; grease will cause grabbing, locking or loss of power. Bearings must be packed with a good wheel bearing grease. Under no circumstances can an Alemite gun be used and all nipples on hubs must be plugged before releasing the unit for service.

When the drum is placed in running position, the axle nut must be pulled up snug

Fig. 4. Method of checking amperage at brakes. NOTE—Use a direct current ammeter having a 10 or 15 maximum scale.



REMOVE EITHER WIRE TERMINAL FROM BRAKE AND CONNECT TO AMMETER. CONNECT OTHER LEAD OF AMMETER TO BRAKE TERMINAL.

(TWO WIRE SYSTEM)

to prevent loose bearings. The brake loses power if the armature is not kept firmly in contact with the magnet. R. H. armature must be mounted on right side of vehicle (facing direction of travel), L. H. armature on opposite side.

To get the best performance out of full wrap brake, it is necessary that the band be round. Check all bands for roundness when service work is done or when the band is relined. The band should fit snugly to the gauge with a light tension to hold it in place. To round a flat spot in the band, lay the band on a board or wood top bench, strike the band where it is necessary between rivets using a ball peen hammer. By placing band in a bench vise and closing, will spring the band out. The bending should be done between rivets. When replacing band on backing plate, do not spring bands out further than necessary. An out of round band can cause a brake to "grab". If the leading end (toe end) of the band is bent away from the band gauge, the brake will be strong or "grabby". When bent in toward the center, the brake will be weak.

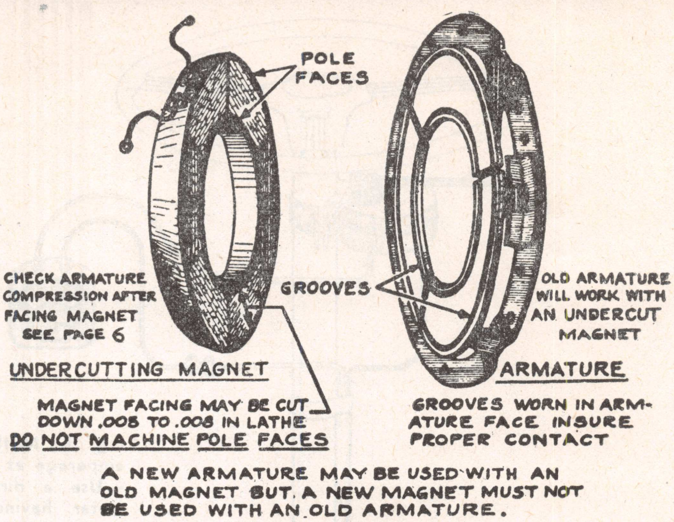

POLE FACES
CHECK ARMATURE COMPRESSION AFTER FACING MAGNET SEE PAGE 6
GROOVES
OLD ARMATURE WILL WORK WITH AN UNDERCUT MAGNET
UNDERCUTTING MAGNET
ARMATURE
MAGNET FACING MAY BE CUT DOWN .005 TO .008 IN LATHE DO NOT MACHINE POLE FACES
GROOVES WORN IN ARMATURE FACE INSURE PROPER CONTACT
A NEW ARMATURE MAY BE USED WITH AN OLD MAGNET BUT A NEW MAGNET MUST NOT BE USED WITH AN OLD ARMATURE.

Fig. 5. Action of armature on magnet.

WEAK OR INTERMITTENT BRAKES

Test wiring for loose or broken connections, or broken wire at the magnet. Use a good voltmeter and test along the entire circuit from the battery to the brake magnets. With the brakes fully applied, the voltage drop should be negligible. If voltage is lower on the brake wire terminal at the controller than at the battery wire terminal, then the controller contacts must be cleaned or replaced. Check plugs and sockets for loose, dirty or corroded connections. Keep ground connections clean and tight, and test for a good ground return where trailers are coupled.

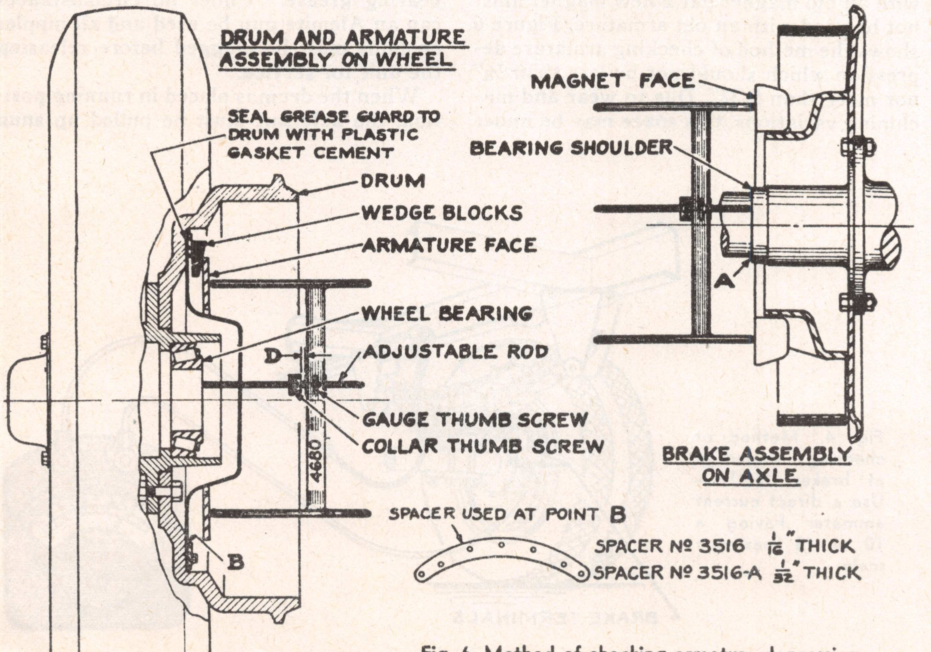

DRUM AND ARMATURE ASSEMBLY ON WHEEL
SEAL GREASE GUARD TO DRUM WITH PLASTIC GASKET CEMENT
DRUM
WEDGE BLOCKS
ARMATURE FACE
WHEEL BEARING
D
ADJUSTABLE ROD
GAUGE THUMB SCREW
COLLAR THUMB SCREW
4680
B
MAGNET FACE
BEARING SHOULDER
A
BRAKE ASSEMBLY ON AXLE
SPACER USED AT POINT B
SPACER Nº 3516 1/16" THICK
SPACER Nº 3516-A 1/32" THICK

Fig. 6. Method of checking armature depression.

RELINE BOTH BANDS WITH SAME LINING

Using the wrong lining will result in weak or grabbing brakes. Greasy, worn out or improper lining must be replaced. Grease or oil on the magnet facing or a glazed or polished surface will not have sufficient friction to operate brakes satisfactorily. The magnet must be kept free of grease and oil. New grease retainers are recommended when brakes are relined. Glazed or polished surfaces may be removed with a medium grade of emery cloth or by refacing magnet in a lathe.

Stop lights **must not** be connected into the brake circuit as they change the graduation of the current as it passes through the controller, resulting in weak or grabbing brakes.

If truck or tractor brakes are adjusted, the brake pedal travel will be shortened, therefore the foot controller for the trailer brakes must be reset to cover the full range of the controller. Make certain that the controller is in the "OFF" position when the tractor brake pedal is fully released. Inversely, the trailer controller must be fully "ON" when the tractor brakes are fully applied.

TROUBLE SHOOTING

ERRATIC OR GRABBING BRAKES

1. Check for loose or worn wheel bearings.
2. Gummy or grease-soaked brake lining.
3. Brake flange loose on the axle.
4. Axle loose on springs or springs loose on frame.
5. Drums out of round.
6. Lining worn down to rivets, lining loose on rivets, bands distorted out of round, weak or broken band spring, only one brake working.
7. Loose electrical connection.

WEAK BRAKES

1. Brake lining worn, greasy or bands out of round.
2. Foot controller not properly adjusted to apply brakes evenly with the tractor brakes.
3. Glazed or greasy magnet facing or incorrect armature spacing.
4. Poor electrical connections, broken wire inside insulation, corroded connecting plug and socket, pitted controller, poor ground connections at the brakes or

trailer coupling or poor wiring.

6. Test battery condition, cable connections and battery ground.

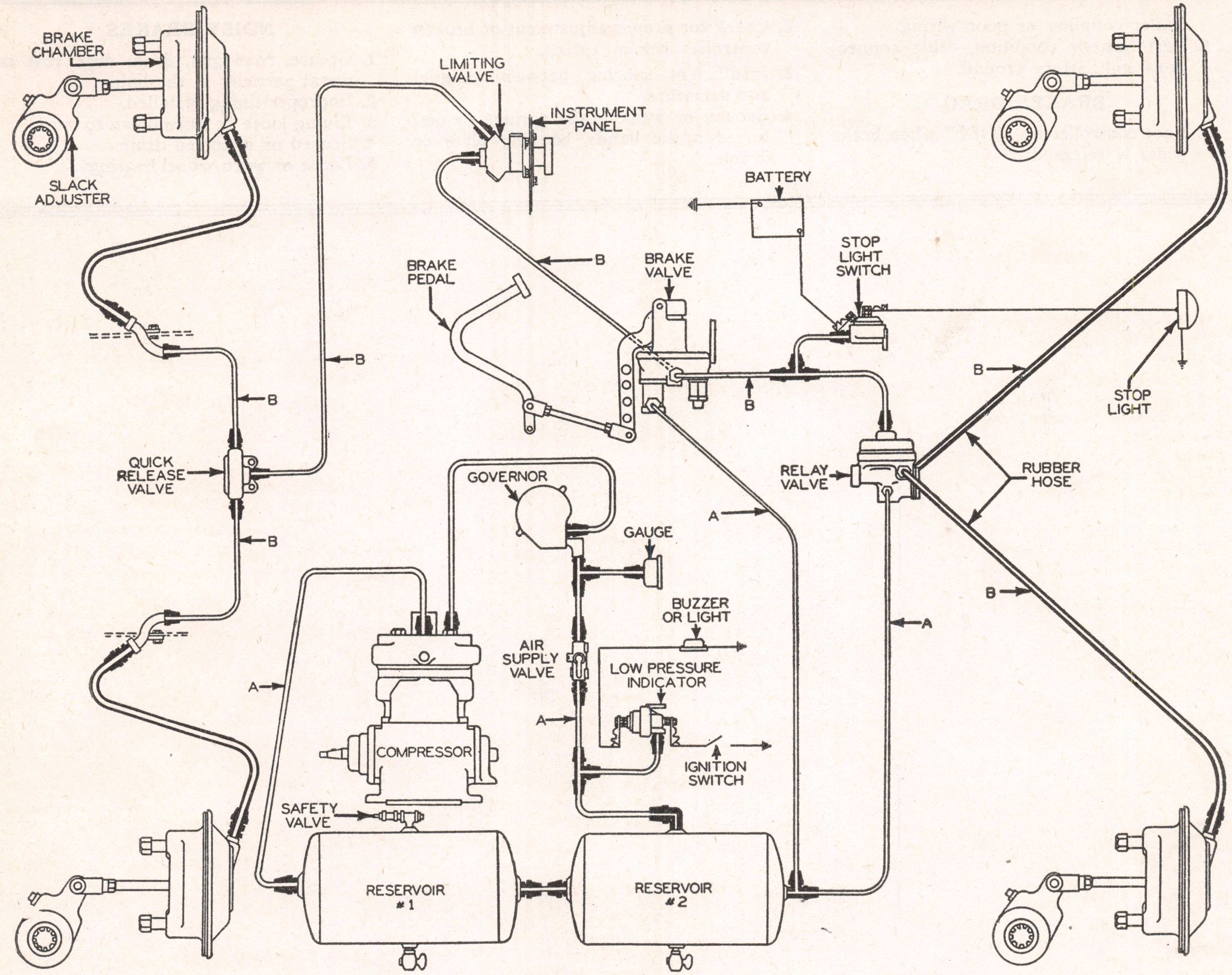
BRAKES DRAG

1. Foot controller not "OFF" when brake pedal is released.
2. Check for proper adjustment or broken controller return spring.
3. Insufficient spacing between magnet and armature.
4. Broken or weak brake springs or distorted brake bands, backing plate or drums.

NOISY BRAKES

1. Grease, road grit, drum dust, rust or metal particles in the lining.
2. Improper lining installed.
3. Lining loose or worn down to rivets.
4. Scored or distorted drum.
5. Loose or worn wheel bearings.

AIR BRAKES



Typical air brake system.

BENDIX-WESTINGHOUSE

OPERATION

Air pressure is built up into one or two reservoirs by a compressor driven by the engine to at least 70 pounds. Observe dash gauge before starting the vehicle. The driver should check this pressure from time to time while vehicle is in operation. If the air gauge should register a rapid drop, the brakes should be applied and held applied until the vehicle is brought to a full stop.

Check for leakage or cause of any sudden drop of pressure before starting vehicle.

When vehicle is in motion the brakes may be applied as hard as speed, road condition and passenger comfort permit, and then graduated off as the speed is reduced. The final stop requires but little air pressure.

In slowing down from any speed, allow engine to remain in gear to help reduce speed, in the same manner as using mechanical brakes, disengaging the clutch when engine idling speed is reached.

In the event of a trailer breakaway, keep the brake pedal applied on truck or tractor until stop is made. Hold truck with hand brake and close cut-out cocks in the service and emergency lines to prevent loss of air. Be sure to open cut-out cocks after repairs and recoupling are made. To release the trailer brakes without recoupling the air connections on truck or tractor, the trailer reservoir drain cock must be opened and pressure completely exhausted.

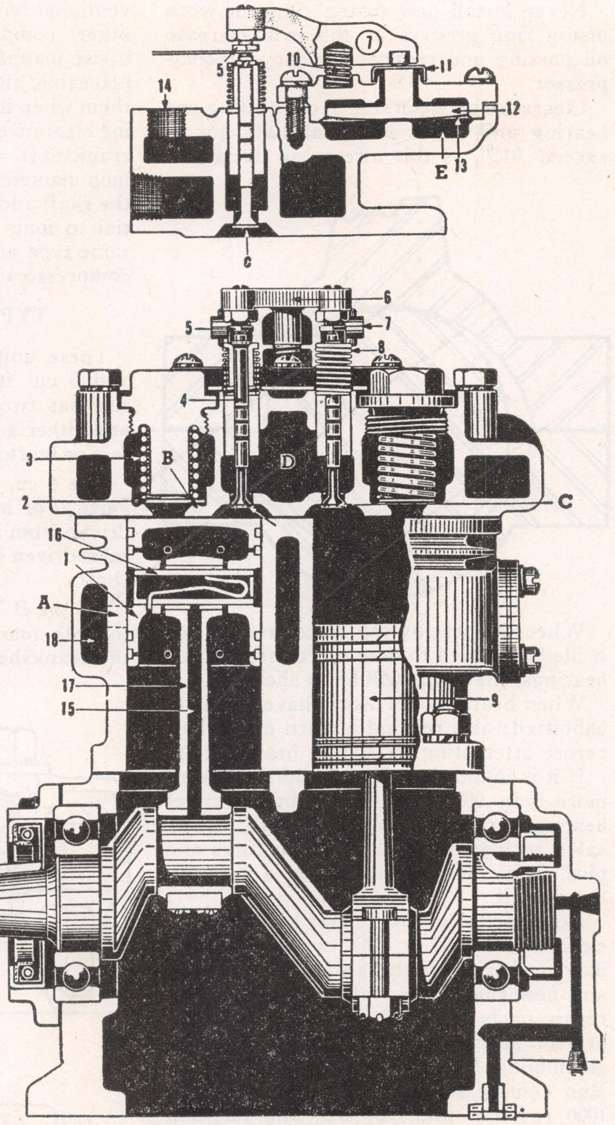
The brake pedal must not be pumped to stop vehicle but moved in a single stroke to the desired brake application. Pumping the pedal decreases the brake application and the air pressure in the reservoir and brake lines. In an emergency, the brake pedal is moved the limit of its stroke, opening wide the brake valve, thus permitting full air pressure to be applied to the brake chamber at the wheels. However, this practice should not be employed in ordinary braking services.

Control devices are used with these brakes to speed up the application and release of the brake system, to control reservoir pressure, and to provide a supply of air for general purposes such as emergency tire inflation, operation of bus doors, windshield wipers, air horns, etc.

TYPE U AIR COMPRESSOR

The air is drawn into the cylinders, when pistons travel on the downward stroke, through a series of intake ports, located radially near the middle of the cylinder bore. The piston serves as an inlet valve by clearing the ports as it nears the bottom of its stroke, allowing fresh air to pass into the cylinder through the manifold and air strainer. The air is compressed after the piston covers the ports, the pressure overcomes the resistance of discharge valve spring and lifts the discharge valve from its seat. The air then is permitted to pass out through the discharge lines to the reservoirs.

When the upper governor setting is reached the governor cuts out, delivering air pressure through the unloader line to the unloader chamber. This air pressure admitted to the cavity E (see cut) forces the unloader diaphragm, diaphragm follower and dust guard to move up, causing the lever arm to rotate on its fulcrum pin. As the lever arm rotates, the adjusting screws are forced down against unloader valves causing the unloader valves to move



Type 2 UE6HW compressor. 1—Piston. 2—Discharge valve 3—Discharge valve springs. 4—Unloader valve. 5—Adjusting screws. 6—Lever arm. 7—Rocker arm fulcrum pin. 8—Unloader valve spring. 9—Piston. 10—Rocker arm spring 11—Dust guard. 12—Unloader diaphragm follower. 13—Unloader diaphragm. 14—Discharge port. 15—Oil passages 16—Wristpin. 17—Connecting rod. 18—Air strainer. A—Intake port. B—Discharge valve seat. C—Seat. D—Cavity. E—Cavity.

from their seats and thereby opening an air passage from each cylinder into cavity D.

While the passages from the cylinders to cavity D are open, the spring-loaded discharge valves remain closed and the air displaced by the upward movement of the piston is permitted to pass without compression through cavity D into the cylinder in which the piston is moving down, instead of being compressed and pushed out through the discharge valve. This method removes the compression force against the piston and greatly reduces wear on practically all parts of the compressor. The compressor continues its unloaded operation until reservoir pressure has dropped down to the lower governor setting. Then the governor cuts in. As the governor cuts in, the air is exhausted from the unloader line and cavity E, thus permitting the rocker arm spring to move the unloader arm up and permitting the unloader valve spring to close the unloader valves. As the unloader valves close, the compressor resumes compression.

If the compressor has been removed, **care must be taken when replacing it to make sure that the mounting bolts are tightened securely and uniformly so that** no side thrust or strain is put upon the compressor crankshaft. Make sure the oil line from the engine is open and clean (if engine-lubricated) and that a minimum of 5 pounds of oil pressure is delivered at idling speeds and a minimum of 15 pounds at governed speeds. Also be sure that the oil return to the engine is open.

Lubrication: Most factory installations have the lubricating system connected to the engine oil pump. However, there are some installations that have self-lubricating compressors having a self-contained oil supply and pump. The method used in both types is the same. Oil is forced through the oil passages to the connecting rod journals and piston pin bearings. Oil forced past these bearings is splashed to the cylinder walls and ball bearings. Excessive oil is drained back into the crankcase or engine oil pan.

Test oil level daily in the self-lubricated compressors. Replenish when necessary.

Drain oil when the engine crankcase oil is changed. Flush out and refill crankcase. **Use S.A.E. 20 in winter or S.A.E. 10 if vehicle is stored in a cold place. For summer operation, use S.A.E. 40 oil.**

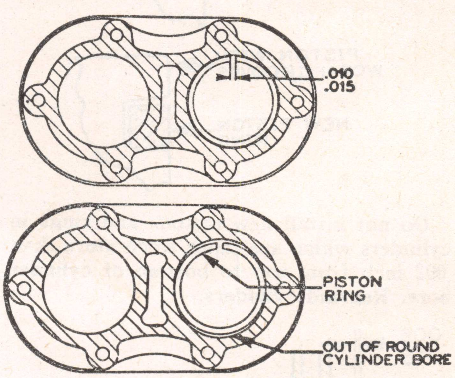
Cooling is maintained by either of two methods, water or air-cooling fins. The water from the engine's cooling system is circulated through the compressor's cylinder head. The air-cooled type must be mounted in a cool place away from the exhaust heat and in a cool place in the direct path of circulating air. The air-cooled compressor speed never exceeds 1250 rev. per min.

SERVICE AND INSPECTION

1. Clean the curled hair from the air strainer in kerosene or gasoline and saturate with a light lubricating oil every 2000 miles. Clean more often if operated under extremely dusty conditions. 10,000 mile inspection or 5000 miles of city operation.
2. Remove cylinder head and clean carbon. If the valves or seats are pitted they may be refaced or ground in with B-W Grade 1000 grinding compound.
3. Check compressor discharge line to be sure it is not choked with carbon.
4. Adjust unloader valve clearance to .010 to .015 inch between valves and adjusting screws.
5. Check drive alignment. Tighten all mounting bolts securely.
6. Oil unloader rocker arm fulcrum pin
7. Remove unloader box cover and inspect unloader diaphragms. Replace if necessary.
8. If the water is drained from radiator in winter to prevent freezing, also remove the drain plug in the side of the compressor head to insure proper drainage

MAJOR REPAIRS

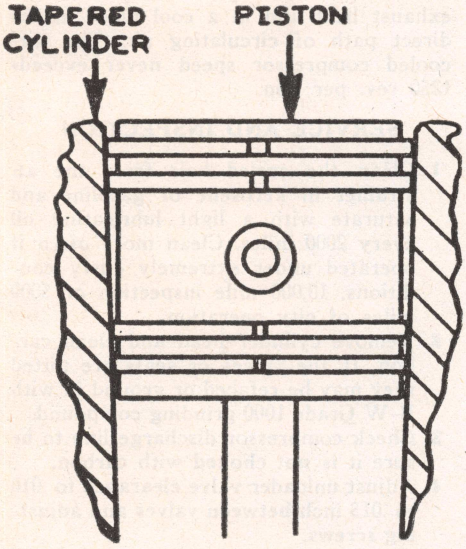
If the cylinders are in good condition, not scored or worn out of round, or not worn more than .002", the compressor may be repaired by cleaning each part thoroughly and rebuilding. Install new pistons, pins and rings, and refit connecting rod bearings. If bearing journal is worn or scored, regrind before fitting bearings. Fit bearing so that entire journal is contacting bearing surface.



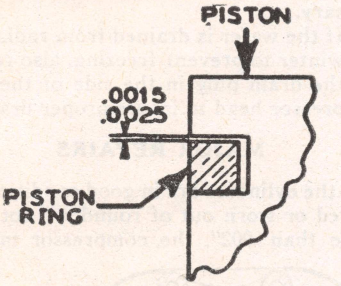
Replace unloader diaphragms with new ones when overhauling compressor.

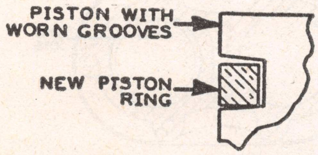
Before installing piston rings on piston, insert ring into cylinder in which it is to operate and make sure there is not less than .010 inch and not more than .015 inch between the ends of the ring.

Do not install new pistons and rings in cylinders which are out of round more than .002 inch. Cylinder should be reground and honed to the standard oversize of .010 inch, .020 inch or .030 inch and the correct oversize pistons and rings installed.

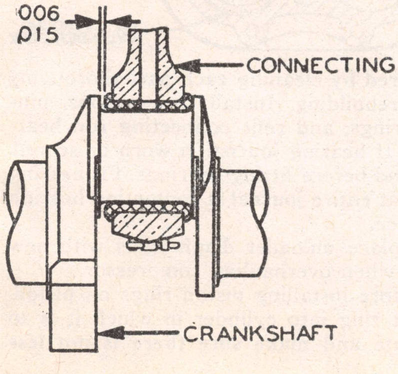


When installing piston rings make sure ring has no less than .0015 inch and not more than .0025 inch clearance in piston ring groove in piston.



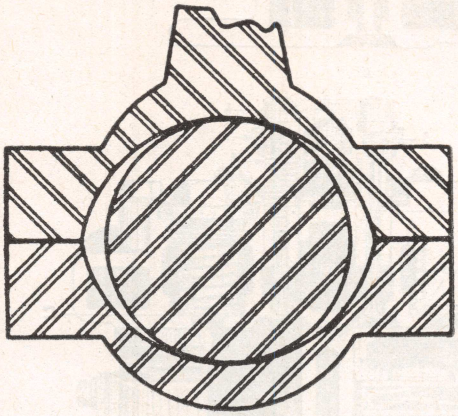


Do not install new pistons and rings in cylinders which are taper worn more than .002 inch from top to bottom of cylinder bore. Regrind cylinders.



Never install new piston rings in worn piston ring grooves as this will increase oil passing and reduce efficiency of compressor.

Clearance between side of connecting rod bearing and cheek on crankshaft not to exceed .015", as this affects oil passing.



When the bearing cap or connecting rod is filed or lapped to take up connecting rod bearings, the effect will be as shown.

When bearings are worn, have them rebabbitted; also regrind a worn crankshaft before attempting to tighten bearings.

If it is found that the cylinders are worn more than .002" and that the ball or roller bearings are worn, together with valves, valve springs, oil seals, pistons, rings and pins, it is advisable to obtain a reconditioned unit.

However the cylinders may be rebored to either .010", .020" or .030" oversize. Pistons may be obtained in these standard oversizes and new rings, pins, valves and necessary repair parts installed. Lubricate all compressor bearing surfaces thoroughly while assembling. Use new oil seals and gaskets. Run compressor in at a speed of 800 to 1000 rev. per min. for one and one-half hours. Open discharge port to atmosphere during this period.

TYPE 2-UcE COMPRESSOR

The 8 cu. ft. compressor operates on the same general principle as the Type "U" compressors but differs somewhat in construction. The crankcase and cylinder block are cast as a single unit, this feature being characteristic of this compressor. The integral design assures correct alignment of cylinders, pistons and crankshaft and the close tolerances maintained under service conditions results in better performance.

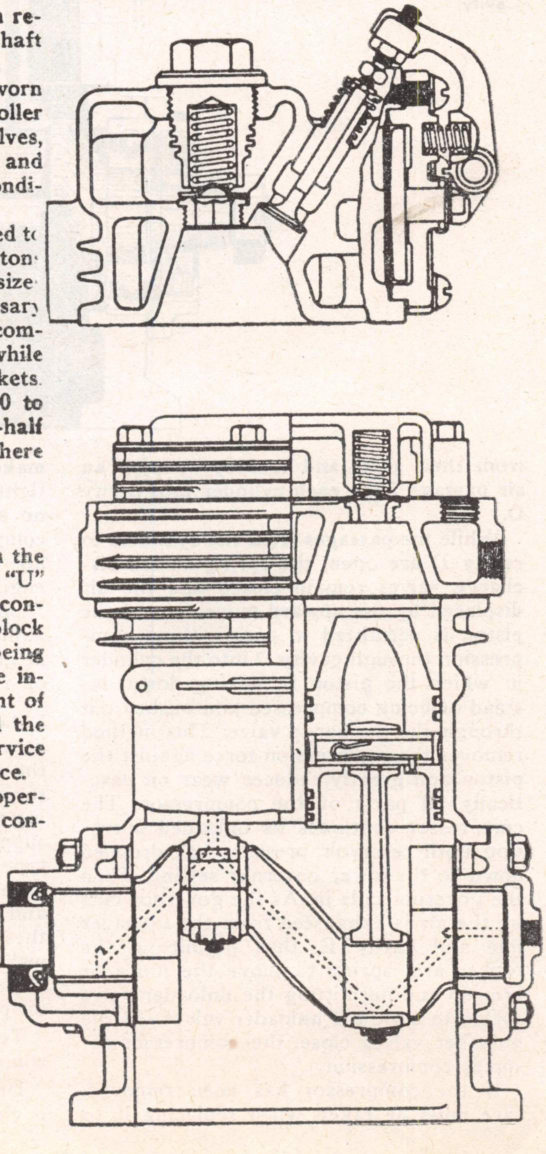
The crankshaft, of regular design, operates on plain bearings instead of the conventional ball-bearing mounting in use on other compressors of Bendix-Westinghouse manufacture. These bearings are replaceable, although it is necessary to finish them when installing to insure proper bearing clearance and alignment. The end of the crankshaft has a standard taper, of one inch diameter, giving maximum strength to the shaft and additional bearing area essential to long life. Connecting rods are the same type and design used in all Type "U" compressors.

TYPE B COMPRESSOR

These units are furnished in 2 sizes, 3 and 6 cu. ft. displacement. The 3 cu. ft. size has two vertical cylinders, air cooled and either a self-contained lubricating system or lubricated from the engine oil pump.

The 6 cu. ft. size is supplied in either a vertical or horizontal type. The vertical is driven from an auxiliary shaft, the horizontal is driven directly from the engine crankshaft.

On the B Type compressors oil is forced to both main bearings and then through the crankshaft to the connecting rod jour-



Compressor. Lower—Plain head. Top—Unloader type head.

nals. Oil is also forced up through the connecting rods to the piston pins. Oil is thrown from these bearings to the cylinder walls thus lubricating cylinder bores and pistons. Like the U Type, the compressor may have a self-contained lubricating system or it may be incorporated in the engine's lubricating system.

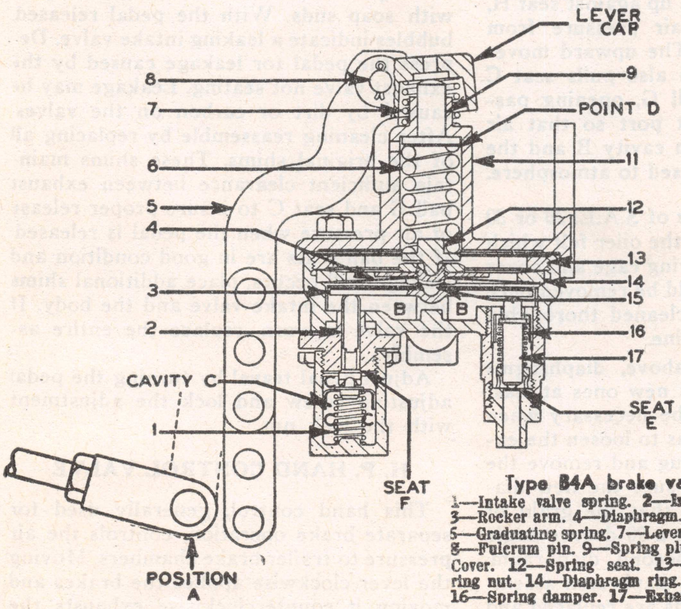
The horizontal type is lubricated from engine's oil pump.

The rotary-type inlet valve, located in the cylinder block, consists of two cast-iron shoes which are applied to one end of the inlet valve shaft. Springs extend through the rectangular valve shaft end and exert their pressure to hold the shoes against the cylinder wall so that rotation of the inlet valve shaft imparts rotation to the valve. The inlet valve shaft is driven from the crankshaft through helical gears, integral with these shafts. Figure 10, upper view, shows the inlet valve which functions to allow the entry of air to one cylinder while closing the port to the second.

The discharge valves are of the disc type, spring loaded and located in the cylinder head.

BRAKE VALVES

Operation: The B4A brake valves are devided into two sections. Above the diaphragm is a regulating or graduating spring; below the diaphragm is the air-tight cavity B, the two brake chamber ports which open into cavity B, and the inlet and exhaust valve assemblies. The illustration shows the valves and lever in released positions, the exhaust valve open and the intake valve closed.



Type B4A brake valve.
1—Intake valve spring. 2—Intake valve. 3—Rocker arm. 4—Diaphragm. 5—Sleeve. 6—Graduating spring. 7—Lever cap spring. 8—Fulcrum pin. 9—Spring plunger. 11—Cover. 12—Spring seat. 13—Diaphragm ring nut. 14—Diaphragm ring. 15—Pivot. 16—Spring damper. 17—Exhaust valve.

Depressing the pedal, pulls the lever towards position A. The lever rotates on its fulcrum pin and forces spring plunger downward, depressing the graduating spring. The graduating spring in turn transfers the force in direct proportion to spring seat, deflecting the diaphragm so that the rocker arm is moved downward. The rocker arm contacts and depresses the exhaust valve and intake valve. The exhaust valve is thus forced against seat E, closing the exhaust, while the intake valve is forced away from seat F, opening the valve and permitting the reservoir air pressure constantly maintained in cavity C to pass up into cavity B and out through the tubing lines to the brake chambers.

When the pedal is released and lever returns, the graduating spring is released and the air pressure which has built up in cavity B lifts the diaphragm. When the diaphragm returns, the rocker arm is released and the intake valve spring forces the intake valve closed against seat F closing off the reservoir from passing into cavity B.

When the rocker arm is released the graduating spring raises the exhaust valve from seat E, opening the exhaust and permitting the air pressure that has been built up in cavity B and brake chambers to escape to atmosphere.

The valve's application or release is graduated by the pressure applied to the graduating spring by the lever. This is due to the valve's self-lapping action; in which a balance of force is established between air pressure below and spring pressure above the diaphragm, when the air pressure equals the pressure applied on the spring.

As this balance is established, the air pressure is strong enough to compress the graduating spring and lift the diaphragm sufficiently to permit the intake valve to close but not enough to open the exhaust valve, thus holding air pressure constant in cavity B and the brake chambers until pressure on the graduating spring is increased or decreased. If the spring pressure is decreased, the air pressure raises the diaphragm, opening the exhaust valve and permitting air to escape to atmosphere until a lower balance point is reached.

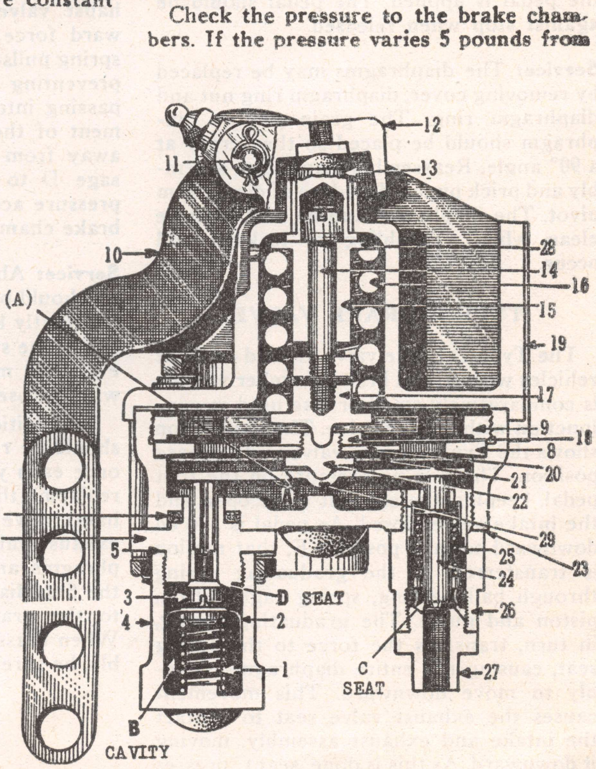
TYPE B4A
REGULAR AND PRELOADED VALVE

There are two types of B4A valves: Regular and Preloaded. In the regular type the pressure applied can be graduated from one pound to the maximum. In the preloaded type, the graduating spring is held loaded so that about 5 pounds pressure is applied to the brake chambers with the first movement of the pedal. Preloading pressure should be set at just enough pressure to take up the slack in the brake rigging. This permits the full pedal travel to be utilized for more efficient braking.

Check for Leaks: With brakes released, cover exhaust port with soap suds. Leakage is caused by intake valve not seating properly. If exhaust port leaks with brakes applied the exhaust valve is not seating.

The exhaust valve opening should not exceed 1/16 inch with brake pedal released and not less than 3/64 inch.

A rounded valve seat due to wear, or if scored or pitted cannot seal air pressure. The valves may be refaced or ground after thorough cleaning or replaced if badly worn or pitted. It is advised that diaphragms be replaced at the same time or exchange the entire valve.

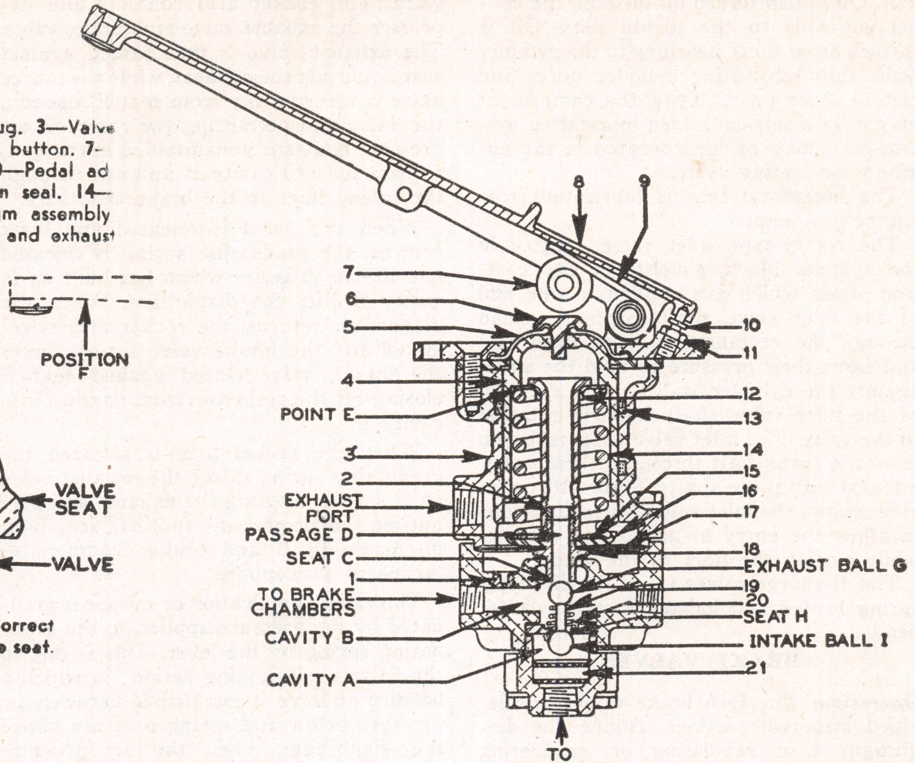


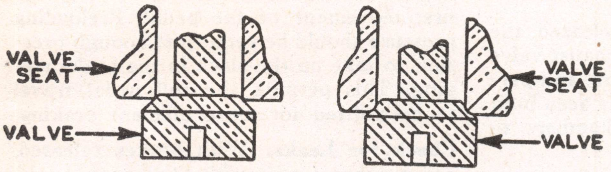
Preloaded brake valve.
1—Intake valve spring. 2—Intake valve damper. 3—Intake valve. 4—Intake valve spring cage. 5—Shim. 6—Intake valve seat. 7—Gasket. 8—Diaphragm ring. 9—Diaphragm ring nut. 10—Lever. 11—Fulcrum pin. 12—Lever cup. 13—Plunger. 14—Stem. 15—Spring guide. 16—Graduating spring. 17—Spring seat. 18—Pivot nut. 19—Cover 20—Washer. 21—Diaphragm. 22—Pivot. 23—Shim. 24—Exhaust valve. 25—Exhaust valve spring. 26—Exhaust valve spring cage. 27—Exhaust valve spring seat. 28—Shim. 29—Rocker arm.

Check the pressure to the brake chambers. If the pressure varies 5 pounds from

AIR BRAKES

Type D brake valve. 1—Threaded valve. 2—Exhaust valve seat lock plug. 3—Valve housing. 4—Piston. 5—Piston cover. 6—Spring cage button. 7—Ball bearing. 8—Pedal. 9—Pedal return spring. 10—Pedal adjusting screw. 11—Lock nut. 12—Guide. 13—Piston seal. 14—Graduating spring. 15—Spring seat. 16—Diaphragm assembly. 17—Diaphragm. 18—Exhaust valve seat. 19—Intake and exhaust assembly. 20—Intake valve spring. 21—Strainer.





Enlarged view of taper-seat valve. Left—Correct type of valve seat. Right—Incorrect type valve seat.

the original setting, adjustments may be made by varying the length of the pedal rod or by moving the clevis higher or lower on the lever. The lever should be free and should not cause undue strain on the valve due to lever cap hitting valve cover when the pedal is applied. The pedal should be against stop when released.

Service: The diaphragms may be replaced by removing cover, diaphragm ring nut and diaphragm ring. The grain of the diaphragm should be placed so they cross at a 90° angle. Reassemble diaphragm assembly and prick punch the edges of diaphragm pivot. The diaphragm and its seat must be clean when assembling or leakage will occur.

TYPE D BRAKE VALVE

The Type D brake valve is used on light vehicles where total brake chamber volume is comparatively small or else used in conjunction with a relay valve. The illustration shows the Type D brake valve in its release position. There is no pressure on the foot pedal, keeping the exhaust valve open and the intake valve closed. As pedal is forced downward toward position F, that motion is transferred to the graduating spring through ball bearing, spring cage button, piston and guide. The graduating spring, in turn, transfers the force to the spring seat, causing the entire diaphragm assembly to move downward. This movement causes the exhaust valve seat to contact the intake and exhaust assembly, moving it downward. As this is done, seat C presses against the exhaust ball, closing off passage D and the exhaust port, while intake ball I is moving away from seat H so that the air pressure in the reservoir and cavity A is permitted to pass up through cavity B and out through tubing lines to the brake chambers.

As the pedal is released, the air pressure which has been built up in cavity B lifts the diaphragm assembly, removing the downward force from the intake and exhaust valve assembly. When the downward force is removed, the intake valve spring pulls intake ball I up against seat H, preventing any more air pressure from passing into cavity B. The upward movement of the diaphragm also pulls seat C away from exhaust ball G, opening passage D to the exhaust port so that air pressure accumulated in cavity B and the brake chambers is released to atmosphere.

Service: About 20 drops of S.A.E. 20 or 30 oil should be applied to the oiler felt which constantly keeps the spring cage and cover oiled. The strainer should be removed once every six months and cleaned thoroughly with kerosene or gasoline.

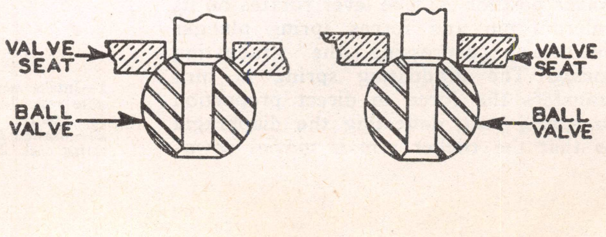
In addition to the above, diaphragms should be replaced with new ones at least once each year. It will be necessary when replacing the diaphragms to loosen the exhaust valve seat lock plug and remove the exhaust valve seat. Be sure the new diaphragms are placed so that the grain of the first diaphragm is at a 90-degree angle to the grain of the second diaphragm. When reassembling the diaphragm assembly, be sure that all shims are replaced and that assembly is held to the original dimension. The distance from the end of ball seat C to the top of the spring seat, point E, should be 3.503" plus or minus .005".

Leakage Tests: Cover the exhaust port with soap suds. With the pedal released, bubbles indicate a leaking intake valve. Depress the pedal for leakage caused by the exhaust valve not seating. Leakage may be caused by dirt or carbon on the valves. After cleaning reassemble by replacing all of the original shims. These shims maintain sufficient clearance between exhaust ball G and seat C to insure proper release of air pressure when the pedal is released. If the ball seats are in good condition and leakage still occurs, place additional shims between the intake valve and the body. If the valve is worn, replace the entire assembly.

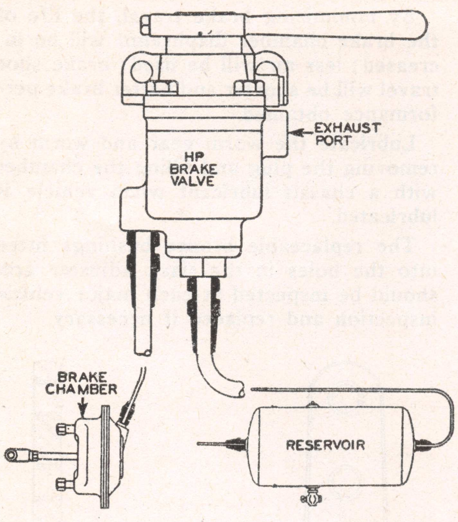
Adjust pedal travel by turning the pedal adjusting screw and lock the adjustment with the lock nut.

H. P. HAND CONTROL VALVE

This hand control, generally used for separate brake operation, controls the air pressure to trailer brake chambers. Moving the lever clockwise applies the brakes and moving it counterclockwise exhausts the



Enlarged view of ball-type valve. Left—Worn ball seat will cause leakage. Right—Correct ball seat to prevent leakage.



Type HP hand control valve installed between reservoir and brake chamber.

pressure built up in brake chambers and releases the brakes.

When the lever is moved to its full release position, putting no pressure on the graduating spring, the intake valve is closed while the exhaust valve is opened.

As the driver moves the lever clockwise, the spring cage rotates downward on the cam, which is a part of the spring cage and cover. This movement of the spring cage causes the graduating spring to move the piston which, in turn, contacts the intake and exhaust valve assembly and moves it downward. This presses seat G against exhaust seat E, closing off passage A and the exhaust port, while intake seat D is moved away from seat G so that air pressure from the reservoir and cavity C is permitted to pass up through cavity B and out through tubing lines to the brake chambers.

As the driver moves the lever counterclockwise, the spring cage rotates upward on the cam, releasing the pressure from the graduating spring. As the pressure is removed from the graduating spring, the combined force of the spring and the air pressure which has been built up in cavity B lifts the piston so that the intake valve spring presses intake seat D up against seat G, preventing any more air pressure from flowing into cavity B. Meanwhile, seat F moves up from the exhaust seat E, opening passage A from cavity B to the exhaust port, releasing air pressure accumulated in cavity B and the brake chambers.

Graduated Application or Release of Air Pressure: The valve's application or release is graduated evenly and directly in proportion to the pressure applied to the graduating spring which, in turn, is controlled by the position of the lever. This is due to the valve's self-lapping action, in which a balance of force is established between air pressure below and spring pressure above the piston, when the air pressure builds up to equal the pressure applied on the spring.

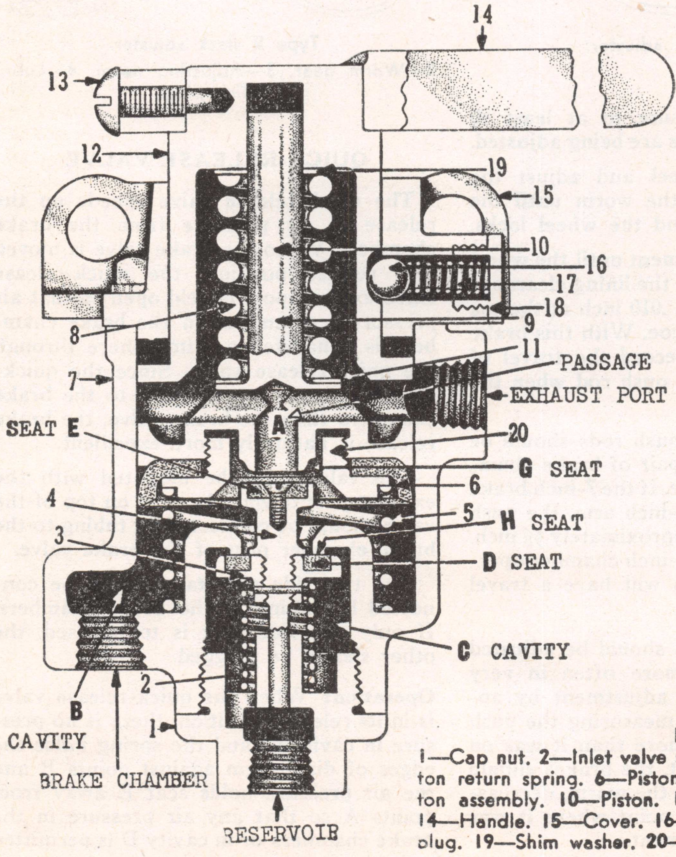
As this balance is established the air pressure is strong enough to compress the graduating spring and lift up the piston sufficiently to permit the intake valve to close but not enough to open the exhaust valve so that air pressure built up in cavity B and the brake chambers is held constant until the pressure on graduating the spring is increased or decreased. If the spring pressure is increased, the process is repeated and the balance is established at a higher pressure. If the spring pressure is decreased, the air pressure lifts up the piston, opening the exhaust valve and permitting air to escape to atmosphere until a lower balance point is reached.

A second Type H. P. valve has the graduated lock. The spring cage is provided with several grooves arranged between full application and full released positions. The spring forces the ball into one of the grooves as the lever is moved. The lever will remain in position until moved by the driver. Thus the brakes will remain applied if the driver leaves the cab. However, if the vehicle is permitted to stand idle for a long time, leakage may occur and release the brakes.

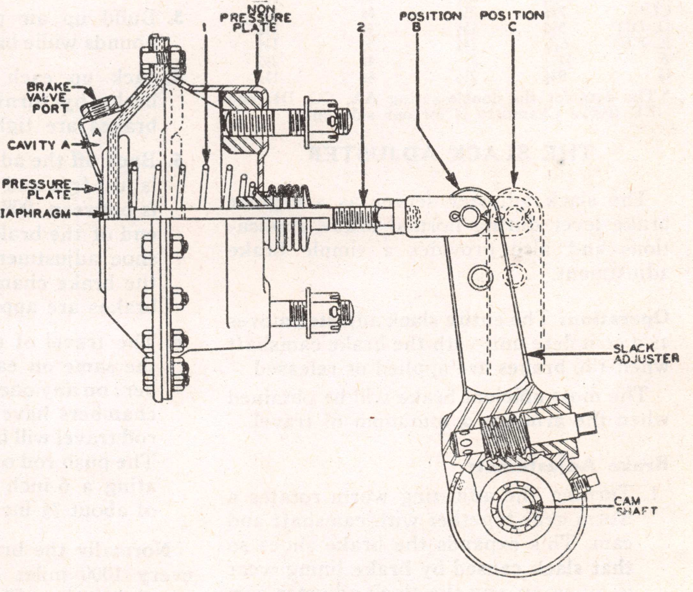
Service: Leakage tests are made the same as for the B4U and the D valves. With lever fully released and with soap suds covering the exhaust port, bubbles indicate a leaking intake valve. With the lever fully applied leakage is caused by exhaust valve not seating properly or by air blowing past the piston cup.

The piston cup is subject to wear and should be replaced at least once a year together with the valve.

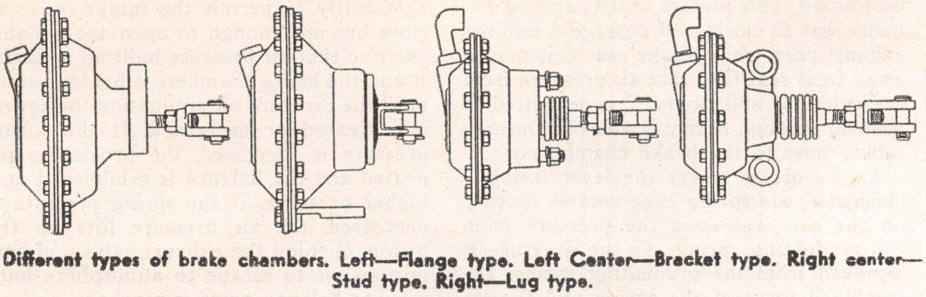
Valves must be thoroughly cleaned and if too badly worn replaced with new ones. If the entire unit is worn the whole valve assembly may be exchanged for a rebuilt valve.



Hand control valve.
1—Cap nut. 2—Inlet valve spring. 3—Inlet valve. 4—Exhaust valve. 5—Piston return spring. 6—Piston cup. 7—Body. 8—Graduating spring. 9—Piston assembly. 10—Piston. 11—Washer. 12—Spring cage. 13—Set screw. 14—Handle. 15—Cover. 16—Lock ball. 17—Lock spring. 18—Check valve plug. 19—Shim washer. 20—Piston nut.



Brake chamber with slack adjuster attached to diaphragm push rod. 1 — Diaphragm return spring. 2—Diaphragm push rod.



Different types of brake chambers. Left—Flange type. Left Center—Bracket type. Right center—Stud type. Right—Lug type.

BRAKE CHAMBER

The function of the brake chamber is to convert the energy of compressed air into the mechanical force necessary to expand the brake shoes against the brake drums. In this operation the push rod moves the slack adjusted toward position C, applying the brakes, as the driver depresses the brake pedal. Then it moves the slack adjuster back to the regular position B, releasing the brakes, as the driver releases the brake pedal.

BRAKE CHAMBER SIZES

In order to meet the various brake requirements, several sizes of brake chambers are used. The size is denoted by letters A to G. The following chart shows the dimensions and travel limitations for the various brake chambers.

Brake Chamber Data, in Inches

Type	Diameter	Maximum Stroke	Rec. ommended maximum stroke when brakes are adjusted	Maximum stroke at which brakes should be readjusted
A, AA*	6 15/16	1 3/4	5/8	1 3/8
B	9 3/16	2 1/4	3/4	1 3/4
C	8 1/16	2 1/4	3/4	1 3/4
CC*	7 7/8	2 1/4	3/4	1 3/4
D, DD*	5 1/4	1 5/8	1/2	1 1/4
E, EE*	6 3/16	1 3/4	5/8	1 3/8
F	11	3	3/4	2 1/4
G	9 7/8	2 1/2	3/4	1 3/4

* The data for the double-acting AA, CC, DD and EE Brake Chambers is for one side only.

THE SLACK ADJUSTER

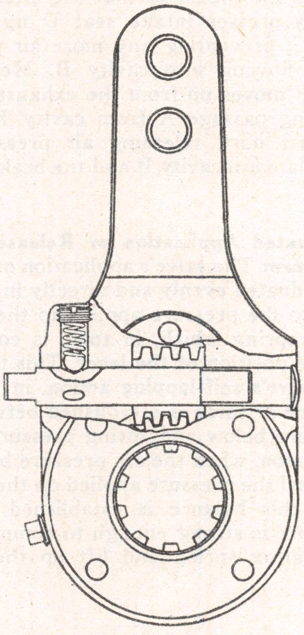
The slack adjuster serves as a regular brake lever during normal brake applications and also provides a simple brake adjustment.

Operation: The entire slack adjuster moves as a complete unit with the brake camshaft when the brakes are applied or released.

The most efficient brake will be obtained when the arm has a minimum of travel.

Brake Adjustment:

1. Turning the adjusting worm rotates a worm gear together with camshaft and cam. This expands the brake shoes so that slack caused by brake lining wear is taken up and the slack adjuster arm travel has a minimum of travel. This may be done with the vehicle standing on its wheels without any jacking up necessary.
2. If brakes have been removed or relined proceed as follows:
3. Build up air pressure to at least 80 pounds while brakes are being adjusted.
4. Jack up each wheel and adjust the brake by turning the worm until the brakes are tight and the wheel locks.
5. Back off the adjustment until the wheel is just free and that the lining clearance is between .008 and .010 inch at the toe end of the brake shoe. With this brake shoe adjustment, record the travel of the brake chamber push rod when the brakes are applied.
6. The travel of the push rods should be the same on each pair of brake chambers on any one axle. If the 7-inch brake chambers have a 4-inch arm, the push rod travel will be approximately ⅝ inch. The push rod of a 9-inch chamber operating a 6-inch arm will have a travel of about ⅞-inch.



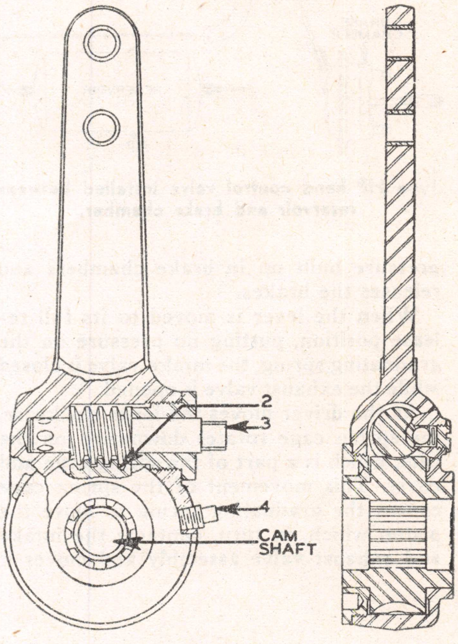
Type K slack adjuster.

Normally the brakes should be adjusted every 1000 miles or more often in very severe service. Check adjustment by applying the brakes and measuring the push rod travel. If this is more than it was on the original adjustment, the brakes should be adjusted by turning the worm, decreasing this travel to the point where it was on the original adjustment.

By minimizing brake travel, the life of the brake chamber diaphragm will be increased; less air will be used; brake shoe travel will be shorter and better brake performance obtained.

Lubricate the worm gear and worm by removing the plug and filling the chamber with a chassis lubricant when vehicle is lubricated.

The replaceable bronze bushings fitted into the holes in the slack adjuster arm should be inspected at each major vehicle inspection and replaced if necessary.



Type R slack adjuster.

2—Worm gear. 3—Adjusting worm. 4—Lubrication plug.

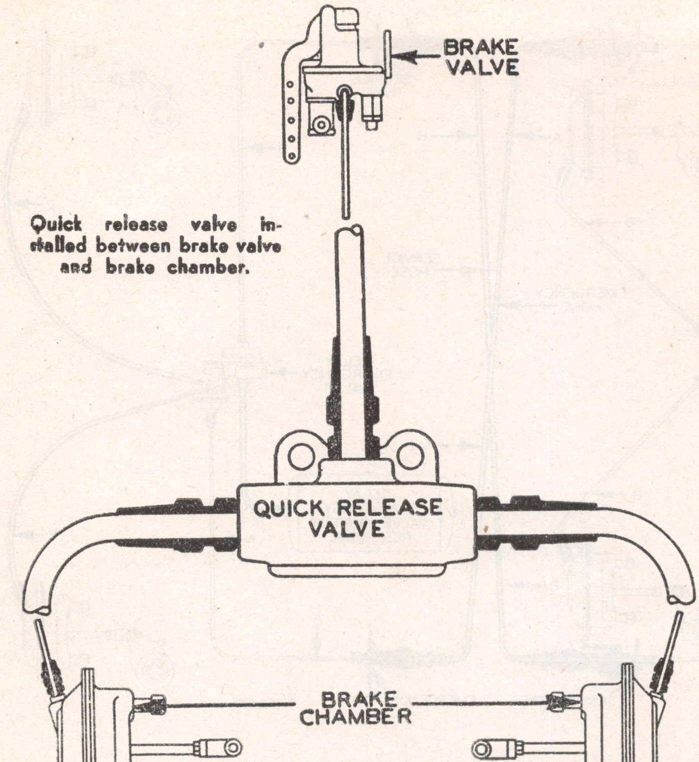
QUICK-RELEASE VALVE

The quick-release valve speeds up the release of air pressure from the brake chambers. When the brake valve is moved into release position, the quick-release valve exhaust port is held open so that air pressure accumulated in the brake chambers is exhausted to atmosphere through the quick-release valve. Since the quick-release valve is much closer to the brake chambers than the brake valve, the brake release is naturally more expedient.

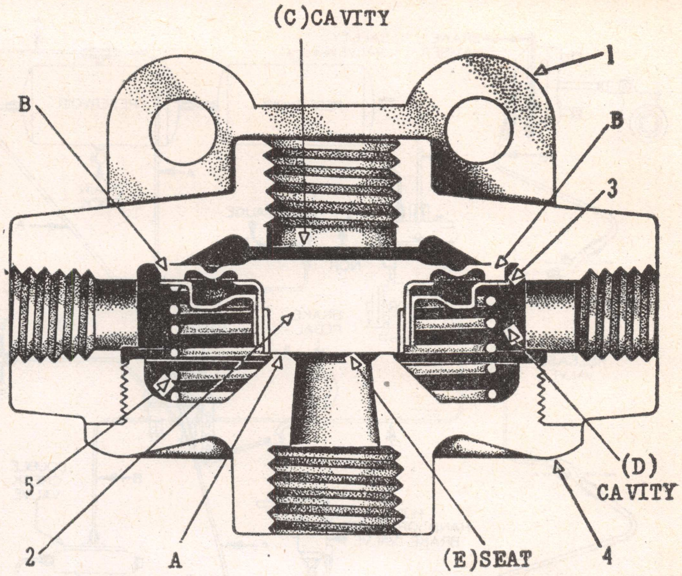
The valve must be mounted with the exhaust port down. The port on top of the valve should be connected by tubing to the brake chamber port of the brake valve.

The two side pipe taps are to be connected by tubing to the brake chambers. If only one side port is to be used, the other should be plugged.

Operation: When the quick-release valve is in its released position, there is no pressure in cavity C, and the spring holds the edges of diaphragm against points B and the air pressure holds seat E away from points A so that any air pressure in the brake chambers or in cavity D is permitted



Quick release valve installed between brake valve and brake chamber.



Quick release valve. 1—Housing. 2—Diaphragm. 3—Spring guide. 4—Exhaust port plug. 5—Spring.

to exhaust to atmosphere through the exhaust port.

As the brake valve is applied, the air pressure passed into cavity C forces seat E to move against points A, sealing the exhaust port, and forcing the edges of the diaphragm from point B so that the air pressure is passed into the brake chambers. This position is held until the brake valve is released and pressure is exhausted from cavity C, then the quick-release valve resumes the release position.

Service: Check for air leaks in valve by covering with soap suds. Soap bubbles at the exhaust port indicate dirt on the exhaust seat or a worn exhaust seat. The seat and diaphragm may be cleaned but if the seat is worn the diaphragm should be replaced with a new one. However, the diaphragm should be replaced once a year.

RELAY VALVE

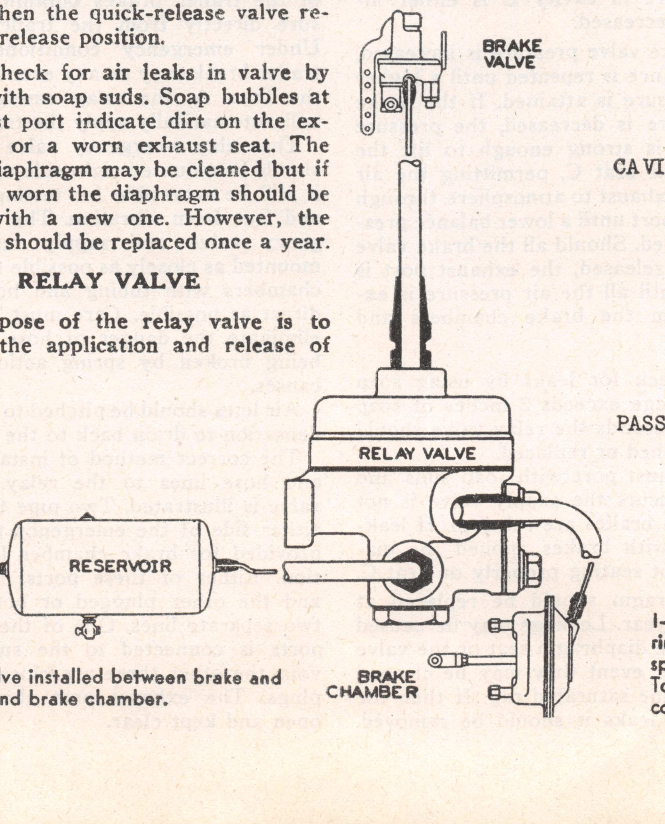
The purpose of the relay valve is to speed up the application and release of rear brakes on long-wheelbased or 6-wheel coaches and trucks. It is also used to speed up brake action where the air from the brake valve would otherwise travel through long tubing lines or operate several large brake chambers.

The relay valve and the relay valve supply reservoir should be mounted as closely as possible to brake chambers which the relay valve is to actuate.

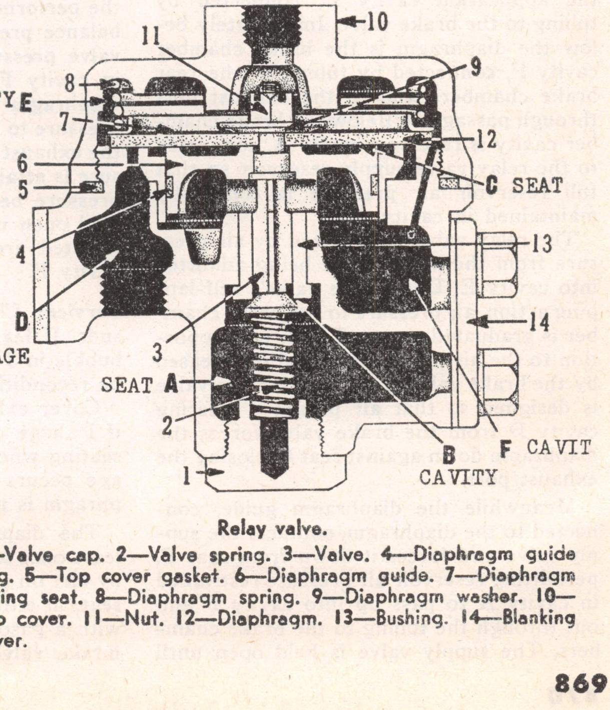
When installing tubing it should be as direct as possible and care must be taken to eliminate the danger of it being broken by spring action or by drive shaft breakage.

The tubing leading from the brake valve should be connected into the pipe tap in the top of the relay valve. Tubing from the brake chambers may be connected into the two upper side pipe taps.

The installation for the relay valve shown permits a great part of the condensed moisture from the air, when it is compressed, to be caught in the pilot reservoir, leaving air in the second reservoir comparatively free from moisture. This helps to keep the relay valve dry, thus lengthening the life of the diaphragm.



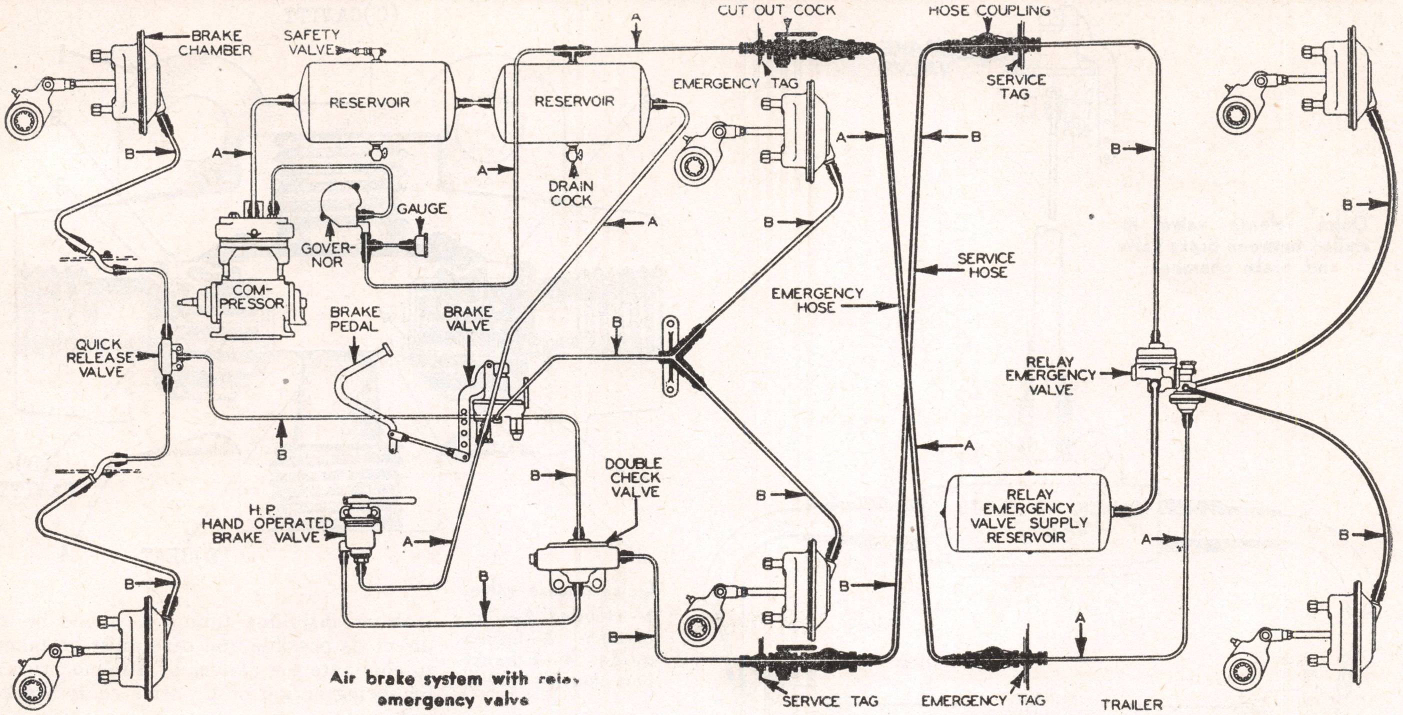
Relay valve installed between brake and reservoir and brake chamber.



Relay valve.

1—Valve cap. 2—Valve spring. 3—Valve. 4—Diaphragm guide ring. 5—Top cover gasket. 6—Diaphragm guide. 7—Diaphragm spring seat. 8—Diaphragm spring. 9—Diaphragm washer. 10—Top cover. 11—Nut. 12—Diaphragm. 13—Bushing. 14—Blanking cover.

AIR BRAKES



Air brake system with relay emergency valve

Operation: Action of the relay valve is rapid, due to the fact that only the small volume of air required to fill cavity E and actuate the diaphragm is supplied by the brake valve. The larger volume of air which is required to build up the pressure in the brake chambers is passed by the relay valve from the nearby relay valve supply reservoir directly to the brake chambers. Also, air pressure in the rear brake chambers is exhausted rapidly to atmosphere through the relay valve, saving time which otherwise would be lost in exhausting the pressure through the brake valve.

The relay valve is divided into three separate cavities. Above the diaphragm is the application cavity E, connected by tubing to the brake valve. Immediately below the diaphragm is the brake chamber cavity F, connected by tubing to the rear brake chambers and to the exhaust port through passage D. Below the brake chamber cavity is reservoir cavity A, connected to the relay valve supply reservoir so that full reservoir air pressure is constantly maintained in cavity A.

The relay valve is operated by air pressure from the brake valve being admitted into cavity E. Due to the valve's self-lapping action, air pressure to the brake chamber is graduated on or off in direct proportion to the air pressure applied or released by the brake valve. To effect this, the valve is designed so that air pressure entering cavity D from the brake valve forces the diaphragm down against seat C, closing the exhaust port.

Meanwhile the diaphragm guide, connected to the diaphragm, contacts the supply valve and forces it down from seat B, permitting reservoir air pressure restrained in cavity A to pass up into cavity F and out through the tubing to the brake chambers. The supply valve is held open until the air pressure in the brake chambers and cavity F has been built up to equal the pressure applied by the brake valve above the diaphragm. Then the valve automatically laps itself. This means that the air pressure in cavity F is strong enough to balance the pressure in cavity D and lift the diaphragm and diaphragm guide sufficiently to permit the spring to close the supply valve, but not enough to open the exhaust port. The self-lapped position, holding the air pressure in cavity and brake chambers constant, is held until the brake valve pressure in cavity E is either increased or decreased.

If the brake valve pressure is increased, the performance is repeated until a higher balance pressure is attained. If the brake valve pressure is decreased, the pressure in cavity F is strong enough to lift the diaphragm off seat C, permitting the air pressure to exhaust to atmosphere through the exhaust port until a lower balance pressure is attained. Should all the brake valve pressure be released, the exhaust port is held open until all the air pressure is exhausted from the brake chambers and cavity F.

Service: Check for leaks by using soap suds. If leakage exceeds 3 inches of soap bubble in 3 seconds the relay valve should be reconditioned or replaced.

Cover exhaust port with soap suds and if leakage occurs the supply valve is not seating when brakes are released. If leakage occurs with brakes applied the diaphragm is not seating properly on seat C.

The diaphragm should be replaced at least once a year. Leakage may be caused by dirt on the diaphragm seat or the valve seat, in either event they may be cleaned with a gasoline saturated rag. If then the intake valve leaks it should be removed, cleaned with kerosene or gasoline, and the reground. Use only a slight pressure when oscillating the valve in regrinding. Remove all traces of grinding compound with gasoline or kerosene after regrinding and then dry thoroughly. If valve, valve seat and diaphragm are worn beyond the servicing stage, the entire relay valve may be exchanged for a rebuilt unit.

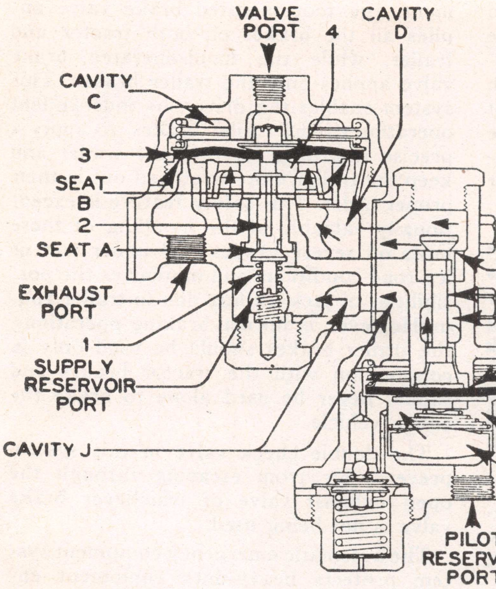
RELAY EMERGENCY VALVE

The relay emergency valve serves as a regular relay valve to speed up the action of the trailer brakes obtaining air pressure directly from the trailer reservoir. Under emergency conditions, such as trailer breakaway or any event that severs the lines A, the relay emergency valve will automatically apply the trailer brakes.

The relay emergency valve installation should be mounted right side up and where it will be accessible for testing or service and free from vibration. The relay emergency valve and supply reservoir are mounted as closely as possible to the brake chambers with tubing and hose lines as direct as possible. Care must be taken to eliminate the danger of hose and tubing being broken by spring action or other causes.

Air lines should be pitched to permit condensation to drain back to the reservoir.

The correct method of installing tubing and hose lines to the relay emergency valve is illustrated. Two pipe taps, one on either side of the emergency portion, are provided for brake chamber line connection. Either of these ports can be used and the other plugged or both used for two separate lines. One of the four lower ports is connected to the supply reservoir, the other three are closed with pipe plugs. The exhaust port should be left open and kept clear.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CAVITY C
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SEAT B
2
SEAT A
EXHAUST PORT
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SUPPLY RESERVOIR PORT
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CAVITY F
SEAT G
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SEAT H
CAVITY I
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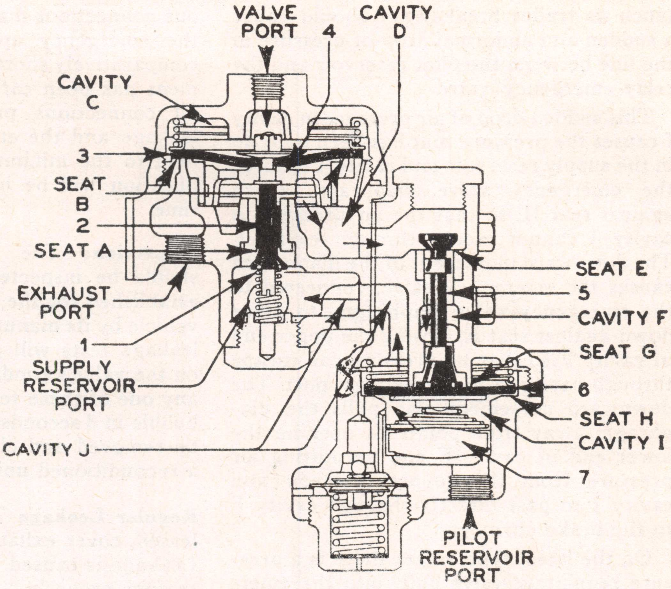
PILOT RESERVOIR PORT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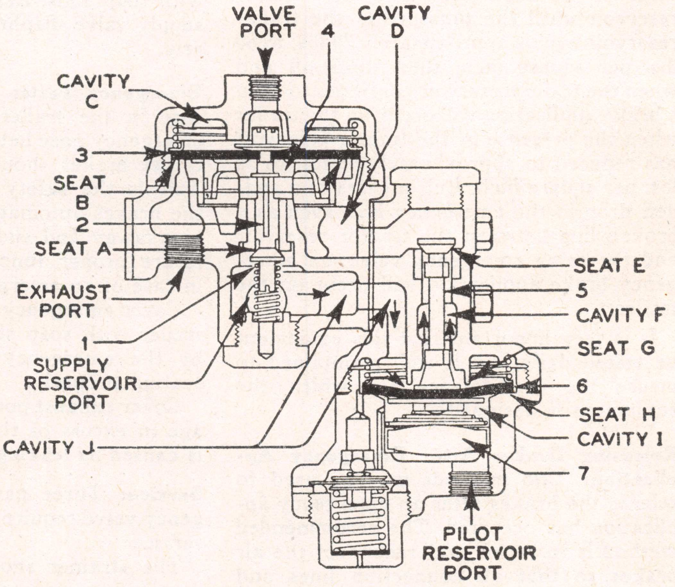
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SEAT E
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CAVITY F
SEAT G
6
SEAT H
CAVITY I
7
PILOT RESERVOIR PORT

Relay emergency valve.

Left—Normal or full release position.

Right—Valve in full emergency position.

Center—Full application position.

1—Spring. 2—Supply valve. 3—Supply valve diaphragm. 4—Diaphragm guide. 5—Emergency valve. 6—Emergency valve diaphragm. 7—Strainer.

Operation: The relay emergency valve operation falls into two classifications: the normal operation and the emergency operation. The normal operation is actuated by the driver and the regular action of the air brake system. The emergency operation is induced by anything (such as trailer breakaway) that would cause a sudden and abnormal drop of air pressure in the pilot reservoir.

The following paragraphs and pictures describe the valve movements necessary to attain each of the various operations illustrated: Figures 37, 38 and 39, valve in the normal or full release position, valve in full application position and valve in full emergency position. By observing these illustrations in conjunction with the following descriptions, it is possible to obtain a complete picture of the valve's operation.

The air pressure built up in cavity I by the pilot reservoir holds the edges of the emergency valve diaphragm above seat H, permitting the air pressure from the pilot reservoir and cavity I to pass into cavity J and out through a tubing line to the relay-emergency valve supply reservoir. By this method, full pilot reservoir pressure is constantly maintained in the supply reservoir and cavity J. The air pressure in cavity I also forces the center of the emergency valve diaphragm up against seat G, sealing the lower end of cavity F against the air pressure held in cavity J. As the diaphragm is held sealed against seat G, the emergency valve, connected to the diaphragm, is held up off seat E so that a direct connection is established between cavity D and the brake chambers which are connected into cavity F.

Normal Application: When in regular brake application the driver depresses the brake pedal, the brake valve will deliver air pressure into cavity C where, due to the relay-emergency valve's self-lapping feature, it causes the relay emergency valve to deliver to the brake chamber the same amount of air pressure applied by the brake valve. The air pressure entering cavity C forces the diaphragm down against seat B, closing off the exhaust port. The deflection of the supply valve diaphragm also causes the diaphragm guide, connected to the diaphragm, to contact the supply valve and move it away from seat A.

As the supply valve is opened the air pressure which has been restrained in cavity J is permitted to pass up into cavities D and F and out through tubing lines to the brake chambers. The supply valve is held open until the air pressure in the brake chambers and cavity D has been built up to equal the pressure applied above the diaphragm by the brake valve, then the valve automatically laps itself. This means that air pressure in cavity D is strong enough to balance the pressure in cavity C and raise the supply valve diaphragm and diaphragm guide sufficiently to permit the spring to close the supply valve, but not enough to open the exhaust port. This self-lapped position holding the air pressure in cavity D and brake chambers constant, is maintained until brake valve pressure in cavity C is either increased or decreased. If the brake valve pressure is increased, the performance is repeated until a higher balance pressure is attained. If the brake valve pressure is decreased, pressure in cavity D is strong enough to lift the diaphragm off points B, permitting the air pressure to exhaust to atmosphere through the exhaust port until a lower balance pressure is attained. If all the brake valve pressure is released, the exhaust port is held open until all the air pressure is exhausted from the brake chamber and cavity D.

Emergency Application: The emergency application occurs only in case an accident (such as trailer breakaway) should cause a sudden and abnormal drop of pressure in the line between the pilot reservoir and the relay-emergency valve.

This sudden drop of air pressure in cavity I causes the pressure that has been built up in the supply reservoir and cavity J to force the emergency valve diaphragm down against seat H, so that the air pressure in cavity J cannot escape through cavity I. The downward movement of the diaphragm causes the emergency valve, connected to the emergency valve diaphragm, to move down against seat E, closing the upper end of cavity F so that no pressure can escape through cavity D to the exhaust port. The downward movement also pulls the diaphragm away from points G, opening the lower end of cavity F and permitting air pressure from the supply reservoir and cavity J to pass directly through cavity F to the brake chambers.

On the latest type valves there is a pressure regulating valve built into the emergency valve cap which allows the trailer reservoir to feed back into the tractor reservoir until the pressure in the trailer reservoir equals approximately 70 lbs. to 80 lbs. per square inch, then shuts off and when the trailer reservoir continues to drop a brake application will occur on the trailer when the pressure in the tractor reservoir has reduced to approximately 45 lbs. to 50 lbs. per square inch. But in cases of a sudden drop in the emergency line, such as a broken line between the tractor reservoir and the relay emergency valve, an emergency brake application will occur on the trailer.

It is very important that this equipment be tested daily and is well maintained to insure the performance for which the equipment is designed.

Releasing Brakes After Emergency Application: Two methods may be used to release the brakes after an emergency application has occurred. The recommended method is to repair and reconnect the air brakes so that all connection lines and equipment are in their original condition and then to operate the compressor to build up air pressure. As the air pressure in cavity I is built up to equal the pressure in cavities F and J, it presses up the emergency valve diaphragm so that the valve resumes its normal operating position. In this position the diaphragm pressing against points G seals the lower end of cavity F against the air pressure in cavity J. Likewise, the emergency valve is held up off seat E opening the upper end of cavity F into cavity D, so that the air pressure in cavity F and the brake chambers is released through cavity D and the exhaust port to atmosphere. The other method is to drain the air pressure from the relay-emergency valve supply reservoir.

Length of Emergency Application: The length of time that the brakes will maintain an emergency application depends upon the care the equipment has been given. Without proper maintenance, the valve and various connections may be leaking freely and the emergency application time will be comparatively short. However, if the equipment has been carefully maintained, with all connections properly sealed against leakage and the emergency valve leakage held to the minimum, the emergency application will be held for a much longer time.

Inspection: The relay-emergency valve should be inspected at the same periods established for the inspection of the motor vehicle by its manufacturers. The following leakage tests will give an accurate check on the valve's condition. In case leakage in any one of these tests causes a 3-inch soap bubble in 3 seconds, the entire valve should be removed and cleaned or replaced with a reconditioned unit if necessary.

Regular Leakage Tests: With brakes released, cover exhaust port with soap suds. Leakage is caused by the supply valve not seating properly.

With brakes applied, cover exhaust port with soap suds. Leakage is caused by the supply valve diaphragm not seating properly.

Emergency Tests: Be sure there is pressure in the trailer reservoir. Disconnect emergency hose between truck and trailer; trailer brakes should apply automatically. This is the safety feature which applies the brakes automatically in case of trailer breakaway and should be tested daily to insure proper functioning of the devices in case of an emergency.

Cover emergency hose or connections on trailer with soap suds. Leakage is caused by the emergency valve diaphragm not seating properly.

Cover exhaust port with soap suds. Leakage in excess of that evident in first test is caused by leaking valve.

Service: Three parts of the relay-emergency valve require periodical maintenance service:

The strainer should be removed about once every six weeks, cleaned thoroughly with gasoline, and replaced.

The diaphragms should be replaced once each year; more often if operating conditions warrant.

When the relay-emergency valve does not meet the inspection test leakage requirements, it will sometimes be found that the trouble is caused by dirt on the valve or diaphragm seat. This condition can be remedied by removing the leaking valve or diaphragm, cleaning the valve and valve seat with kerosene, and then regrinding the valve. If leakage is caused by a badly worn valve, it will be necessary to replace valve with a new one.

INDEPENDENT TRAILER CONTROL

The independent trailer control for tractor-trailer equipment has a hand-operated brake valve and the regular foot-operated brake valve, both of which are connected to the trailer brake application line through the double check valve. Under this arrangement, the foot-operated brake valve applies all the brakes on both tractor and trailer, while the hand-operated brake valve applies only the trailer brakes. This system enables the driver, by independent operation of the trailer brakes, to apply a precise retarding force to the trailer and keep the trailer units stretched out in their proper order. This safety feature is exceptionally valuable in the handling of these units on severe grades and under wet or icy road conditions and minimizes the possibilities of jack-knifing due to trailer run-in. However, in normal braking operations, the trailer brakes should be used only in conjunction with the tractor brakes and should never be used alone to brake the entire vehicle.

The double check valve in this system prevents air from escaping through the open exhaust valve of whichever brake valve is not being used.

The automatic emergency equipment system protects heavy-duty equipment engaged in special types of service by means of an automatic application of the brakes should any hose or tubing line be broken due to collision or other extraneous causes.

This system utilizes the relay-emergency valve and emergency valve reservoir of suitable volume on each unit so that if any hose or tubing line is broken the following braking actions are accomplished automatically.

Should any of the constantly charged lines denoted as A be broken, the relay-emergency valve on both units cuts in, immediately applying the brakes on the rear wheels of the truck and on all four wheels of the trailer.

Should either of the two lines labeled C break, the relay-emergency valve on the other unit cuts in, passing air to its brake chambers. For example, should line C on the trailer break, the rear wheel brakes on the truck are applied. Likewise, should line C on the truck break, then the trailer brakes are applied.

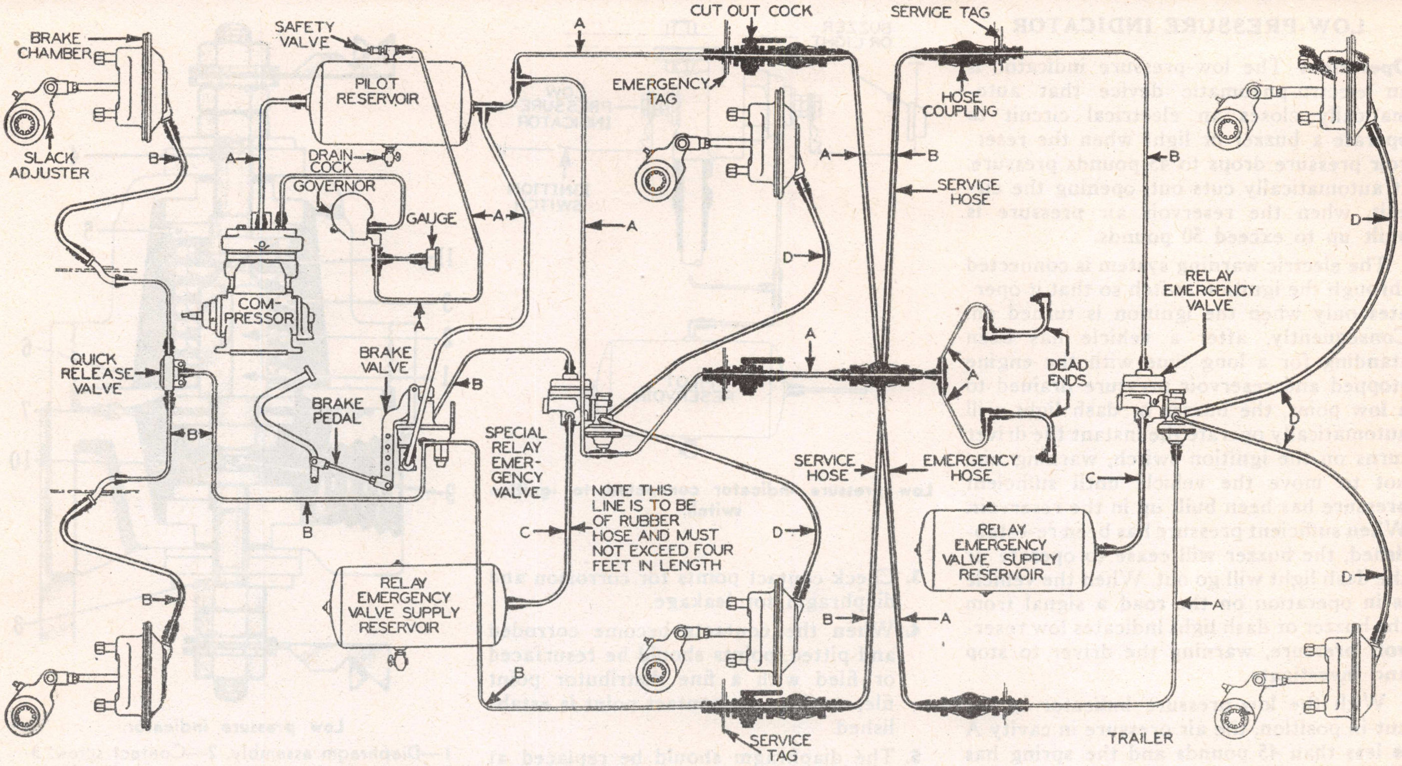
Should any of the non-charged lines labeled B break, the application of the brake pedal would cause both emergency valves to cut in, applying the rear brakes on the truck and all the brakes on the trailer.

Should any of the lines labeled D break, the relay-emergency valve on the other unit cuts in upon the next brake application.

Inasmuch as this equipment is designed for absolute safety, the automatic features which apply the brakes should be tested daily to insure proper functioning of the equipment in an emergency. This test may be made by disconnecting the emergency line between the truck and trailer and observing that the rear brakes on the truck and all brakes on the trailer or trailers are automatically applied.

All reservoirs in this system should be drained daily.

The length of time the equipment will hold the brakes applied in an emergency application depends upon the maintenance the equipment has been given. If the equip-


BRAKE CHAMBER
SAFETY VALVE
PILOT RESERVOIR
SLACK ADJUSTER
DRAIN COCK
GOVERNOR
GAUGE
COM-PRESSOR
QUICK RELEASE VALVE
BRAKE VALVE
BRAKE PEDAL
SPECIAL RELAY EMER-GENCY VALVE
NOTE THIS LINE IS TO BE OF RUBBER HOSE AND MUST NOT EXCEED FOUR FEET IN LENGTH
RELAY EMERGENCY VALVE SUPPLY RESERVOIR
CUT OUT COCK
EMERGENCY TAG
SERVICE TAG
HOSE COUPLING
SERVICE HOSE
EMERGENCY HOSE
DEAD ENDS
RELAY EMERGENCY VALVE
TRAILER
A
B
C
D

Air brake system with automatic emergency equipment for tractor or trailer control.

ment has not had proper maintenance and the valve and various connections are leaking freely, the application time will be comparatively short. However, if the equipment has been properly maintained and all connections carefully sealed against leakage and the emergency valve leakage is held to the minimum, the time the brakes are held applied will, of course, be greatly lengthened.

Two methods may be used to release the brakes after an emergency application. The first, and most advisable method, is to repair and re-connect the air system so that all connection lines are in their original positions and then start the engine. As the compressor builds up sufficient pressure in the pilot reservoir, the brakes will automatically release themselves and normal braking can be resumed. The second method is to drain the air pressure from the emergency valve reservoir.

STOP LIGHT SWITCH

Operation: The stop light switch, operating in conjunction with the brakes, illuminates the stop light the instant the driver touches the brake pedal and breaks the connection as soon as he releases the pedal. Upon a brake valve application of only 5 pounds of air pressure the stop light switch cuts in, completing an electrical circuit and illuminating the stop light. As the brake valve exhausts air pressure the stop light switch cuts out, breaking the circuit.

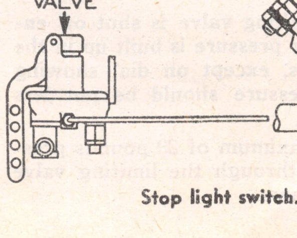
With the stop light switch in the cut-out position, there is no air pressure in cavity A and the spring holds the contact plunger away from the contact terminal, breaking the electrical circuit. As the brake valve is applied and air pressure exceeding 5 pounds per square inch is built up in cavity A, the pressure overcomes the resistance of the spring and forces the contact plunger up against the contact terminal. This establishes a direct connection between the contact terminals through the contact connector, spring and contact plunger and closes the electrical circuit. The circuit is held closed until the brake valve is released and the pressure exhausted from cavity A, then the stop light switch cuts out, breaking the electrical circuit.

Inspection and Service: The stop light switch should be checked at the same periods established by the manufacturer for the inspection of the vehicle. The following tests will give an accurate check on the condition of the stop light switch:

With test gauge in operating line, apply brakes. Stop light switch should operate at 5 pounds pressure.

Check contact points for corrosion and diaphragm for leakage.

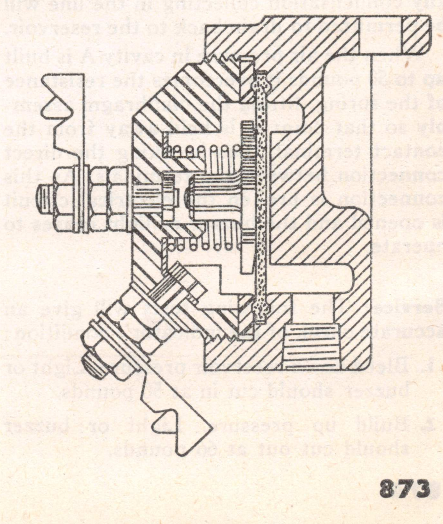
Only two parts of the stop light switch require maintenance service: the contact points and the diaphragm. The contact points sometimes become corroded and pitted until a true contact cannot be obtained. When this condition occurs the points should be resurfaced or filed until the pits are removed and a true contact point is established.


BRAKE VALVE
STOP LIGHT SWITCH

Stop light switch.

A fine file, similar to one used for filing distributor contact points, may be used on the stop light switch contact points. The diaphragm should be replaced at least once a year.

A short in the electrical system builds up an extremely high temperature through the spring, which causes the spring to lose its tension. Therefore, care should be taken when working with the electrical system connected directly through the switch. This spring is ample to carry the load for operating the stop lights but not for the overload caused by a short in the circuit.



LOW-PRESSURE INDICATOR

Operation: The low-pressure indicator is an electro-pneumatic device that automatically closes an electrical circuit to operate a buzzer or light when the reservoir pressure drops to 45 pounds pressure. It automatically cuts out, opening the circuit, when the reservoir air pressure is built up to exceed 50 pounds.

The electric warning system is connected through the ignition switch so that it operates only when the ignition is turned on. Consequently, after a vehicle has been standing for a long time with the engine stopped and reservoir pressure drained to a low point, the buzzer or dash light will automatically operate the instant the driver turns on the ignition switch, warning him not to move the vehicle until sufficient pressure has been built up in the reservoir. When sufficient pressure has been re-established, the buzzer will cease to operate or the dash light will go out. When the vehicle is in operation on the road a signal from the buzzer or dash light indicates low reservoir pressure, warning the driver to stop and investigate.

With the low-pressure indicator in the cut-in position, the air pressure in cavity A is less than 45 pounds and the spring has depressed the diaphragm assembly so that point B of the contact screw touches the contact terminal. As this contact is made a direct connection is established between the terminals through the contact screw, washers and spring, closing the electrical circuit and causing the light or buzzer to operate.

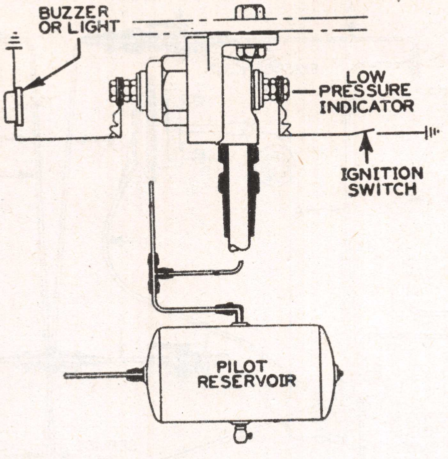
The electrical hook-up may be varied to meet the particular mounting needs of the various vehicles. However, it is essential for the low-pressure indicator and the buzzer or light to be hooked up in series with the ignition switch so that the indicator's circuit is automatically broken when the ignition switch is turned off.

The low-pressure indicator should be mounted as illustrated, in a place where it will be accessible for testing or servicing and where both the electrical connections and the air line will be as direct as possible. The one air line used to connect the low-pressure indicator leads directly from the reservoir and should be so installed that any condensation collecting in the line will be permitted to drain back to the reservoir.

When the air pressure in cavity A is built up to 50 pounds it overcomes the resistance of the spring, lifting the diaphragm assembly so that point B is held away from the contact terminal, thus breaking the direct connection between the terminals. As this connection is broken the electrical circuit is opened and the buzzer or light ceases to operate.

Service: The following tests will give an accurate check of the indicator's condition:

1. Bleed down reservoir pressure. Light or buzzer should cut in at 50 pounds.
2. Build up pressure. Light or buzzer should cut out at 66 pounds.



Low pressure indicator connected to ignition switch.

3. Check contact points for corrosion and diaphragm for leakage.
4. When the contacts become corroded and pitted, points should be resurfaced or filed with a fine distributor point file, until a true contact point is established.
5. The diaphragm should be replaced at least once a year, with an entire assembly. If only the diaphragm is replaced, care must be taken to prick-punch the nut back in place so that the diaphragm is held securely.

LIMITING VALVE

The limiting valve enables the driver to set his brake power in accordance with the varying road conditions. When operating a vehicle unloaded or over slippery roads the driver may limit the maximum air pressure admitted to the brake chambers. This will avoid severe brake application and wheels sliding.

The limiting valve is mounted through the instrument panel with two tubing lines connected. One tube from the brake valve, the other leads to the brake chambers.

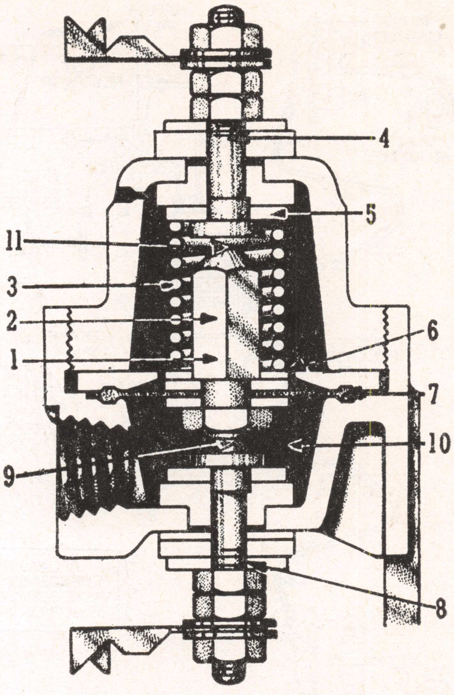
Operation: The driver sets the limiting valve by turning the control knob so that the arrow points to one of the four figures on the dial.

Ratched grooves are arranged in the stem so that when arrow points to these marked spots, the ball drops into the corresponding groove and holds it in place until the driver moves it again.

The limiting valve is so designed that when the arrow is moved into any of these marked positions the maximum "set" pressure built up in the brake chamber is as follows:

OFF. The limiting valve is shut off entirely and no air pressure is built up in the brake chambers, except on dial showing "low", then pressure should be not less than 15 pounds.

Line H. A maximum of 20 pounds pressure is passed through the limiting valve to brake chambers.



Low pressure indicator.

1—Diaphragm assembly. 2—Contact screw. 3—Spring. 4—Contact terminal. 5—Contact washer. 6—Contact washer. 7—Diaphragm. 8—Contact terminal. 9—Contact point. 10—Cavity. 11—Contact point.

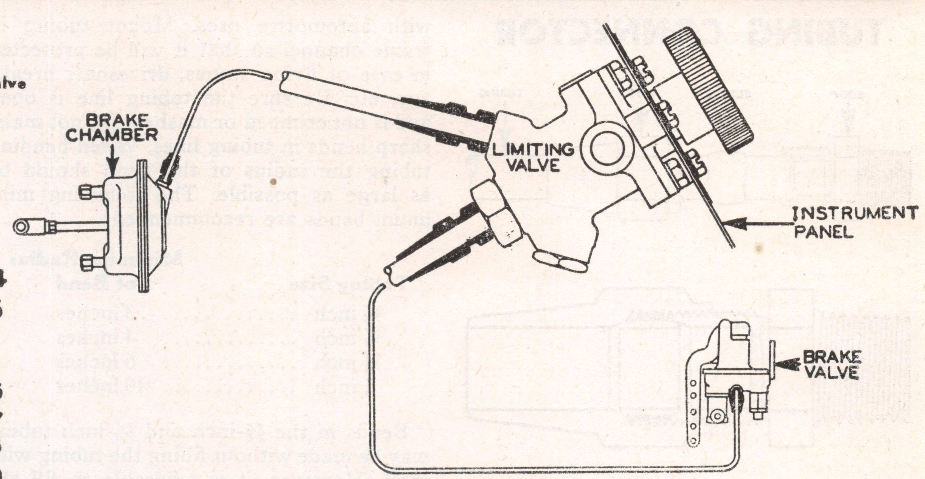
Line J. A maximum of 40 pounds air pressure is passed through the limiting valve to brake chambers.

FULL. The maximum air pressure built up by the brake valve is passed through the limiting valve to the brake chambers.

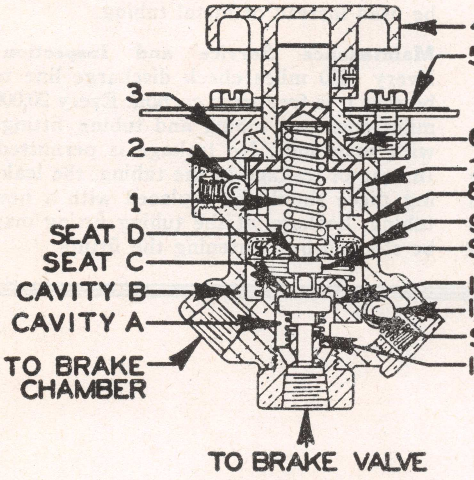
The maximum set pressure passed through the limiting valve to brake chambers is controlled by the amount of tension placed on the graduating spring. This tension, in turn, is governed by the position of the control knob. As the knob is turned clockwise, the screw rotates downward, placing more tension on the spring and increasing the maximum pressure passed through the limiting valve to the brake chambers. As the knob is turned counterclockwise, the screw is rotated upward, lessening the tension placed on the spring and decreasing maximum air pressure passed through the limiting valve to the brake chambers.

The tension placed on the graduating spring forces the piston downward. As this is done seat D abuts against seat E, causing the intake valve assembly to move downward, removing intake valve F from seat C so that the intake valve is held open. This permits the air pressure built up or released by the brake valve to pass freely between the brake valve and brake chambers through cavities A and B unless pressure built up in cavity B is equal to the tension placed on the spring.

When this occurs the air pressure is strong enough to compress the spring, lifting the piston upward sufficiently to permit the intake valve to close so that no further pressure is passed from cavity A



Limiting valve between brake valve and brake chamber.



Limiting valve. 1—Graduating spring. 2—Ball. 3—Cover. 4—Control knob. 5—Dial. 6—Screw. 7—Stem. 8—Piston. 9—Piston seal. 10—Ball. 11—Intake valve.

to cavity B. In this case, when the air pressure is exhausted by the brake valve the air pressure in cavity B pushes the ball away from seat G, permitting the air pressure from cavity B to be exhausted out through cavity A and the brake valve. As this air pressure is exhausted, the graduating spring again opens the intake valve.

If the control knob is moved to FULL position, the stem abuts against the piston, holding the intake valve open at all times. Or, if the knob is turned to the OFF position, all tension is removed from the graduating spring so that the intake valve is held closed at all times and no pressure is permitted to pass into cavity B or the brake chamber.

Service: The limiting valve should be inspected both for leakage and for pressure at the regular inspection period established for the vehicle by its manufacturer.

Leakage Test: Install a gauge in the line between the limiting valve and brake valve. Turn the limiting valve arrow to FULL position on the dial. Apply brake pedal until gauge reaches 50 pounds, then cover the limiting valve exhaust port with soap suds. Leakage is caused by the exhaust valve or ball not seating properly or by air passing the piston cup.

Move arrow to OFF position, apply brake pedal and cover exhaust port with soap suds. Leakage is caused either by the intake valve or by ball not seating properly.

Pressure Tests (Install gauge in brake chamber port): Turn limiting valve to OFF position and apply brake pedal until gauge 1 reads 50 pounds. Note that gauge 2 should register zero, except on dial showing "low", then pressure should be not less than 15 pounds.

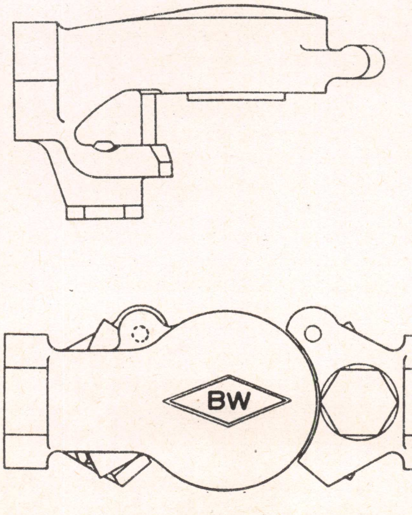
Turn arrow to line A and apply brake pedal until gauge 1 reads 50 pounds. Note that gauge 2 should register 20 pounds.

Turn arrow to line H. Apply brake pedal to full position. Note that gauge 2 should register 40 pounds, plus or minus 2 pounds.

Turn arrow to FULL position. Apply brake valve to full position and note that both gauges read identically.

If leakage in the above tests exceeds a 3-inch bubble in 3 seconds, the limiting valve should be cleaned and repaired or replaced if necessary.

The valve may not meet leakage tests due to dirt on the body walls, or the exhaust seat or on ball and seat G. When this is true the leakage can be remedied by cleaning both the seats and the walls thoroughly. However, if the leakage is caused by a worn valve, it will be necessary to replace the entire intake valve assembly and generally it will be found that both the intake valve and the piston cup are worn so that the entire valve is in need of a general reconditioning. In this case it will likely be more economical and more satisfactory for the operator to replace the entire limiting valve with a factory-reconditioned unit. In any case the piston cup should be replaced at least once each year.



Trailer coupling

TRAILER COUPLING

The trailer connections are made up through hose couplings as illustrated. When couplings are installed and connected they should resemble the set-up illustrated. This arrangement minimizes the possibility of accidental unhooking or uncoupling. The rubber seal in the couplings should be replaced at least every six months; more often with severe usage.

TUBING FITTINGS

Fittings are furnished in sizes to correspond with the various tubing measurements.

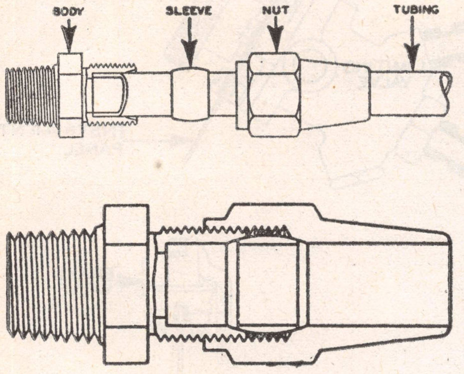
Installing Tubing Fittings on Tubing: If reasonable care is exercised in carrying out the following steps, no leakage will occur at the tubing fitting when it is installed on tubing line:

Cut tubing. After the cut is made, make sure the end of the tubing is smooth and is cut squarely at right angles to the outside wall. Also, make sure the end of tubing is not crimped or closed. Blow out tubing with an air line. Remove all burrs, cuttings or filings. Place nut and sleeve on tubing. Place end of tubing against the bottom of the bore in the tubing fitting body. Hold tubing at bottom of bore and tighten tubing fitting nut only enough to seal the joint against leakage.

Tubing Line Installations: In all tubing line installations, the following points should be carefully observed:

Use Bendix-Westinghouse tubing in all cases. This tubing is designed specially to withstand the vibration, etc., that comes

TUBING CONNECTOR



Tubing connector. Top—Connector parts disassembled. Bottom—Assembled connector.

with automotive uses. Mount tubing in frame channel so that it will be protected in case of flying stones, driveshaft breakage, etc. Be sure the tubing line is open and is not crimped or mashed. Do not make sharp bends in tubing lines. When bending tubing the radius of the bend should be as large as possible. The following minimum bends are recommended:

Tubing Size	Minimum Radius of Bend
⅜ inch	3 inches
½ inch	4 inches
¾ inch	6 inches
1 inch	10 inches

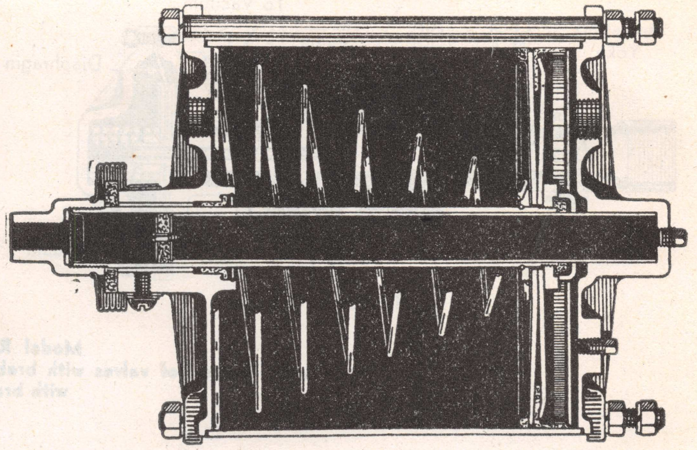
Bends in the ⅜-inch and ½-inch tubing may be made without filling the tubing with sand. However, it is advisable to fill the ¾-inch and 1-inch tubing with sand before making the bends to keep the tubing from wrinkling or crimping.

Clamp tubing to the frame at intervals of 30 to 40 inches. Keep tubing lines straight and as short as possible. Install all tubing lines on a slant so that any condensation in the lines will be permitted to drain back to the reservoir. Wherever the natural action of the vehicle will cause a repeated bending or twisting of the line, hose should be used instead of metal tubing.

Maintenance Service and Inspection: Every 5000 miles check discharge line to be sure it is free from carbon. Every 20,000 miles cover all tubing and tubing fittings with soap suds. No leakage is permitted. In case of leakage in the tubing, the leaking piece should be replaced with a new tubing. Leakage at the tubing fitting may be stopped by tightening the fitting.

VACUUM POWER BRAKES

BENDIX B-K



Power Cylinder

Brakes on many trucks require higher pressure than can be supplied with the foot. To secure this increased pressure, vacuum in the intake manifold is used to operate the piston in a power cylinder which applies pressure to some part of the braking system in addition to foot pressure. The difference between manifold pressure and atmospheric pressure is used to move the piston which in turn exerts pressure on some part of the regular braking system depending upon the type of brake used. Adjustments of the brakes are described in the Brake chapter elsewhere in this manual. Various controls are used to regulate the operation of the piston.

Two types of power cylinders are used. On one type the operating valve, which controls the delivery of air or vacuum to the power cylinder, is in the power cylinder while on the other type, an external type of operating valve is fitted with no valve in the power cylinder. On these two types there is a vacuum on both sides of the piston when the brakes are released. When the brakes are applied, air is admitted into the power cylinder on one side of the piston and the pressure of the air forces the piston toward the vacuum on the other side of the piston. The piston rod is connected to the brake linkage and assists in applying the brakes so that more effort is applied to the master cylinder than would be possible with the driver's foot. When the brake pedal is released, both sides of the piston in the power cylinder are closed to air and thus the piston and linkage are returned to their off position so that the piston is again suspended in a vacuum position by the piston return spring and the linkage return spring.

Testing: To determine if the vacuum brake units are working, stop the engine and apply the brakes several times to eliminate the vacuum from the brake system. Then apply the brakes lightly and while holding them in this position, turn on the ignition switch and start the engine. If the power units are working, pressure required to hold the brake pedal will be partially relieved. If the pedal does not change position after the engine is started, something is wrong with the vacuum brake equipment. If the vacuum equipment is satisfactory, check the brake adjustments as described in the Brake section.

To check the vacuum system for leaks, remove the pipe plug in the vacuum end of the power cylinder. Insert the hose connection with a vacuum gauge into the pipe plug hole. Start the engine and the gauge should show a vacuum of 17 to 20 inches. Now stop the engine and note the rate of vacuum drop. If the rate of drop is greater than 1" every 15 seconds, it indicates a leak which may be in the vacuum or air lines or in the check valve seat.

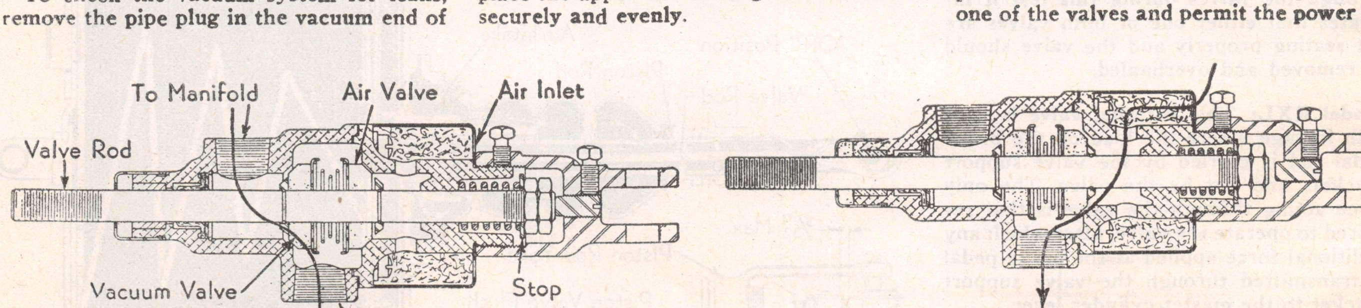
Check Valve: A check valve is used with both types of power cylinders and seals the vacuum in the power cylinder and lines assuring sufficient vacuum for at least one maximum power brake application in case the engine stalls. To test the check valve, idle the engine for a few seconds after a brake application, then shut off the engine and allow it to stand for 5 or 10 minutes. If the first brake application after this interval requires more physical effort than when the engine is operating it indicates that there is a leak at either the valve seat or in the vacuum lines connections.

The check valve can be disassembled for inspection and replacement of the valve seat assembly by removing the screws holding the halves of the body together. Lift the valve out of the lower half of the housing and inspect it for evidence of failure. Inspect the valve seat and clean it with an abrasive such as steel wool. When replacing the valve, place the long stem of the valve in the lower housing and be sure that the stem is free in the housing guide. Replace the upper half and tighten the screws securely and evenly.

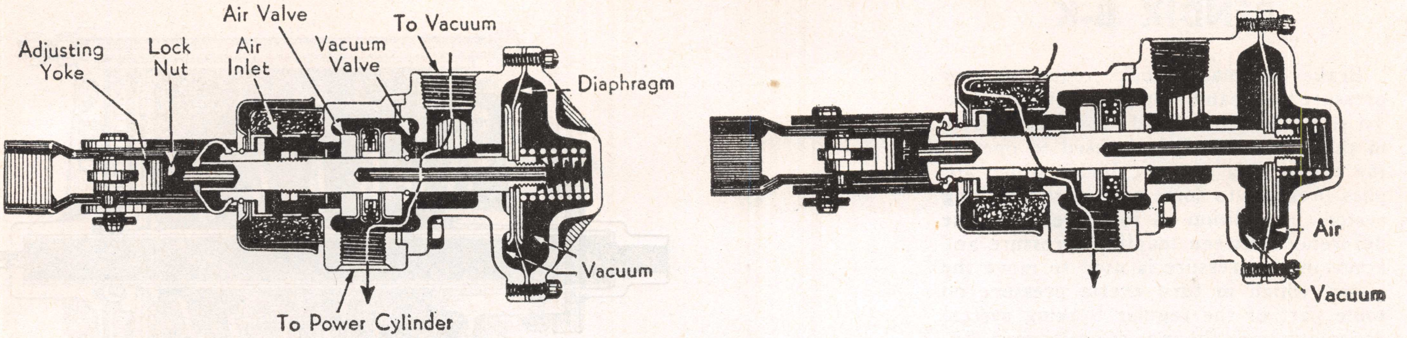
EXTERNAL OPERATING VALVE TYPE OF POWER CYLINDER

With the external operating valve type of power cylinder there are no valves in the power cylinder and therefore no adjustments are possible. Two types of operating valves are used with this type of power cylinder, Model XT and Model RXL.

Model XT: This valve is mounted in the pedal linkage so that movement of the brake pedal causes the vacuum and air valves to function. When the brake pedal is released, the air valve is closed and the vacuum valve open to the power cylinder so that vacuum is present on both sides of the power cylinder piston. When the brake pedal is depressed, the valve rod closes the vacuum valve and opens the air valve permitting air to enter at the rear side of the piston where its pressure forces the piston toward the front end of the piston. This movement is transmitted through the brake linkage to the master cylinder, assisting in the application of the brakes. The amount that the brake pedal is depressed determines the amount of air that is admitted to the power cylinder which controls the amount of piston travel. When the forward movement of the pedal stops, the cylinder pushes the brake mechanism slightly, moving the operating valve casing forward just enough to close the air valve. With both valves closed, the brake pedal must be depressed further or released to open either one of the valves and permit the power cyl-



Model XT operating valve.
Left: Position of valves with brakes released. Right: Position of valve with brakes applied.



Model RXL operating valve.
Left: Position of valves with brakes released. Right: Position of valves with brakes applied.

inder valve to move again. When the pedal **is released**, the air valve closes, shutting off **air** from the power cylinder and the vacuum **opens** so that both sides of the power cylin**der** are connected to the intake manifold and the piston will return to its off position and brakes can then be released by their retracting springs.

Operating Valve Adjustment: The length of the operatnig valve between eye centers must be the same as the length of the connecting link when the brakes are in their released position. Before adjusting the operating valve the pick-up lever must be correctly adjusted. The clearance between the power cylinder pick-up lever and the idle lever should be .030" when the brakes are released. To make an adjustment, loosen the lock nut at the adjustable yoke and turn the yoke in the direction necessary to permit installation of the clevis pin when the clearance between the ball on the end of the pick-up lever and the idler lever is .030". Then tighten the adjusting yoke lock nut when the adjustment is finally complete.

Now loosen the adjustable yoke lock nut at the operating valve rod. Then turn the valve rod in the direction necessary to obtain the same direction between the operating valve link pins as between the connecting link pins. Then tighten the lock nut.

To test the valve, shut off the engine. With the brake pedal in its released position, remove both hose from the valve. Close the opening leading to the manifold with your finger. If the air valve is seating properly no air can be drawn through the cylinder opening. If air can be drawn through the valves during this test it indicates that either one or both valves are not seating properly and the valve should be removed and overhauled.

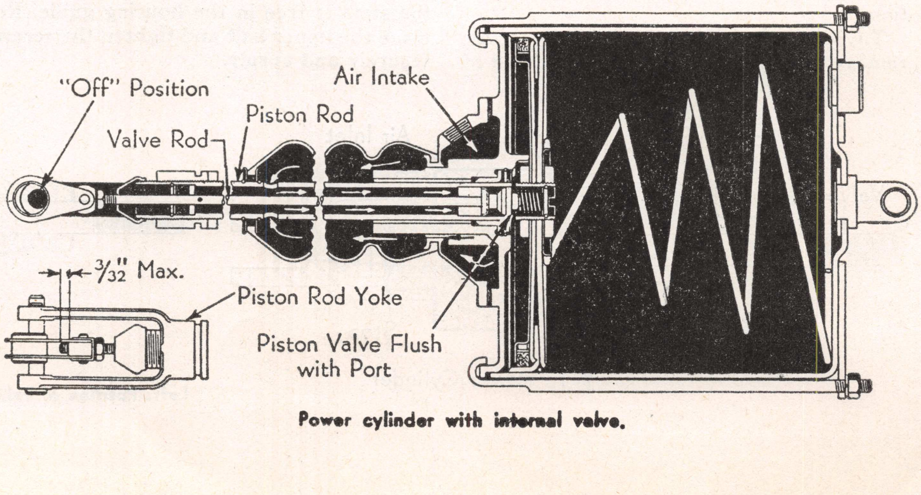
Model RXL: This external valve is used with linkage where the load on the brake pedal rod is carried by the valve support brackets and not by the valve. The only force acting through the valve is that required to operate the valve, after which any additional force applied at the brake pedal is transmitted through the valve support bracket to the master cylinder lever.

The air and vacuum valves control the flow of air and vacuum to the power cylinder in the same way as they do on XT valve but the method of moving the valves is somewhat different. There is a diaphragm at the end of the valve and when the brakes are released the vacuum valve is open and the chamber on both sides of the diaphragm is connected to vacuum. The chamber on the inner side of the diaphragm is connected to the vacuum intake side of the valve through a hole in the valve body while the chamber on the outer side of the diaphragm is connected to the power cylinder side of the valve through a drilled passage in the valve shaft.

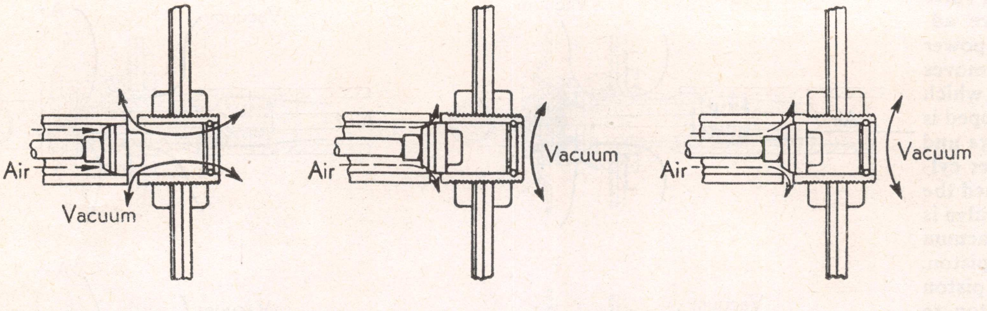
As long as the brakes are in their released position the air and vacuum valves are held in their released position by the spring between the diaphragm and the diaphragm cover. When the brake pedal is depressed the valve shaft moves toward its applied position with the vacuum valve closed and the air valve open so that air is delivered to the power cylinder and its piston starts its power stroke.

The entrance of air to the power cylinder also permits air to reach the chamber on the outer side of the diaphragm through the drilled passage in the valve shaft. This upsets the balance of vacuum on each side of the diaphragm and an opposing force is created in the valve which tends to move the shaft forward and close the air valve. This can be accomplished as soon as follow-up occurs in the linkage, which takes place when air is admitted to the power cylinder, the power stroke from which causes the operating valve and body to move forward. This forward movement of the valve body combines with the action of the diaphragm to close the air valve, with the vacuum valve also closed, to hold the brakes in their partially applied position. The valve remains in this position until the brake pedal is depressed further or released. This action provides complete control of the power cylinder operation and prevents the power cylinder applying more brake action than is desired. When the brake pedal is released the air valve closes and the vacuum valve is opened to the power cylinder so that there is again a vacuum on both sides of the power cylinder piston as well as on both sides of the operating valve diaphragm.

Adjustment: There is only one adjustment and it is made at the yoke on the forward end of the valve rod. To make an adjustment, loosen the yoke lock nut and make sure that the brake pedal and brake linkage are in their fully released position. Idle the engine and screw the yoke rod out of the yoke until the power cylinder piston starts to move forward. When this point is reached, turn the yoke rod into the yoke until the power cylinder valve shaft begins to move toward the released position. Then screw the yoke rod still further into the yoke until the yoke rod has .002" to .015" end play in the valve shaft recess. Turn off the ignition and depress the brake pedal slowly, at the same time noting if the valve shaft moves approximately 5/16" with moderate pressure on the pedal. This indicates



Power cylinder with internal valve.



Type I power cylinder with position of operating valve when brakes are in different positions. Left: Fully released. **Left center:** Partial holding. **Right center:** Fully applied. **Right:** Holding position.

the yoke rod has been adjusted

To determine whether or not the operating valve is functioning properly, disconnect the line from the valve to the power cylinder and plug this port in the valve with an air tight plug. If the air valve is seating properly no air can be drawn through the vacuum port. The air valve may also be tested, if the check valves have been tested and are known to be tight, by disconnecting the vacuum line to the power cylinder and installing a gauge in the line. Run the engine for a short time and note the gauge reading. Stop the engine and if the rate of vacuum drop is not greater than 1" in 15 seconds the valve seat may be considered satisfactory. If the vacuum drops off quickly it indicates that the air valve is leaking.

The vacuum valve can be tested in the same manner as described above for testing the air valve except that the pedal must be held down in its fully applied position while the test is made.

INTERNAL OPERATING VALVE TYPE POWER CYLINDER

With the power cylinder of the vacuum suspended type with internal operating valves, air within the power cylinder is taken through an air cleaner connected to the power cylinder cover and is passed through the piston rod to the air valve. When the brakes are applied, air passes the valve to the rear side of the piston. Upon releasing the brakes the air in the cylinder is withdrawn through the holes in the piston rod into the vacuum line. The amount of air admitted to the cylinder determines the amount of piston travel and depends upon how far the brake pedal is depressed. After the pedal is depressed and stopped in any position, the power cylinder piston will continue to pull the brake mechanism slightly, moving the operating valve to its holding position. To move the piston in either direction from this position, the brake pedal either must be depressed further or released.

The power cylinder is connected to the master cylinder through linkage consisting of the brake pedal, rod, and levers and pins. The valve lever is connected to the pedal rod, while the power lever is connected to the master cylinder. The valve lever has a set screw in it. One end of the power lever is connected to the power cylinder clevis pin and the other end pivots on the valve lever. The valve lever is forked on one end which fits over the power cylinder operating valve rod bushing. The outer end pivots in frame brackets.

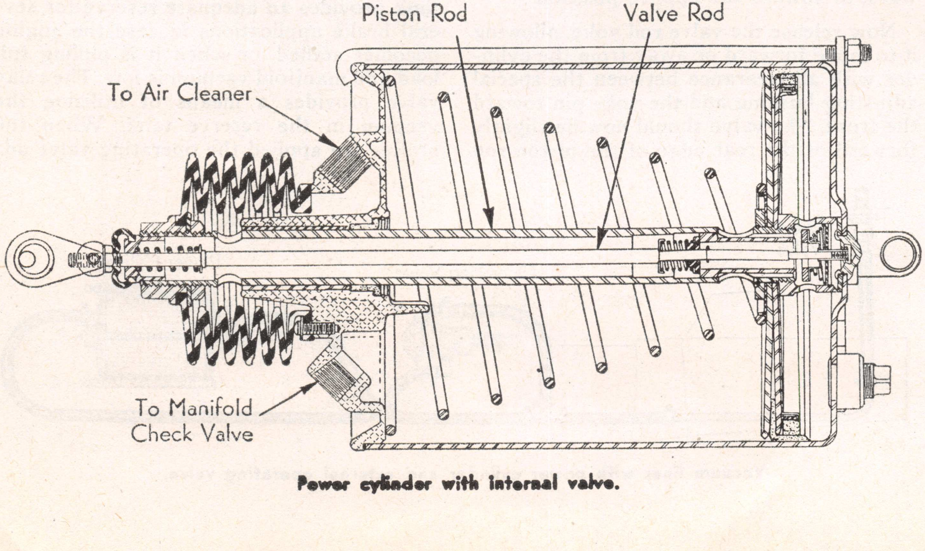
When the pedal is depressed, the pedal rod pulls the valve lever forward and the operating valve in the power cylinder is opened to air. When the set screw in the valve lever contacts the power lever, both levers act as one, pivoting on the linkage mounting and the master cylinder stroke starts.

Linkage Adjustment: The need of an adjustment of the brake linkage is indicated when clearance between the brake pedal and the floor board is more than 1½" or less than 1" when the brakes are released; when more than ½" movement of the pedal is necessary to close the by-pass hole in the master cylinder and start the power stroke or to admit air to the power cylinder and bring the vacuum brake system into operation; when the master cylinder piston does not return to its released position as the brake pedal is released.

With the brake pedal, master cylinder and power cylinder mounted, connect the power and valve lever, being sure that the valve lever set screw is backed off far enough so that it does not touch the power lever. Connect the brake rod to the valve lever with the operating valve in its off position and the brake pedal against its stop. Tighten the clevis nut. With the linkage completely connected, the brake pedal movement should be ¼" to ⅜" before the brakes begin to apply. With the operating valve in its fully applied position, squeeze the power and valve levers together with the fingers and turn the set screw finger tight against the power lever. Tighten the lock nut.

With the operating valve in its fully-applied position and the power and valve levers held together with the fingers against the set screw stop, connect the master cylinder piston rod yoke to the power lever. Adjust the master cylinder yoke by rotating the piston rod until contact is made with the piston. Tighten the rod lock nut. The piston rod floats in the piston and this adjustment should provide the right amount of play in the master cylinder.

Operating Valve No. 1: The operating valve consists of vacuum and air valves which open and close in accordance with brake pedal movement and controls vacuum and air pressure on both sides of the power cylinder piston. The outer end of the valve rod is connected to a copper bushing which floats on the clevis pin. The position of this bushing actuates the valve rod and determines the position of the valve. When the



Power cylinder with internal valve.

brake pedal is depressed the operating valve moves forward and opens its air valve, admitting air to the rear side of the power cylinder piston and the piston moves toward the end of the cylinder in which vacuum still exists. Power thus developed is transmitted through the brake linkage and assists in the application of the master cylinder. When the brake pedal is released the air valve is closed while the vacuum valve is opened and through valve slots a vacuum again exists on both sides of the piston. With vacuum on both sides of the piston the retracting spring pushes the piston to its off position, releasing the brakes.

Adjustment: Any change in the position of the piston rod yoke or in the length of the piston rod will necessitate readjusting the operating valve.

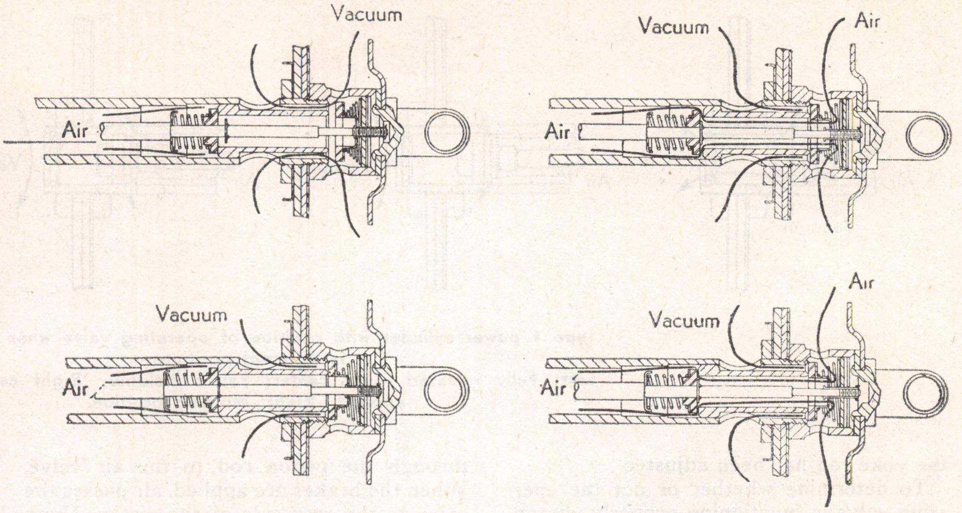
If an adjustment is to be made with the cylinder mounted in the truck, disconnect the piston rod yoke from the power and valve levers and with the engine idling, check the adjustment in the following manner. If the adjustment is to be made on the bench, connect power cylinder to a vacuum.

Place a special adjusting bushing, as illustrated, in position in the valve and insert the piston rod yoke pin in position. With vacuum in the cylinder, move the valve rod yoke away from the cylinder until the test bushing bottoms against the rear side of the piston rod yoke pin, having all clearance away from the cylinder. Due to spring pressure on the valve, care must be exercised to exert a slight outward pressure on the piston rod while moving the valve outward or away from the cylinder, in order that any movement of the piston rod will be due to the admission of air through the air valve, and not from pressure on the valve rod yoke. In this position the air valve should be just open, allowing air to enter the rear chamber of the cylinder. The piston should move slowly forward, or toward its applied position.

Now release the valve rod yoke, allowing it to move toward the cylinder, with all clearance between the test bushing and the yoke at the rear as shown. The air valve should be closed and the vacuum valve open, admitting vacuum to the rear of the piston, causing the piston to move slowly toward the rear or off position.

If the valve does not operate properly, loosen the valve rod locknut and turn the valve rod yoke by ½ turns, in the direction necessary for the proper adjustment. In making this adjustment, it is advisable to hold the valve rod firmly and rotate the valve rod yoke rather than to turn the rod. For best valve action and cylinder performance, turn the valve rod yoke out ½ turn after the correct setting has been obtained. Then tighten the locknut. Use a new pin or a special test pin of the correct diameter.

Operating Valve No. 2: The valve adjustment must always be made after the piston rod has been set to its proper position. Any change in the position of the piston rod yoke will necessitate an adjustment of the operating valve.



Type two power cylinder with position of operating valves when the brakes are in different positions.

Upper left: Fully released.
Upper right: Fully applied.
Lower left: Holding position.
Lower right: Partial holding.

If an adjustment is to be made on the bench, connect the cylinder to the source of a vacuum or if the adjustment is to be made with the cylinder mounted on the vehicle, disconnect the piston rod yoke from the power and valve levers and, with the engine running at idle speed, check the adjustment in the following manner:

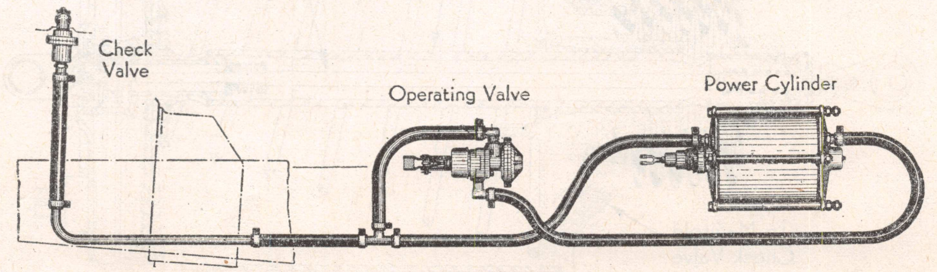
Place a special adjusting bushing on the valve yoke and insert the piston rod yoke pin in position. With vacuum present in the cylinder, move the valve rod yoke toward the cylinder until the special adjusting bushing bottoms against the front side of the piston rod yoke pin, having all clearance toward the cylinder. Due to spring pressure on the valve, care must be exercised to exert a slight outward pressure on the piston rod while moving the valve inward, toward the cylinder, in order that any movement of the piston rod will be due to admission of air through the piston rod valve port and not from pressure on the valve rod yoke. In this position the rear edge of the valve should just pass the front edge of the port in the piston rod, allowing air to enter the front chamber of the cylinder. The piston should move slowly rearward, or toward the applied position.

Now release the valve rod yoke, allowing it to move forward or away from the cylinder with all clearance between the special adjusting bushing and the yoke pin toward the front. The valve should now be slightly forward of the rear edge of the piston rod port, admitting vacuum to the front chamber of the cylinder, causing the piston to move slowly forward or toward the off position.

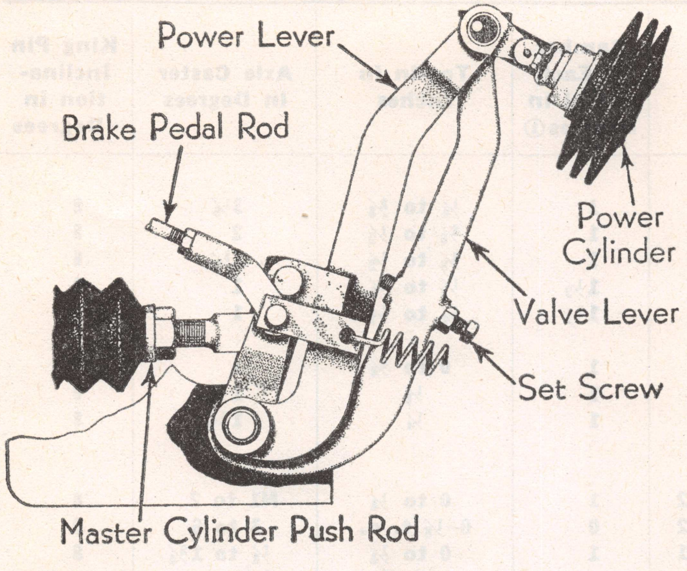
If the valve yoke positions outlined above do not cause the corresponding piston movement, the valve is improperly adjusted. To correct the adjustment, loosen the locknut at the valve rod yoke and adjust the valve rod yoke by half turns, in the direction necessary to position the valve as previously described. The valve push rod should not extend more than 3/32" through the yoke when the adjustment is completed. When making this adjustment it is advisable to hold the valve rod firmly and rotate the valve rod yoke rather than to make any attempt to turn the valve rod.

For best valve action and cylinder performance, turn the valve rod yoke out a half turn after the foregoing setting has been obtained, then tighten these adjustments. Use a new pin or a special test pin having a diameter of .322" to .318".

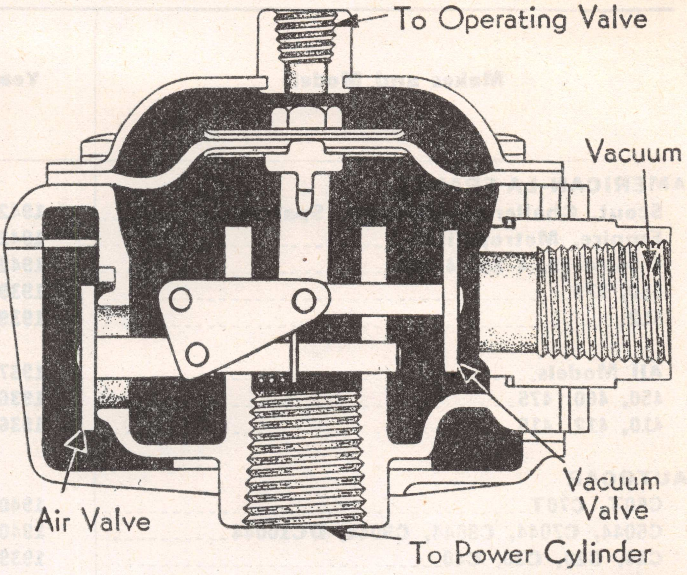
Relay Valve: Models using two rear axles are equipped with a vacuum reserve tank and a relay valve located at the rear of the brake power cylinder. Use of a vacuum tank provides an adequate reserve for several brake applications in case the engine becomes stalled, or when it is pulling full load and manifold vacuum is low. The relay valve provides a means of utilizing the vacuum in the reserve tank. When the brakes are applied the operating valve ad



Vacuum lines with power cylinder and external operating valve.



Master cylinder and power cylinder linkage.



Relay valve

mits atmosphere to the relay valve. Atmosphere thus admitted causes the relay valve to function and opens the outside of the power cylinder piston to atmosphere, admitted through the air cleaner.

When the brakes are not being used, the relay valve is in its released position. In this position, the atmospheric valve is closed, and the vacuum valve is open. The valve body and front of the power cylinder piston are connected to vacuum by a tube between the intake manifold and the vacuum storage tank. As long as the atmospheric valve remains closed, and the vacuum line is open, both sides of the piston are balanced by manifold vacuum.

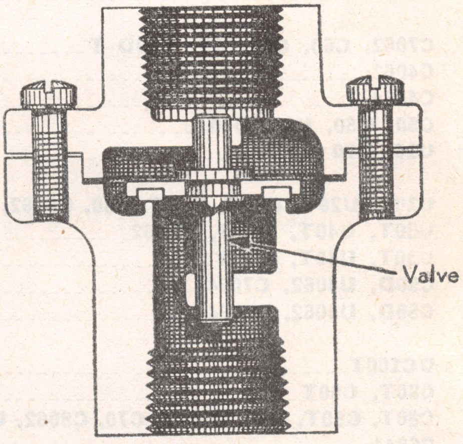
When atmospheric pressure on the outer side of the diaphragm is sufficient to cause the diaphragm to move, the triangular shaped linkage is operated so as to close the vacuum valve and open the atmospheric valve. This permits atmosphere taken in through the air cleaner to pass through the relay valve and into the power cylinder and the piston in the power cylinder then commences its power stroke.

Atmospheric pressure against the diaphragm in the valve body chamber upsets atmospheric pressure against the outer side of the diaphragm, thus an opposing force is created in the relay valve which tends to move the diaphragm toward its released position and close the atmospheric valve. This movement of the diaphragm, combined with action of the triangular linkage, closes the atmospheric valve and, with the vacuum valve also closed, to hold the brakes in partially applied position. While the relay valve remains in this position, with both atmospheric and vacuum valves closed, the power cylinder does not move in either direction until atmospheric pressure at the relay valve is changed by action of the operating valve. This action provides complete control of the power cylinder operation and prevents the cylinder applying more brake action than is desired.

When the brake pedal is released, atmospheric pressure at the relay valve, through action of the operating valve is relieved and the atmospheric valve closes, shutting off atmospheric pressure in the power cylinder, and vacuum valve opens so that the inner side of the relay valve diaphragm, as well as both sides of the power cylinder piston is again connected to the intake manifold and vacuum reserve tank. Vacuum on both sides of the power cylinder piston is thus equalized and the brakes are released instantly by their retracting springs.

Testing Relay Valve: To determine whether or not the relay valve is functioning properly, disconnect the air cleaner atmosphere line from the relay valve body. Light air pressure, not more than 10 pounds, should be applied slowly through the atmospheric inlet. If air pressure is retained or does not show rapid drop it indicates that the valve is seating satisfactorily. If the leak is apparent or audible it may be around one of the gaskets, instead of at the atmospheric valve. Vacuum may also be tested at this time; except, that the brakes must be applied to close the vacuum valve while attempting to draw air through the vacuum inlet tube.

The system may also be tested by inserting a vacuum gauge in the vacuum line at the relay valve inlet. Start the engine and note the vacuum reading at the gauge. Stop the engine and note the rate of vacuum drop. If the vacuum does not drop off faster than 1" every 15 seconds, this indicates that the system is satisfactory. Rapid vacuum drop indicates that a leak exists in the vacuum lines or at the valves in the relay valve. Also see "Testing Vacuum Power Brake Equipment" and "Vacuum Test for Leaks".



Check valve.

Air Cleaner: An air cleaner is provided for atmospheric intake and is mounted near the relay valve. This cleaner should be removed and cleaned at least twice a year. The cover can be taken off and the curled hair cleaning element removed. Clean the cover and all dirt around the housing. Wash the curled hair in gasoline and saturate it with light engine oil. When replacing the cleaning element be careful that the hair is placed evenly around the housing and is not matted down in spots.

WHEEL ALIGNMENT

Makes and Models	Year	Camber of Each Wheel in Degrees①	Toe-in in Inches	Axle Caster in Degrees	King Pin Inclination in Degrees
AMERICAN-LA FRANCE					
Scout, Challenger, Invader, Spartan	1942	1	¼ to ⅜	3⅛	8
Empire, Metropolitan	1942	1	⅜ to ½	2	8
4-65, 4-75, 4-85, 4-100	1942	1	⅜ to ½	1⅝	8
550, 575	1939	1½	⅛ to ¼	1	8
512	1939	1½	¼ to ½	1	8
All Models	1937	1	0 to ¼	1	8
450, 460, 475	1936	1	⅛	1½	8
410, 412, 415	1936	1	¼	1½	8
AUTOCAR					
C60T, C70T	1940–42	1	0 to ¼	N1 to 2	8
C6044, C7044, C8044, C9044, DC10044	1940–42	0	0–⅛ t. o.	3 to 6	0
C10, C20, C30, C40	1939–41	1	0 to ¼	¼ to 1¾	8
C10T, C20T, C30T	1939	1	0 to ¼	¼ to 1¾	8
C40D-T, C10T, C7062, C60, C70, C20T, C30T, C4064	1940–41	1	0 to ¼	0 to1½	8
C7062, C60, C60–70T, C40D–T	1939	1	0 to ¼	0 to 1½	8
C4062	1939–41	1	0 to ¼	½ to 2	8
C4064	1939	1	0 to ¼	½ to 2	8
C50, U50, U30, U40	1939–42	1	0 to ¼	N¼ to 1¼	8
U10, U20	1939	1	0 to ¼	N½ to 1	8
U10T, U20T, U60T, U70T, C80, C8062, C90, C9062	1939–42	1	0 to ¼	N½ to 1	8
U30T, U40T, U40D, U7062	1940–42	1	0 to ¼	N½ to 1	8
U30T, U40T, U40D	1939	1	0 to ¼	N¼ to 1¼	8
C50D, U4062, C7064	1940–41	1	0 to ¼	0 to 1½	8
C50D, U4062, C7064	1939	1	0 to ¼	N¼ to 1¼	8
DC100T	1939	1	0 to ¼	N1½ to 0	8
C80T, C90T	1940–42	1	0 to ¼	N1 to 2	8
C80T, C90T, U10, U9062, C70, C8062, U7064, U20	1939	1	0 to ¼	N½ to 1	8
C6044	1939	0	0–⅛ t. o.	2½ to 5	0
U60, C70D	1939–41	1	0 to ¼	N¾ to ¾	8
U7064	1940–41	1	0 to ¼	N¾ to ¾	8
U10, U20, DC100T	1940–42	1	0 to ¼	N½ to 1½	8
C7044, C8044, C9044, DC10044	1939	0	0–⅛ t. o.	5 to 7	0
C80D, C90D	1939–41	1	0 to ¼	N1½ to 0	8
C8064, C9064, DU100T, 6X4TC (1939)	1939–42	1	0 to ¼	N1 to ½	8
U60D, DC100T	1940–41	1	0 to ¼	1½ to N½	8
UDP, 6X4UTO (1939), U60D, U8064	1940–42	1	0 to ¼	N1½ to N½	8
U70–8,0, U80–90D, U9064, U8062, US, 6X4UTD (193 9)	1940–41	1	0 to ¼	N1¼ to N¼	8
U90D, U7062–8062–4–9064, U70–80	1939	1	0 to ¼	N1¼ to ¼	8
U80T U9062, U90, U90T	1939–41	1	0 to ¼	N1 to 0	8
6X4TD, UDF, UN, UNF, 6X2UN, 6X2UNF, (1939), U80D, U8062 (1940–42)	1940–41	1	0 to ¼	N1¼ to ¼	8
U80D, UT, 4-5UTR, 6X2UT (1939), U90, U90T, U9062 (1940–42)		1	0 to ¼	N1 to 0	8
DC100D, DC10062-64, DU10062-64	1939–42	1	0 to ¼	N2½ to N1½	8
A, B, RL, RM, D, DF	1938	1	0 to ¼	1¾ to 2½	8
N, NF, T	1938	1	0 to ¼	¾ to 1½	8
RMT, 1TR, 2TR, 3TR, 4TR, 5TR	1938	1	0 to ¼	1½ to 2½	8
UA, UB	1938	1	0 to ¼	½ to 1½	8
UD	1938	1	0 to ¼	1½ to 2	8

Continued on next page

Makes and Models	Year	Camber of Each Wheel in Degrees①	Toe-in in Inches	Axle Caster in Degrees	King Pin Inclination in Degrees
AUTOCAR (Continued)					
UDF, UN, UNF, UT	1938	1	0 to ¼	½ Neg. to 0	8
1-2-3-4-5UTR	1938	1	0 to ¼	¾ to 2	8
All Models	1936	1	⅛	1½	8
AVAILABLE					
C100-200-250-300-350, CS100-200-250-300-300L	1942	1	3/16	2½	8
C400-400L-500-550, CS400-L-500-550-600-650-700	1942	1	3/16	3	8
All	1941	1	⅛ to 3/16	1½ to 2	8
All Models	1936-38	1	3/16	2	8
BIEDERMAN					
10, 20, 30, 40, 45, 50, 60, 70, 75, 80, 100	1936-37	2	3/16	1 to 1½	7½
BROCKWAY					
78, 83, 88	1941-42	1	1/16 to ⅛	1 to 2	8
92, 94, 112, 128, M83, M88, M92, 146, 147, 152, 153, 154, 156, M94, M112, M128, M146, M152, M162, M166, 162, 166, 175X, 240X, 220X, 260X	1941-42	2	1/16 to ⅛	1 to 2	0
School Busses L21, L25, L31, K31, L37, K37, J37, K43, J43, G43, J49, G49, H49, J55, G55, H55-31-37-43-43X-49-55	1941-42	1	1/16 to ⅛	1 to 2	8
112, 128, M83, M88, M92, M94, M96, M110, M125X, M130, M145, M150X4-5	1938	1	1/16 to ⅛	1 to 2	8
165X	1938	2	1/16 to ⅛	1 to 2	0
Bus A17-21-25, B17-21-25, C31-37-43, ES49-55-61, F49-55-61, E43	1938	1	1/16 to ⅛	1 to 2	8
78, 83, 88, 92, 94, 96, 110, 125X, 130, 145, 150X4, 150X5	1936-40	1	1/16 to ⅛	1 to 2	8
B31, B37, B43, 310, 371, D43, D49, 430, 433, 492, 493, E49, E55, E61, 551, 553, 610, 613	1937	1	1/16 to ⅛	1 to 2	8
160X, 170X, 175X, 195X, 180SBTX, 220X, 240X, 260X	1936-40	2	1/16 to ⅛	1 to 2	0
80, V1200, 78, 87, 371, 372, 431	1936	1	1/16 to ⅛	1 to 2	8
CHEVROLET					
Light Del. ¾ T, ¾ T Spec	1941	1 ± ½	5/64 to ⅛	1¾ ± ½	7⅙ ±1
Heavy Duty Conv	1941	1 ± ½	5/64 to ⅛	2¾ ± ½	7⅙ ±1
H. D. Cab over Engine	1941	1 ± ½	5/64 to ⅛	3 ± ½	8 ±1
1½ ton Cab over Engine	1940-42	1 ± ½	5/64 to ⅛	3 ± ½	8
½ T(1935-42) ¾ T(1937-42) 1 T(1937-8)		½ to 1½	5/64 to ⅛	1¼ to 2¼	7⅙
1½ ton (1935-42), 1 ton (1939-42)		½ to 1½	5/64 to ⅛	2¼ to 3¼	7⅙
Utility	1936-37	1	5/64 to ⅛	2¾	7⅙
Commercial	1936-37	1	5/64 to ⅛	1¾	7⅙
CONDOR					
A, B, C, D, E, ACW, BCW, CCW, FCW	1936-37	1	⅛	1¾	9
G, H, J, K, GCW, CDW, CEW	1936-37	1	⅛	2	8
CORBITT					
All Two-Wheel Drive	1938-39	1	1/16 to ⅛	1½ to 2½	8
All Front Drive	1938-39	1	1/16 to 3/16	5 to 7	0
All 2 Wheel Drive	1936-37	1	1/16 to ⅛	1 to 1½	8
All 4 and 6 Wheel Drive	1936-37	1	1/16 to ⅛	5 to 7	0
DAY ELDER					
76, 86, 111, 131, 151, 161, 25B	1936-37	1	¼	1½	8
201, 241, 286, 346, 403, 30B	1936-37	1	2	⅜	8
200, 240, 285, 345, 402, 30B	1936	1	⅜	2	8

Continued on next page

WHEEL ALIGNMENT

Makes and Models	Year	Camber of Each Wheel in Degrees①	Toe-in in Inches	Axle Caster in Degrees	King Pin Inclination in Degrees
DIAMOND T					
404–SC, 406, 614SC, 509SC, 612SC, 513, 615	1942	1	⅛	1½	9
805H–W, 806H–W, 900W	1940–42	1	⅛	2½	8
201, 305, 305C, 306, 306C, 306SC, 201C	1939–42	1	⅛	4¾	9
509, 612, 614–C, 513C, 404C, 509C, 612C	1939–42	1	⅛	1½	8½
615C, 803C, 804C	1939–42	1	⅛	1½	8
80, 301, 304	1938	1	⅛	1½	8
404, 405, 406, 513, 615	1938–41	1	⅛	4¾	9
509, 611, 612, 613, 614	1938	1	⅛	1½	9
412DR, 512B, 512DR	1938–42	1	⅛	1½	8
807W, 808W	1938–42	1	⅛	2½	8
513, 615, 401, 402, 507, 508, 607, 609, 610	1938	1	⅛	1½	8½
802, 803, 804	1938	1	⅛	1½	8
80	1937	1	1/16 to ⅛	3½	9
212A, 212B, 221, 228	1936–37	1	⅛	1½	9
244, 313, 320, 353, 360	1936–37	2	⅛	1½	7½
412B, 412DR, 512B, 512DR	1936–37	2	¼	2½	7½
DODGE					
WC, WD–15, WD20–21	1941–42	1½	0 to ⅛	2	4
WFM, WG, WH, WGM, WHM	1941–42	2	(1/16″ pref.)	2	7
WF	1941–42	2	(1/16″ pref.)	1½	7
WK, WL, WKD, WLD	1941–42	1	(1/16″ pref.)	2	8
MC, MD, PT50–57–81, FE 1–16, FE 2, RC, RD, FG 1–2, TC, FH 1–2–15, TD 15–20–21, VC, VD	1937–40	1½	⅛	2	4
ME, MF, FE 3–4, FG3–4, FH 3–4, RE, RF, TE, TF, VF	1937–40	2	1/16 to ⅛	1½	7
VM, VR, VS, VG, VH	1940	2	1/16 to ⅛	2	7
VL, VK, VLD, VKD	1940	1	1/16 to ⅛	2	8
MG, MH, FE 6, FGZ6, RG, RH, RZ	1937–39	2	1/16 to ⅛	2	8
ML, MK, RL, RK, RX, TL, TK, TLD, TKD	1937–39	1	1/16 to ⅛	2	8
MO, MP, RO, RP	1937–39	1	1/16 to ⅛	2½	8
TG, TH, FH–6	1937–39	2	1/16 to ⅛	1½	8
LK, LM	1936	1	1/16 to ⅛	2	8
G80	1936	2	⅜	3½	9
K50V, K60V	1936	1	1/16 to ⅛	2	8
LC	1936	1	⅛	2	8½
LE, LF	1936	2	1/32 to 3/32	1½	7
LG, LH, LS, LT	1936	2	1/32 to 3/32	1½ to 2	7
DUPLEX					
S, SAC, M	1936–37	2	3/16	2	0
K	1936–37	2	3/16	2¼	0
ESCO					
236, 236H, 236–O, 237, 237–O	1936–37	1½	3/16	1	7½
336, 336–O, 337, 337–O	1936–37	1	¼	1	7½
136	1936	½	⅛	1	9
335, 335–O	--------	1	¼	1	7½
235, 235–O	--------	1½	3/16	1	7½
135	--------	½	⅛	1	9
FAGEOL					
All Models	1936–38	1	0 to ⅛	----	8

Continued on next page

WHEEL ALIGNMENT

Makes and Models	Year	Camber of Each Wheel in Degrees①	Toe-in in Inches	Axle Caster in Degrees	King Pin Inclination in Degrees
FEDERAL					
10, 9, 11, 11H, 12, 18, 20, 25, 29, 16, 17, 35, 45, 55, 55H, 77, 80, 85, 89, 62, 63, 65, 66	1941–42	1	3/16	3	8
7, 8, D7, D8, M7, M8	1941–42	1	1/8	3½	8
11, 12, 14, 15, 18, 20, 25, 29, 29H, 40, 50, 50H, 75, 80, 85, 89, 62, 63, 65, 66, 9, 10	1939–40	1	3/16	3	8
7, 8, M7, M8	1939–40	1	1/8	3½	8
X8, X8R	1936–38	1	3/16	2¾	0
T10B, T10W	1936–38	1	3/16	3	9½
9E, 11E, C7, C8, C7W, C8W, 75, 80, 85, 89	1936–38	1	3/16	3	8
10E, 40E, 50E, 15D, 18D, 20D, 25D, 28D, 29D	1936–38	1	3/16	3	8
FORD					
C. O. E.	1942	¾	1/16	3½	8¼
118T, 119T, 11T, 19T, Reg	1941–42	¾	1/16	3	8¼
11W, 19W, 111W, (Reg.), 191W, (C. O. E.)	1941–42	¾	1/16	4¼	8¼
110, 11Y, 1NY, (¾ to 1 ton), Comm	1941–42	1	1/16	3	8
11C, 1NC, (Comm.)	1941–42	1	1/16	8	8
122″ Wheelbase	1938	¾	3/32	8②	8
Tonner	1938–40	¼ to 1	EO	4½ to 9	8¼
Cab over Engine 101″, 134″, 157″ Wheelbase	1938–40	¼ to 1	1/16	1 to 3½	7¼
131½″, 134″, 157″ W. B	1936–40	¼ to 1	EO	3 to 5	8¼
F. W. D.					
HS, "U" Series	1942	1	⅛ to 3/16	2	0
HA-HR	1942	1	⅛ to 5/16	2	8
"M" Series	1942	1	⅛ to 3/16	2	4½
M	1940–41	1	0 to 1/16	3	0
HS, HG, T32	1938–41	¾	0 to 1/16	3	0
SU, CU	1938–41	1½	0 to 1/16	2	0
M10, M6X6	1938	1	0 to 1/16	2	4½
HS, HG, T26, T32, T40, T60, CU, CUA, SU, SUA, YU	1937	1½	0	2	0
MJ5, MJ6, M7, M10, MJ6X6, M6X6, T65, T72	1937	1½	0	2	4½
Balloon Tires	1936	1½	0	2	0
High Pressure Tires	1936	3	0	2	0
GMC					
AC500–520–550–600–620–650, ACR520–620, ACS500, ACT500–600, ACW600, AF500–520–550, AFR520, AFT500, AY700–800–850	1942	1	3/16 to ¼	½	8
AF600–620–650, AFR620, AFT600, AFW600	1942	1¼	3/16 to ¼	½	8
AC700–720–750–770–800, ACR720–750, ACT700–800, ACW700–800	1942	1¼	3/16 to ¼	¾	8
AF700–720–750–800–850, AFR720–750, AFT700–800–850, AFW700–800–850, AC850, ACT850, ACW850, ACX870–890	1942	1	3/16 to ¼	¾	8
CC100	1941	1½	9/64 to 7/32	3	7¼
CC260, CC300	1941	1½	3/16 to ¼	3	7¼
CC350, CF350, CC400, C7400	1941	1	3/16 to ¼	1½	8
AC500–550–600–650, AF500–550–600–650, AC450, AF450	1939–40	1	3/16 to ¼	½	8
AC350–700–800–850, AF700–800–850	1939–40	1	3/16 to ¼	¾	8
AC100–150–250–300	1939–40	1½	9/64 to 7/32	2¾	7⅙
AC, AF240, AC250	1940	1½	9/64 to 7/32	2½	7⅙

Continued on next page

WHEEL ALIGNMENT

Makes and Models	Year	Camber of Each Wheel in Degrees①	Toe-in in Inches	Axle Caster in Degrees	King Pin Inclination in Degrees
GMC (Continued)					
AC400, AF300–350–400, AF310	1939–40	1	³⁄₁₆ to ¼	1	8
T14	1937	1½	⁹⁄₆₄ to ⁷⁄₃₂	2¾	7¼
T16	1937	1½	¼ to ⁵⁄₁₆	2¾	7¼
F16, F16H, F18H, F23, F23H, F33, F33H, F46, F61, F61H, T18, T18H, T16H, T23, T23H, T33, T33H, T46, T46–400, T61, T61H	1937	1	³⁄₁₆ to ¼	1½	8
T23, T23H	1936	1	³⁄₁₆ to ¼	1½	8
T18, T18H, T16, T16H	1936	1½	¼ to ⁵⁄₁₆	½	7⅛
T14	1936	1½	⁵⁄₃₂ to ⁷⁄₃₂	1¾	7⅛
GRAMM					
71, 76, 86, 96, D71, D76, D86, D96	1940	1	³⁄₁₆	2	8
11	1940	1½	⅛	2	7
41, 46, D46	1940	1	⅛	1¾	8
15, 25, 30, 40, 45, DJX40, 21, 31	1936–40	1	⅛	1¾	9
50, 55, 70, 75, 85, DJX55, DJX70, DJX75, DJX85, 56, D56	1936–40	1	⅛	2	8
GRASS-PREMIER					
425, 435	---------	1	³⁄₁₆	2	8
445, 455	---------	1	¼	2	8
465, 475, 485	---------	1	¼	1½	8
HAHN					
All models	1936–37	1	¹⁄₁₆ to ³⁄₁₆	½	8
HUG					
All Models	1939–42	2	¹⁄₁₆ to ³⁄₁₆	1	0
43, D43, D43L, 70K, 99, 87K, 87Q, 97L, 43–4, D99, D99–S, D87Q, D70K, 87K–4, 87Q–4, D70K, J87K	---------	2	¹⁄₁₆ to ³⁄₁₆	1	0
15, 19, D19, 23, 42, D42	---------	2	¹⁄₁₆ to ³⁄₁₆	1	8
23, 42, 42K, 23W, 42W	---------	2	¹⁄₁₆ to ³⁄₁₆	1	7½
33, 43, 63, 70, 87K, 87Q, 99, 85W, 87, 87W, 98, 998, 15W, 19W, 83W, All Wheel Drives	---------	2	¹⁄₁₆ to ³⁄₁₆	1	0
INDIANA					
64, 74	---------	2	³⁄₁₆	2½	9
89, 92, 120, 121, 140	---------	2	³⁄₁₆	2½	7
300	---------	2	³⁄₁₆	1⅝	9
11, 11X, 20DR–41, 49DR, 111, A, XW, 115A, 126, 127, 127A, 127AW, 138, 141, 170, 175, 190, 195, 220, 250, 290, 400, 611, 615A, 626, 627, 627A, 627AW, 628, 638, 640, 641, 6111	---------	2	³⁄₁₆	1½	0
17–A–ADR–ASW151–DR, SBT251–SW251, 19DR, 47DR, 43DR, 106DR, 106SW, 151	---------	2	³⁄₁₆	1½	0
12SB, 14B, 16, 70, 85–DR, 95–DR–SBT151, SW75	---------	1	³⁄₁₆	1½	8
86, 86T, 87	---------	1½	0 to ⅛	1½	7
INTERNATIONAL					
D2, D5, D15, D2M	---------	2	⅛ to ³⁄₁₆	1 to 2	7½
D186T, DS186T, D300, D216T, DS300, DS216T	---------	1	³⁄₁₆ to ⁵⁄₁₆	2 to 3	8
D30, DS30, D35, DS35, D40, DS40, D40B, D30B	---------	1	³⁄₁₆ to ⁵⁄₁₆	2 to 3	8
D50, D60, DR60, DR500, DR70, D246T, D246F, DR346T, D346F, DR426F	---------	1	³⁄₁₆ to ⁵⁄₁₆	½ to 2	8
DR246T, DS246T, D500	---------	1	³⁄₁₆ to ⁵⁄₁₆	½ to 3	8

Continued on next page

WHEEL ALIGNMENT

Makes and Models	Year	Camber of Each Wheel in Degrees①	Toe-in in Inches	Axle Caster in Degrees	King Pin Inclination in Degrees
INTERNATIONAL (Continued)					
C1, C5, C15	---------	2	⅛	2	7½
C10, C20, M2, M3	---------	1	3/16	2	8
C30, B3, B4	---------	1	3/16	1	8
C35, C40, CS35	---------	1	3/16	1¼	8
DS30B–35B, D15M, D35B	---------	1	3/16 to 5/16	2 to 3	8
DR50–700, DS50–500	---------	1	3/16 to 5/16	½ to 2	8
A5, A6, C55, C60	---------	1	7/32	2½	8
A7, A8	---------	1	7/32	½	8
W1, W2	---------	1	7/32	0	8
W3	---------	1	7/32	1	8
AR626F	---------	1	3/16 to 5/16	0 to 1	8
SPD, X, S24–6, SF34–6, SL34–6, SD44–6, SF46, 15BUS, AW1–2, AL3	---------	37/64"	3/16"	2⅜	8
HS54, HS54C	---------	21/32"	7/32"	0	8
HS74, HS74C, HS104C	---------	21/32"	7/32"	1	8
K–1, K–2, K–3, K–1–M, K–3–M	---------	2	⅛ to 3/16	2 to 3	7
K–4, KS–4, K–5, KS–5	---------	1	1/16 to ⅛	2 to 3	8
K–5–COE, KS–5–COE, K–6, KS–6, K–6–T, KS–6–T, K–6–F, K–7, KS–7	---------	1	1/16 to ⅛	2 to 3	4
K–7–COE, KS–7–COE, K–8, KR–8, KS–8, K–8–COE KR–8–COE, KS–8–COE, K–8–T, KR–8–T, KS–8–T, K–8–F	---------	1	1/16 to ⅛	1½ to 1¾	4
K–10, KR–10, KS–10, KR–11, KS–11, KR–11–COE, KS–11–COE, KR–11–T, K–11–F, KR–12–F	---------	1	1/16 to ⅛	1½ to 1¾	4
KENWORTH					
505 to 538	---------	1	⅛ to ¼	1	8
539	---------	0	N1/32 to P⅛	5	0
540, 541, 542, 552	---------	0	N1/32 to P⅛	4½ to 7	0
543 to 551, 553 to 559	---------	1	⅛ to ¼	1	8
Bus 600, 601, 610, 611, 612, 631	---------	1	⅛ to ¼	1	8
513, 514, F209	1937–40	0	⅛ to N1/32	5	0
All Models	1936–40	1	⅛ to ¼	1	8
KLEIBER					
All Models	1936–37	1	¼	1½ to 2	8
LAFRANCE-REPUBLIC					
C3, D–E–F–M4, H6, K1	---------	1	3/16 to 5/16	1½ to 2	8
MACK JR.					
1M, 2M4, 2M6	1937–38	1½	0 to ⅛	2½ to 3	8
2M4S, 2M6S	1937–38	1½	0 to ⅛	2	7
10M, 10MF, 11M, 20M, 21M, 30M, 31M, 91M	1937–38	1½	⅛ to ¼	¾	8¼
30MT, 90M	1937–38	1	⅛ to ¼	¾	8¼
MACK					
EE, EEU, EF, EFU, EG, EE–EF–EG (rh)	---------	1	⅛	1 to 2	8
AB–4, BM	---------	1	⅛	2¾	7
AC–4, FH	---------	1	⅛	0 to 1	3½
AC–6, FC	---------	1	⅛	2 to 3	3½
AK–4, AK–6, AP, BQ	---------	1	⅛	1 to 2	3½
EB	---------	¾	⅛	½ to 1½	7
EC, EM, EMU, EQU, EQ, EQ–SW, BG	---------	¾	⅛	0 to 1	7

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WHEEL ALIGNMENT

Makes and Models	Year	Camber of Each Wheel in Degrees①	Toe-in in Inches	Axle Caster in Degrees	King Pin Inclination in Degrees
MACK (Continued)					
BX, CD (hd)	---------	1	⅛	1 to 2	7
CH, CJ, CJ (hd), BXSW, 21, BM-BX-DR	---------	1	⅛	0 to 1	7
BXDR (hd)	---------	1	⅛	½ to 1½	3½
BM, BX, DR, BX, CD (std), FG	---------	1	⅛	½ to 1½	7
CJ	---------	1	⅛	2	7
50, 50-5, 55, 60, 75, 19, 80	---------	1	⅛	0 to 1	8
EH, EHU, EHD, EJ, ER	---------	1	⅛	0 to 1	8
Six wheel AK, AP, BQ	---------	1	⅛	1⅜	3½
Six wheel BX	---------	1	⅛	1	7
MARMON-HERRINGTON					
All wheel Drive Fords of 1½ ton capacity	1942	0	0 to ⅛	2½	0
1 Ton	1942	0	0 to ⅛	2½	8
Passenger and Commercials	1942	0	0 to ⅛	2	8½
All Models	1936-39	0	0 to ⅛	1½	0
MORELAND					
All Models	1936	1	⅛ to ¼	2 to 2½	8
NETCO					
A, B	1936	1	¼	1¾	7½
C, D, E, J, K	1936	1½	¼	2	8
OSHKOSH					
W-100, W-200	1941-42	1½	⅛ to 3/16	1	8½
W-300, W-304, W-500, W-400, W-600, W-700, W-2300	1941-42	1	⅛ to ¼	1	3
W-800	1941-42	1½	⅛ to ¼	1	6
W-904, W-900, BG3, GD	1942	1½	⅛ to ¼	1½	6
W500, W600, W700	1939-40	1	⅛ to ¼	1	3
W800, W900	1939-40	1½	⅛ to ¼	1	6
FD	1938	1½	⅛ to ¼	1	6
JCB, JD, JCBX	1936-42	1½	⅛ to 3/16	1	8½
WLX, WLD, B3S, B3D, C3S, C3D, R3S, FC-35, FB35, FS, FC, FB	1936-42	1½	⅛ to ¼	3½	0
BG3, GD, BG3X	1936-40	1½	⅛ to ¼	1½	8
REO					
19-20, 119-120, 21-22-23, 121-122-123, 21-22-23H, 25, 27, OSL41, NWL41	1941-42	1	⅛ to ¼	¾ to 1¼	8
All Models	1940	1	⅛ to ¼	¾ to 1¼	8
Truck 4-50, 6-50	1937-38	1½	0 to ⅛	2	8
Truck 4-75, 6-75	1937-38	1½	0 to ⅛	2	7
Truck 1AM7, 1BM7, 2BM7	1937-38	1	⅛ to ¼	1	8½
Bus 1L5, 2L4, 2L4H	1937-38	1½	⅛ to ¼	¾	8½
Bus 3L6H	1937-38	1	⅛ to ¼	1¼	8½
Bus 3P7	1937-38	1	⅛ to ¼	½	8½
Bus 2LM7, 2LMH7	1937-38	1	⅛ to ¼	1⅛	8½
6AP	1936	1½	0 to ⅛	2½	8
1-2B4, 1-2D4, 1C-1D4H, 1A4-H, 1C4, 2H5, 2J5, 1B4H, 2LC4, 2DM4-H	1936-37	1 to 1½	⅛ to ¼	¾	8½
3H5, 3J5, 3K5	1936-37	1	⅛ to ¼	1⅛	8½
3HR5, 3JR5, 3KR5, 4H5, 4J5, 4K5	1936-37	1	⅛ to ¼	1¼	8½
6, 1½ to 2 ton SN, SM, 1-2B, 1-2D, 1B4, 2B4, 1D4, 2D4	1936	1½	⅛ to ¼	¾	8

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WHEEL ALIGNMENT

Makes and Models	Year	Camber of Each Wheel in Degrees①	Toe-in in Inches	Axle Caster in Degrees	King Pin Inclination in Degrees
SCHACHT					
8A, 10A, 12A, 15A, 18A, 20A, 25A, 28A, 10B, 15B, A20H, 20HA, 115CU, 120CU, 125CU, 128CU	1936–37	1	⅛	2	8
10–15H, 10–15HA, 20–25H, 20–25HA	1936	1	¼	0	8
35–40H, 40HA, 40HB, 66H–HA, TRD–A–D	1936	2	3/16	2 to 2¼	0
STERLING					
All Models	1942	1	⅛ to 3/16	1½ to 2	8
FB50–60–70–80, DeL, FC–90–100–135, FD90–97–115, FBT130–152, HC140	--------	1	3/16 to 5/16	1½ to 2	8
STEWART					
49A	1940–42	2	0	1½ to 1¾	9
40HC, 60G	1938	1½	0	1¼ to 1½	-------
47A, 61H	1938	1	0	1¼ to 1½	-------
45A, 38A	1938	1	0	1 to 1¼	-------
S Gears, 49A, 50A, 51A, D30A	1938	2	0	1½ to 1¾	-------
S Gears, 58A, 59A	1938–42	2	0	1¾ to 2	8
S Gears, 36–6, 31X	1937–38	2	0	1 to 1¼	8
S Gears, D10A	1938	1	0	1¼ to 1½	-------
S Gears, 47AB, 49AB, 51AB	1938–42	1	0	1½ to 2	8½
T Gears, 45A	1938	1	0	1 to 1¼	-------
T Gears, 47A	1938	1	0	1¼ to 1½	-------
T Gears, 49A, 50A, 51A	1938	2	0	1½ to 1¾	-------
40H, 60H	1936	1½	1/32 to 1/16	1½	7
18X3, 58X, 32X	1936	2	1/32 to 1/16	1½N	7½
46HB, 47HB, 48HB, 49HB	1936	2	1/32 to 1/16	½N	7½
48H, 50H	1936	2	1/32 to 1/16	1¾N	7½
49H	1936	2	1/32 to 1/16	0	7½
41H, 46H, 47H	1936	1	1/32 to 1/16	0	9
58–8, 48–8, 58X, 18X	1936	2	1/32 to 1/16	2⅛ Rev.	7½
STUDEBAKER					
M5, Coupe Express	1941–42	1	1/16 to ⅛	--------	7½
M15, Standard and Heavy Duty	1941–42	1	1/16 to ⅛	--------	8
M16	1941	1	1/16 to ⅛	1 to 1¾	8
K20, K20M, K20D	1939–40	1	1/16 to ⅛	1½ to 2	8
K25, K25M	1939–40	1	1/16 to ⅛	1 to 1½	8
K5	1939–40	1	1/16 to ⅛	¾	5½
K10	1939–40	1	1/16 to ⅛	2½	9
K15M	1939–40	1	1/16 to ⅛	1½ to 2	9
K15	1939–40	1	1/16 to ⅛	2	9
K15B	1939–40	1	1/16 to ⅛	2¾	9
K20MB	1939–40	1	1/16 to ⅛	2¼	8
K25MB	1939–40	1	1/16 to ⅛	2½	8
K30, K30M	1939–40	1	1/16 to ⅛	1 to 2	8
K5	1938	¼ to ¾	1/16 to ⅛	N¼ to ¾	5½
K10, K15	1938	1	1/16 to ⅛	½ to 1	9
K20, K25, K30	1938	1	1/16 to ⅛	½ to 1¾	8
Cab forward K15M, K20M, K25M, K30M	--------	--------	------------	½ to 1	-------
J5	1937	1 to 1½	1/16 to ⅛	1 to 1½	9
J15, J15M	1937	1	1/16 to ⅛	½ to 1	9
J20, J25, J30	1937	1	1/16 to ⅛	½ to 1¼	8

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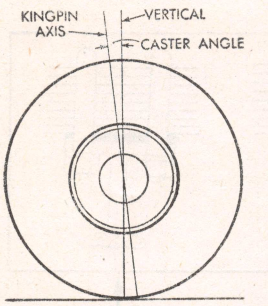
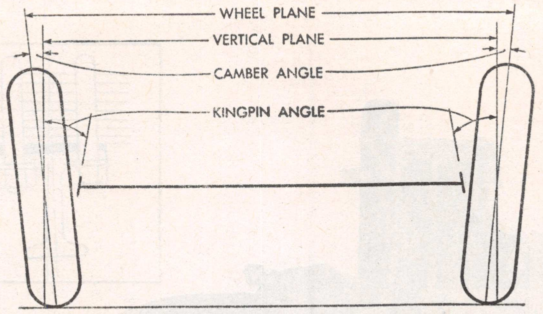
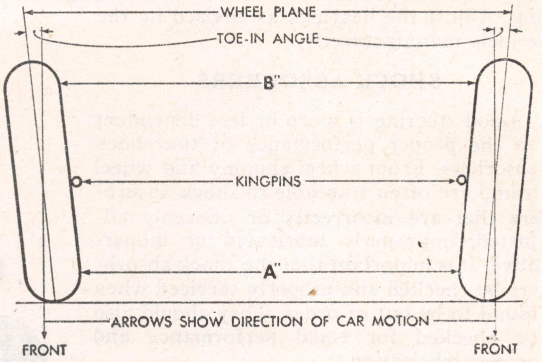
WHEEL ALIGNMENT

Makes and Models	Year	Camber of Each Wheel in Degrees①	Toe-in in Inches	Axle Caster in Degrees	King Pin Inclination in Degrees
STUDEBAKER (Continued)					
J20M, J20MB, J25MB, J30M	1937	1	1/16 to ⅛	½ to 1	8
2T2	1936	1	1/16 to ⅛	E¼ to 1	9
2W6, 2W7, 2W8	1936	1	1/16 to ⅛	E¼ to 1	8
WARD LaFRANCE					
125, 127D, LFQ, APP, 55RH, TIMK, 3300H, 26452H, TW, W	1939–40	1	⅛ to 3/16	½ to 1½	8
131, 136, 138, 156, 156S, 156D, 176, 201, 201D, 672B1, 672B121, Shuler 15682B, 672B, Shuler 15693WB, 672B12	1939–40	2	⅛	½ to 1½	0
15R, 25R14, 25R16, 25R18, 30R19, 30R23, 35R	---------	1	⅛	1	8
55RH, 75RW, 100RW	---------	1	⅛	1	8
125, 127D, 131, 136, 138D, 85F, 120F, 47F, 56F, 66F, 75F	1941–42	1	⅛ to 3/16	½ to 1½	8
WHITE					
500, 510, 700, 800, 800M, 802, 804, 1010, 1012	---------	1	-------------	1½	8
54, 54A, 712, 713	---------	1	-------------	2¾	8½
65, 65A	---------	1	-------------	1¾	8½
684, 686	---------	1	Balloon Tires ⅛ ± 1/16	1	8½
701, 702, 784, 786, 788	---------	1		1½	8½
708	---------	1	-------------	3	8
703, 704, 704K, 706, 709, 710, 720, 720T, 722, 805, 809, 810	---------	1	-------------	3	8½
706M, 7786, 7788, 812, 818, 850	---------	1	-------------	3½	8½
718, 750, 750T	---------	1	-------------	2	8½
820, 822	---------	1	-------------	3½	8
White Horse, 99, S99, 116, S116, H116	---------	1	-------------	1½	9
99A, S99A, S116A	---------	1	-------------	1	9
WA14-16-18-20-134-2064	---------	1	-------------	2½	8
WA-22, WA-26, WA-34, WA-114, WA-118, WA-120-122-126, WA2264	---------	1	-------------	2½	8½
700, 800, 800M, 802, 500, 510, 1010, 1012, 804	---------	1	-------------	1½	8
784, 786, 788	---------	1	-------------	1½	8½
750, 750T, 718	---------	1	-------------	2	8½
703, 704, 704K, 706, 708, 720, 720T, 722, 804, 805, 809, 810, 709, 710	---------	1	-------------	3	8½
812, 818	---------	1	-------------	3½	8½
58, 685, 782	---------	1	-------------	2½	8½
820, 822	---------	1	-------------	3½	8
730, 731	---------	1	-------------	2½ to 3½	8½
59	---------	1	-------------	2⅝	8½
701, 702, 707, 53	---------	1	-------------	1½	8½
684, 686	---------	1	-------------	1	8½
618, 618K, 620-1, 630K, 631, 631K, 640K, 641, 641K, 642-3, 642-SW, 643-SW, 58SS	---------	1	All Models solid & high pres. ¼ ± 1/16	3¼	8½
60, 60K, 601, 602, 160, 161, 162	---------	1		3¾	8½
61, 611, 612, 612K, 613, 210, 211, 212	---------	1		3⅛	8½
65–65A	---------	1	-------------	1¾	8½
54A, 59A, 59ASW, 691, 712, 713, 54	---------	1	Balloon tires ⅛ ± 1/16	2¾	8½
15–15B	---------	1½		1½	0
20, 20A, 20D	---------	1½	-------------	3	0
40, 40A, 45, 45A-D, 50B, 52, 52D, 52T, 55, 40D	---------	1½	-------------	0	0
51–51A (Eliot)	---------	1½	-------------	2⅝	0
56	---------	1½	-------------	1⅛	0
57	---------	1½	-------------	2½	0
58S, 63, 620K, 630, 51AS, SW200, 640, 64, 621K, 51A, 50B, (rev. Eliot), 706M, 850, 7786, 7788	---------	1	-------------	3½	8½

WHEEL ALIGNMENT







Front wheel alignment is the mechanics of keeping all interrelated parts affecting steering in proper adjustment. Correct alignment is essential to keep the front wheels in their true running position for easy and efficient steering and the prevention of abnormal tire wear.

The elements involved in front wheel alignment are caster, camber with the inclination of the steering knuckle kingpins, toe-in and toe-out on turns. These elements are all related and dependent upon each other. In addition to these elements, there are several other factors that affect the alignment of the wheels, namely: tire inflation, wheel wobble, wheel and tire balance, straightness of wheel suspension parts and the frame, alignment of the wheels with the frame, adjustment of the wheel and steering knuckle bearings, the steering gear and connections, adjustment and proper lubrication of the shock absorbers.

No set rule can be given for the sequence of operations in checking and correcting front wheel alignment. Neither can the exact cause of any form of misalignment be given, as much depends upon the age of the vehicle, and consequently, the condition of the parts. The factors affecting alignment and the elements of alignment should, however, be checked in the following order as closely as possible.

FACTORS AFFECTING ALIGNMENT

1. Tire inflation: Checking and inflating the tires to the proper pressure is the very first operation of any wheel alignment job.
2. Running of wheels such as out of true, out of balance and not tracking.
3. Adjustment of front wheel bearings.
4. Condition of shock absorbers.
5. Adjustment of steering gear and connections.

ELEMENTS OF ALIGNMENT

After checking and adjusting the factors referred to in the preceding paragraph, continue with the elements of alignment in the following order:

1. Caster angle of the steering knuckle support.
2. Camber angle and kingpin inclination.
3. Toe-in of front wheels in straight-ahead position.
4. Toe-out of front wheels on turns.

NOTE—All alignment checks should be made with the weight of the vehicle on the wheels.

TIRE PRESSURE

One of the most important factors in the maintenance of good steering and in the prevention of excessive tire wear is proper inflation of the tires. Low tire pressure not only causes hard steering and undue tire wear, but it also aggravates any tendency of the front wheels to shimmy or tramp. The use of tires of different make, design or size, may also contribute to wheel misalignment.

When a tire is soft or under-inflated, a broad surface is formed at the bottom where it contacts with the ground, which results in excessive tire friction and hard steering. A condition of slight misalignment is also caused by under-inflation which tends to result in erratic performance of the wheels, and consequently the steering system.

WHEEL WOBBLE

Wheel wobble must be corrected or eliminated as much as possible before checking the elements of alignment. Any remaining wobble or high spot on the tire should be marked with chalk, to aid in locating the wheels in the proper position when checking the alignment angles.

Excessive wobble will cause spotty tire wear and prevent correct alignment of the axle assembly.

WHEEL ECCENTRICITY

The wheels and tires should also run as nearly concentric as possible with the steering knuckle spindle. Aside from causing unnecessary tire wear, eccentricity in wheels and tires also tends to set up a vertical movement in them which is closely associated with shimmy and tramp.

WHEEL & TIRE BALANCE

Proper balance of the front wheels, tires and brake drums, is another essential factor in the maintenance of good steering. Each wheel assembly should be properly balanced in order to avoid the possibility of tramp or high-speed shimmy. Tire balance also affects tire wear. Likewise, the rear wheels should be balanced, as an unbalanced condition will set up vibrations which will affect the performance of the front wheel suspension system, as well as the riding quality of the vehicle.

TRACKING OF WHEELS

Another essential factor in the maintenance of good steering and in the prevention of excessive tire wear, is the tracking of the rear wheels with the front ones. Failure of the wheels to track is usually quite obvious when following the vehicle on the highway.

It is very important to check the position of the rear axle on the springs, and to make sure that the spring center bolts are not sheared, as these bolts serve to keep the axle in place. If the wheels do not track, and the axle is straight and in the proper position, the wrong type of spring may be in use, the spring eye may be partly straightened out, or the frame may be bent.

WHEEL BEARINGS

Correct adjustment of the front wheel bearings is essential for the proper performance of the front wheel suspension system, and consequently, efficient steer

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NOTE—A dash between two numbers such as 1—2 does not signify a minus sign but means 1 to 2.

[1]—Camber specifications are listed in degrees unless shown as inches (").

[2]—Curb weight—the weight—resting on wheels—of a vehicle with its full complement of fuel, lubricating oil, water, tools and standard equipment accessories—but no passengers.

E. Empty. Same as curb weight.
N. Negative—or reverse.
P. Positive—or plus.
± Plus or minus. More or less tolerance allowed for adjustment limits.
T. O. Toe-out.

Compiled by Bear Mfg. Co.

ing. Adjust the bearings as advised by the vehicle manufacturer.

SHOCK ABSORBERS

Good steering is more or less dependent on the proper performance of the shock absorbers. Front wheel shimmy and wheel tramp are often traceable to shock absorbers that are incorrectly or unevenly adjusted, improperly lubricated or inoperative. It is important that the shock absorbers be checked and properly serviced when found to be out of order. They should also be checked for equal performance and proper lubrication.

STEERING GEAR & CONNECTIONS

Another important factor in maintaining good steering is the proper adjustment and lubrication of the steering gear and connections. An incorrectly adjusted steering system may cause any of the steering complaints, even though the front wheels are in correct alignment.

Before any attempt is made to adjust the steering gear, the steering connections should be checked and readjusted, or new parts installed if necessary. Binding or excessive looseness in the connections should be tested for by raising the front wheels off the floor and moving the connections by hand.

Correct lubrication of the steering system is also necessary to good steering. The recommendations of the vehicle manufacturer should be followed.

CASTER ANGLE

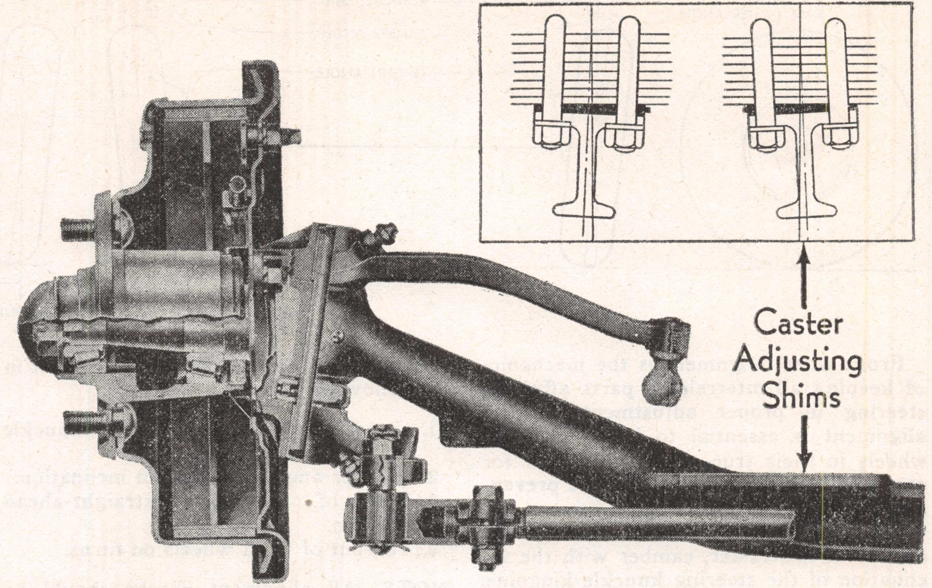
Caster is the angle of the backward inclination between the steering knuckle kingpin and the verticle plane. The caster angle is obtained by tilting the top of the steering knuckle support back, and is established by the design of the front wheel suspension system.

Only a slight amount of caster is necessary to stabilize steering. Excessive caster causes hard steering due, among other factors, to the increasing tendency of the front wheels to toe-in. Too much caster is also undesirable, as the weight of the vehicle then has a tendency to turn the wheels in, at the front, around their respective kingpins, resulting in wheel shimmy.

Insufficient caster results in vehicle wander, which makes it difficult to keep a vehicle travelling ahead in a straight course. Reverse caster results in erratic steering. A vehicle under this condition will tend to go from one side of the road to the other, will turn curves easily but will be difficult to straighten out at the end of the curve.

Before checking the caster angle, it is important to remove all extras, such as, shimmying dampening devices, etc., from the front wheel suspension system. The car is then lowered to bring all the weight of the car on the wheels, after which, it should be moved back and forth a full turn of the wheels to relieve the tire tension.

The caster angle should come within the limits specified by the car manufacturer. Equal caster, or the same within ½ degree, on both sides of the car is extremely important. Unbalanced caster will cause a car to pull to one side, usually toward the side with the least amount of caster, causing undue tire wear, hard steering and wheel shimmy.



The caster adjustment on cars utilizing the independent front wheel suspension should be accomplished according to the instructions as given by the car manufacturer, which can be found under their respective chapters.

For cars using the leaf type front spring suspension, caster is given to the front end by means of its mounting to the front springs, except on cars using a transverse front spring, in which case it is controlled by radius rods. Usually the spring seat on the front axle is machined to a 90 degree angle with the kingpin, but on some cars the spring seat slopes. In either case, however, it is bolted to the spring to give the proper caster. From this it will be seen that when the curvature of the front spring changes, the axle caster will also change. Front wheel brakes may also change the caster, for when they are applied, they tend to roll the axle forward. Should the spring clips be loose, this action can actually take place.

If the spring has permanently changed its contour, or the angle is twisted, the caster will be wrong. If it is out only one or two degrees, the insertion of tapered shims between the spring seat on the axle and the spring, will form a new seat for the spring, and restore the caster angle. Changing the caster alters the camber and toe-in, and therefore must be the first adjustment.

CAMBER & KINGPIN INCLINATION

Camber is the outward tilt of the front wheels at the top and results in the bottom of the wheels coming more nearly under the load. The purpose of camber is to support the greater part of the vehicle weight on the inner wheel bearings, to reduce side thrust on the kingpins, to compensate for looseness and wear in the steering knuckle and wheel bearings, and to bring the point of pivot near the center of the tire tread in contact with the road for center point steering.

The many advantages of camber, however, are partially offset by the undesirable effect it has on the tire contact with the road. With cambered wheels, the outer edge of the tread rolls on a smaller circumference than the inner edge, and this condition increases with an increase in camber, or a decrease in the tire inflation pressure. Since the wheel moves straight ahead, a portion of the tire must slip under this condition, causing excessive wear. This is one of the many reasons why the tires should be kept inflated to the recommended pressure.

Reverse camber also causes excessive tire wear, due to the inner edge of the tread rolling on the smaller circumference.

Since too much camber is undesirable, some other means is necessary to give the effect of camber which is required for easy steering and minimum wear of parts. This condition is obtained by inclination of the kingpin. It is obvious, therefore, that the angle or inclination of the kingpin is closely associated with wheel camber in its effect on steering. The angle of the kingpins is determined by the design of the front wheel suspension system, and varies in different vehicle models.

When checking the camber, the front wheels should be turned on their bearings to bring the high spot on the side of the tires in the horizontal plane toward the front or rear of the vehicle.

The camber angle should come within the limits specified by the vehicle manufacturer, and should be the same on both sides of the vehicle within ½ degree. Unequal camber may cause a vehicle to pull to one side, usually the side having the greatest camber, thus contributing to wheel shimmy and spotty tire wear.

When the camber angle is found incorrect on knee-action vehicles, the inclination of the kingpin should also be checked, because the knuckle or the knuckle support may be bent and not the suspension arms. Incorrect inclination of the kingpin indicates bent suspension arms or steering knuckle support, while wrong camber may be due, either to a bent knuckle support or suspension arms, or to a bent steering knuckle.

It is also advisable, after making a camber correction, to change the tires, putting the front ones on the rear wheels and the rear ones on the front, to provide a normal contact on the tires on the front wheels with the ground.

For vehicles using the solid type front axle with leaf springs, the camber measurement usually shows if the axle is bent. Equipment is available for straightening axles cold and without removing them from the vehicle. If the camber is only slightly incorrect on this type suspension, replacing the kingpins and bushings, or perhaps wheel bearings will correct the condition.

TOE-IN

The setting or adjustment of the front wheels, so that the distance between them is less at the front than at the rear is called toe-in. Toe-in is necessary as camber tends to cause the wheels to run out or separate at the front. Sufficient toe-in is necessary, therefore, to compensate for this tendency, and make the wheels roll straight ahead.

Excessive toe-in or toe-out will cause abnormal tire wear. Too much toe-in will cause the tread sections to wear with a feathered edge at the inner side of the tire. Insufficient toe-in or toe-out of the wheels in the straight-ahead position, will cause the tread to wear with the feathered edges toward the outside.

Before checking the toe-in, however, the wheels and tires should be made to run as nearly true as possible, regardless of the type of equipment used for measuring the toe-in.

To check the toe-in, the front wheels should be in the straight-ahead position and when the measurements are taken from the side of the tire, the wheels should be turned on their bearings to bring the high spot on the side of the tires in a verticle plane at the top or bottom. The toe-in dimensions should be as specified by the manufacturer.

Toe-in of the front wheels is adjusted by changing the length of the tie-rods on vehicles with centerpoint steering, and by the tie-rod on the solid axle type cars, and must be set to make the front tires run with a true rolling contact. Large errors in toe-in indicate bent steering knuckle arms.

Toe-in must be corrected before checking the toe-out on turns.

TOE-OUT ON TURNS

In addition to the front wheel settings previously described, there is another important action of the front wheels, which has a great effect on tire wear. This action is toe-out on turns. In other words, when the front wheels are turned to the right or left, they separate slightly at the front, depending on the amount of deflection from the straight-ahead course, instead of retaining their toe-in relation. The wheel making the inside, or smaller circle, turns a greater angle than the outside wheel, thus making toe-out necessary on curves. The amount of toe-out increases as the turn increases, due to the increasing angle between the wheels.

Toe-out of the front wheels is a result of steering knuckle arm design, and is dependent on the alignment of these arms. The setting of the arms is at an angle with one another, and with the center line of the vehicle, instead of straight back, in order to maintain the proper relation of the front wheels on turns. In other words, if these arms were extended back far enough toward the rear of the vehicle, they would intersect, or cross at a point in front of the rear axle, varying with the wheelbase of the vehicle. The angle of these arms depends upon their length, the wheelbase of the vehicle and the distance between the kingpins.

The toe-out is checked by turning the wheels to the right or left, locating the outside wheel in a definite position. With the outside wheel located at this position, the setting of the inside wheel should be as specified by the manufacturer.

Errors in the setting of the inside wheel are due to bent steering arms. When these arms are bent, the wheels will not turn in the proper relation on curves, which condition will affect the toe-out and result in excessive tire wear. Bent arms, however, will not necessarily affect the straight ahead driving.

Wh n the steering arms are found to be bent, or sprung out of line, they should be replaced with new ones. Before discarding them, however, a careful check should be made to make sure that the steering knuckle support or suspension arms are not bent; see that the camber and caster are correct, and the same on both sides; the toe-in is correct and the front and rear wheels are parallel.

DRAG LINK

The drag link connects the steering gear drop arm, at the frame, to the steering linkage at the front axle, or to the intermediate steering arm on knee action vehicles. It also serves to prevent irregularities of the road from being transmitted, from the front wheels to the frame.

There are three types of drag link assemblies on vehicles with a conventional front axle which differ through the manner of spring suspension.

The first type is where the front end of the spring is connected to the frame by a stationary eye bolt and has the spring shackle at the rear of the spring. With this, the drag link should be on the center line between the pivot ball at the end of the drop arm and the eye bolt. If adjustment is necessary the drop arm must be dropped or the spring re-arched.

The second type of drag link is where the spring is anchored at the rear and the shackle is at the front. With this type the drag link should be on the center line between the pivot ball at the drop arm and the center line of the lower shackle bolt.

The third type is where transverse front spring is used and the axle is held in position by a radius rod. With this type the drag link must line up with the radius rod ball at the engine housing.

REAR WHEEL ALIGNMENT

Rear wheel alignment is comparatively simple since there should be neither camber nor toe-in, but it is important that the relationship of the rear wheels to the front wheels be correct so that they will follow the front end in a parallel position and retain the original steering radius. This is known as tracking.

There are four causes of improper tracking: a swung rear end, a swung front end, a swayed frame and a diamond frame. Each will cause tire scuffing and difficult steering. Their presence can be determined by measuring the wheelbase, the distance from the front axle to the end of the frame, and the distance from the rear axle to the end of the frame on each side of the vehicle.

When the measurements at the front axle check while the measurements at the rear axle and the wheelbases do not check, it indicates a swung rear end. A swung rear end can be caused by the rear axle housing slipping on the spring, weak or broken springs or one of the rear frame members being bent at the horn. This condition causes the vehicle to be continually steered and because the wheels are in an improper position scuffing results on both front tires and possibly all four.

When the measurements at the rear axle check while the measurements at the front axle and the wheelbases do not check, it indicates a swung front end. This is often caused by bumping the right wheel against the curb when parking. In time this practice causes the front axle to slip on the spring. A weak or broken spring or a bent frame horn may also cause this condition. With this condition the vehicle must be continually steered and usually both front tires will show considerable wear.

When the measurements at the rear axle and the front axle check while the wheelbases do not check it indicates a swayed frame. This also causes the vehicle to pull toward one side, resulting in constant steering and severe tire scuffing. It is usually the result of a collision.

When all the measurements check, yet the tracking is not correct, check the wheels with a straight edge to make sure that they are in parallel planes or else measure the diagonals to make sure that they are the same. If they are found to be out the frame is diamond. When this condition is present the direction of the vehicle might remain true but all four tires would be severely scuffed and show rapid wear.

WILLYS CIVILIAN JEEP

1946 MODEL CJ-2A

ENGINE SPECIFICATIONS

TYPE	L Head
Number of Cylinders	4
Bore	3⅛"
Stroke	4⅜"
Piston Displacement	134.2 cu. in.
Compression Ratio	6.48 to 1
Horse Power Max. Brake	60 @ 4000 R.P.M.
Compression	111 lbs. per sq. in. @ 185 R.P.M.
S.A.E. Horse Power	15.63
Maximum Torque	105 Lbs.-Ft. @ 2000 R.P.M.
Firing Order	1-3-4-2

CYLINDER BLOCK

Bore Size	3.125"—3.127"

CYLINDER HEAD

Torque Wrench Pull Cylinder Head Stud Nut	60-65 Lbs. Ft.

CRANKSHAFT

Counter Weights	4

CRANKSHAFT MAIN BEARINGS

Bearing Journals	3
Front	2.3340" x 1.924"
Center	2.3340" x 1.8125"
Rear	2.3340" x 1.75"
Thrust	Front
End-play	.004"-.006"
Bearing Clearance	.001"
Type	Steel back, babbitt lined
Non-Adjustable	Replaceable Without Reaming
Torque Wrench Pull	65-70 Lbs. Ft.

CONNECTING ROD

Center to Center Length	9.1875"
Upper End	Piston Pin Locked in Rod
Lower Bearing Type	Steel back, babbitt lined, replaceable
Lower Bearing Diameter and Length	1 15/16" x 1 5/16"
Clearance on Crankshaft	.0008"-.0023"
Side Clearance	.005"-.009"
Torque Wrench Pull	50-55 Lbs. Ft.
Installation	From Top

Offset away from nearest main bearing

Oil spray hole away from camshaft

PISTON

Lo-Ex Lynite T-Slot Oval Ground Tin Plated—Heat dam

Length	3¾"
Clearance Top Land	.0205"-.0225"
Clearance Skirt	.003"
Oversize pistons Available	.010", .020", .030"
Number Rings	3
Compression Ring	2—Width 3/32"
Oil Ring	1—Width 3/16"
Ring Gap	.008"-.013"
Ring to Groove Clearance	.0005"-.0015"
Piston Pin Hole Diamond Bored	13/16" (.8007"-.8119")

PISTON PIN

Length	2 25/32"
Diameter	.8125"
Type	Locked in Rod
Clearance in Piston	.0001"-.0009"

CAMSHAFT

Number of Bearings	4
Bearing Journal Diameter:	
Front	2 5/16"
Front Intermediate	2¼"
Rear Intermediate	2 3/16"
Rear	1¾"
Thrust Taken	Front
End Play Control	Plunger and Spring

CAMSHAFT BEARINGS

Front	Steel Back Babbitt Lined
Clearance	.002"-.0035"

INTAKE VALVE

Tappet Clearance Hot or Cold	.014"
Seat Angle	45°
Diameter Head	1 17/32"
Length Over-all	5¾"
Stem Diameter	.373"
Stem to Guide Clearance	.0015" to .00325"
Intake Opens	9° BTC Flywheel (.039" Piston travel)
Intake Closes	50° ABC Flywheel (3.772" Piston travel)
Lift	23/64"

EXHAUST VALVE

Tappet Clearance Hot or Cold	.014"
Seat Angle	45°
Diameter Head	1 15/32"
Length Over-all	5¾"
Stem Diameter	.3725"
Stem to Guide Clearance	.002"-.00375"
Exhaust Opens	47° BBC Flywheel (3.799" Piston travel)
Exhaust Closes	12° ATC Flywheel (.054" Piston travel)
Lift	23/64"

VALVE SPRING

Free Length	2½"
Spring Pressure Valve Closed	50 lbs. Length 2 7/64"
Spring Pressure Valve Open	116 lbs. length 1¾"
Closed Coil End of Spring	Installed Up Against Block

VALVE TAPPET

Overall Length	2⅞"
Stem Diameter	.6240"-.6245"
Clearance To Guide	.0005"-.002"
Adjusting Screw	Self-locking

TIMING CHAIN

Link-Belt	
Number Links	47
Width	1"
Pitch	½"
Type	Non-adjustable

FAN BELT

Type	"V"
Angle of Vee	45°
Length outside	45.65"-44.43"
Width	11/16"

OIL PUMP

Type	Planetary Gear
Drive from Camshaft	Gear

OIL PRESSURE RELIEF

Early: Pressure 40 lbs. actual—75 gauge at 30 miles per hour.

Late: Pressure 25 lbs. actual—50 gauge at 30 miles per hour.

Adjustable	Shims in Spring Retainer
Oil Filter	Purolator No. 27078

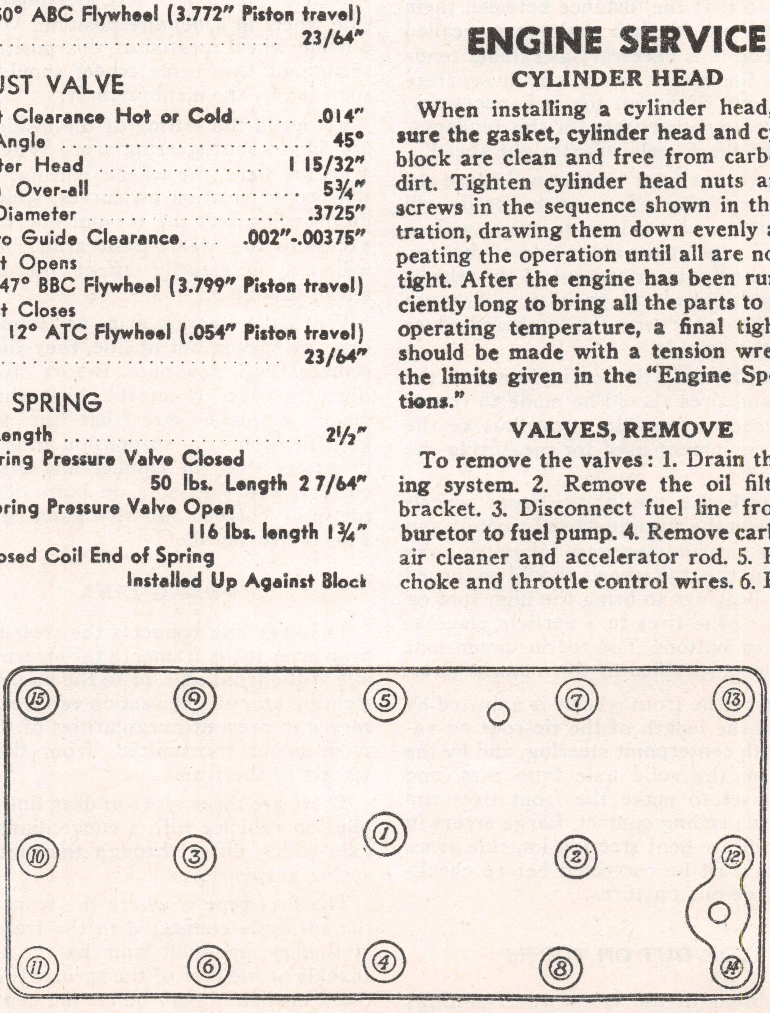
ENGINE SERVICE

CYLINDER HEAD

When installing a cylinder head, make sure the gasket, cylinder head and cylinder block are clean and free from carbon and dirt. Tighten cylinder head nuts and cap screws in the sequence shown in the illustration, drawing them down evenly and repeating the operation until all are normally tight. After the engine has been run sufficiently long to bring all the parts to normal operating temperature, a final tightening should be made with a tension wrench to the limits given in the "Engine Specifications."

VALVES, REMOVE

To remove the valves: 1. Drain the cooling system. 2. Remove the oil filter and bracket. 3. Disconnect fuel line from carburetor to fuel pump. 4. Remove carburetor air cleaner and accelerator rod. 5. Remove choke and throttle control wires. 6. Remove



CYLINDER HEAD TIGHTENING SEQUENCE

carburetor. 7. Disconnect exhaust pipe from manifold. 8. Remove manifolds. 9. Remove upper radiator hose and spark plugs. 10 Remove all cylinder head nuts and cap screws and temperature gauge bulb. 11. Screw lifting hooks in the No. 1 and 4 spark plug holes and lift off the cylinder head.

CAUTION—Do not use a screw driver or any other sharp instrument between the head and block in an attempt to break the head loose from the gasket.

12. Remove the valve cover, using care when removing the breather tube not to lose the copper gasket under each screw as well as the screen and gasket.

NOTE—Before removing the valve locking keys, use cloth to cover the holes in the valve chamber so as to prevent the keys from dropping down into the crankcase.

13. Remove the valve tappet clearance springs by placing a screw driver on the top edge and snapping the spring out. 14. With a valve spring compressor inserted between the valve tappet and the spring retainer, raise the springs on those valves which are in the closed position and remove the valve locking keys. Then crank the engine with a hand crank or by pulling the fan belt until the other valves are closed and repeat the operation.

15. Remove the valves and place them in a suitable carrying board so that they can be identified as to the cylinders from which they were removed, after which, take out all the valve springs.

VALVE SPRINGS

Check all valve springs whenever removed and replace any that do not meet with the specifications given under "Engine Specifications." If a valve spring testing tool is not available, replace any springs which do not measure 2½ inches free length.

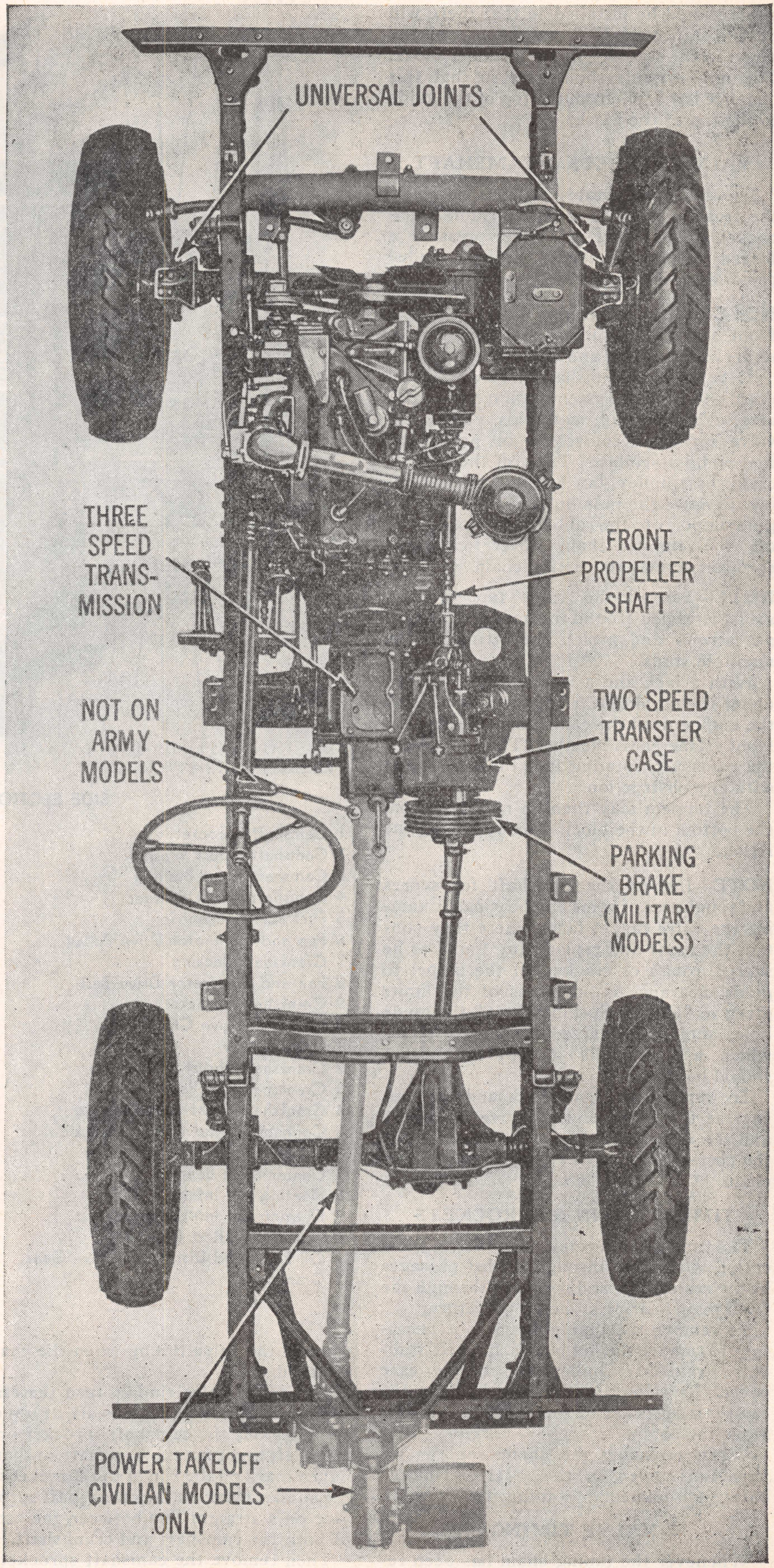
NOTE—Valve springs should be installed so that the closely coiled ends are to the top against the cylinder block.

VALVE STEM GUIDES

A special tool is available to remove and install valve stem guides. If a regular puller is not available, a suitable substitute can be made from a 2" pipe, 6" long, together with a ⅜" bolt 10" to 12" long with a long threaded end and a small hexagon nut which will pass through the hole in the cylinder block and a 2" washer with a ⅜" hole.

In the absence of a special driver to replace the guides, one can be made with a piece of ½" round stock 6" long and turning down one end to ⅜" in diameter for 2" of its length.

As shown in the illustration, the exhaust


UNIVERSAL JOINTS
THREE SPEED TRANS- MISSION
FRONT PROPELLER SHAFT
NOT ON ARMY MODELS
TWO SPEED TRANSFER CASE
PARKING BRAKE (MILITARY MODELS)
POWER TAKEOFF CIVILIAN MODELS ONLY

guide should be installed so that there will be a distance of 1" from the top of the guide to the top face of the cylinder block. The intake guide should set so that this distance is 1 5/16" from the top of the guide to the top of the block.

VALVE TAPPETS & CAMSHAFT

The camshaft rotates on four bearings, the front bearing being a removable steel-backed babbitt liner. Oil under pressure is forced to the bearings through drilled passages in the crankcase.

NOTE—When necessary to replace the front bearing, be sure to stake it in place to prevent rotation and endwise movement.

To remove the camshaft or valve tappets, drain the cooling system, remove the radiator, cylinder head, manifolds, valves and valve springs. Remove the oil pump and fuel pump assemblies. Take off the oil pan, crankshaft pulley, fan belt and fan assembly. Remove the nuts holding the front engine supports to the rubber insulators. Take off the timing chain cover, camshaft sprocket screws and timing chain.

NOTE—Tie all the valve tappets with string wrapped around the heads of the tappet screws and attach the string to the manifold studs.

With a jack and a wooden block placed under the crankcase, raise the front end of the engine until the camshaft will clear the front frame cross member. Then withdraw the camshaft, rotating it if the cams meet with any obstruction.

The tappets may then be removed from the bottom of the block after removing the string.

NOTE—Inspect the camshaft for scores and roughness of cams and bearings. Examine the valve tappet faces where they contact the cams and replace any found to be scored, rough or cracked. If the tappet to guide clearance is in excess of the limits given in "Engine Specifications," the guide holes should be reamed and new lifters—which are available in .004" oversize—should be installed.

To replace the camshaft and tappets, reverse the order of the above procedure and see the "Valve Timing" paragraph for the correct method of replacing the timing chain.

TIMING CHAIN & SPROCKETS

The timing chain is not adjustable. Lubrication is positive through drilled passages in the crankshaft and sprocket through the front main bearing and oil filter return.

To remove the timing chain, it is necessary to remove the fan blades, fan belt, radiator, crankshaft pulley and timing case cover. Take out the screws holding the camshaft sprocket to the camshaft and remove the chain.

When replacing the chain, see the instructions given in the "Valve Timing" paragraph immediately following.

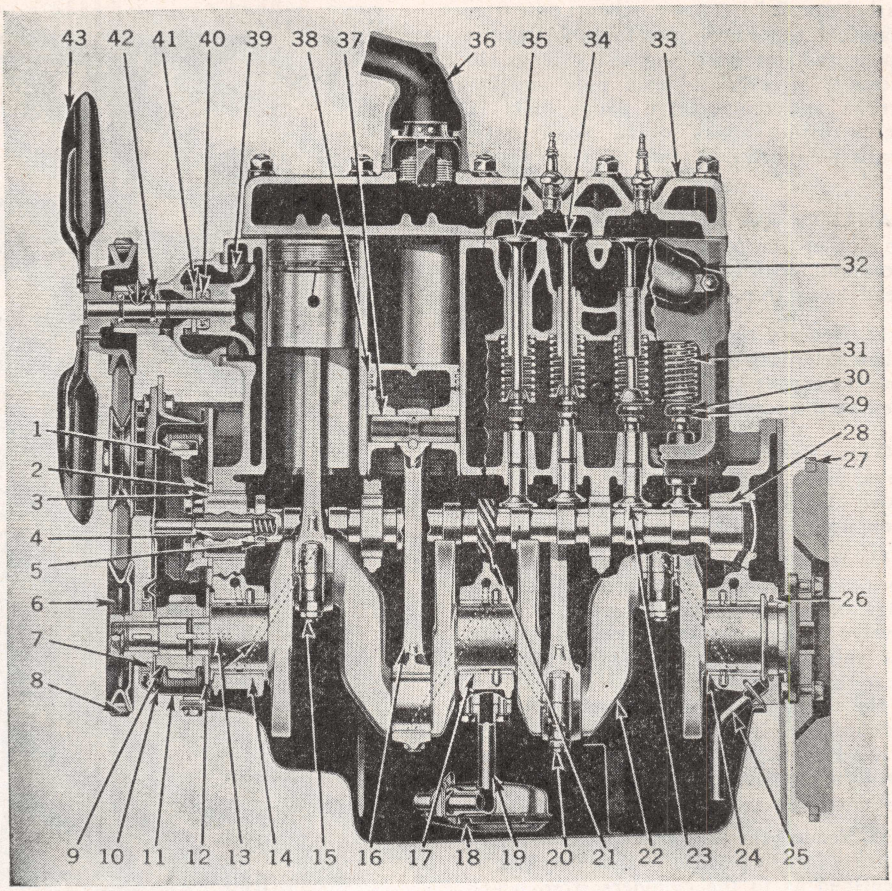
VALVE TIMING

Whenever the timing chain has been removed for any purpose, it will be necessary to reset the valve timing when the chain is replaced.

To set the valve timing, turn the crankshaft so No. 1 and 4 pistons are at top dead center. Place the camshaft sprocket on the camshaft and turn the camshaft so that the punch mark on the rim of the sprocket faces the similar mark on the crankshaft sprocket—or on a straight line between the centers of both the camshaft and crankshaft.

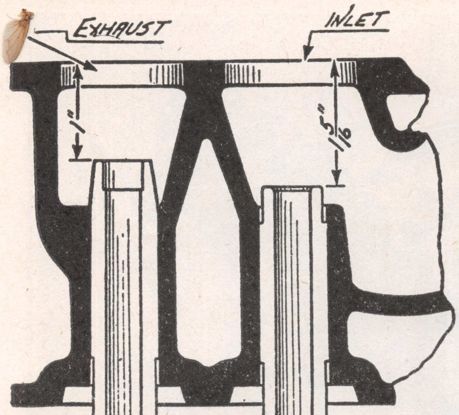
Then remove the camshaft sprocket and put on the chain. Position the chain on the crankshaft sprocket, changing the position of the camshaft sprocket within the chain until the cap screw holes in the sprocket are in line with the corresponding holes in the end of the camshaft.

To check the valve timing, adjust the No. 1 intake valve tappet to .020". Rotate the crankshaft in the clockwise direction until the piston in No. 1 cylinder is ready for the intake stroke, at which time the tappet should be tight against the end of the valve stem and the "I O" mark on the flywheel

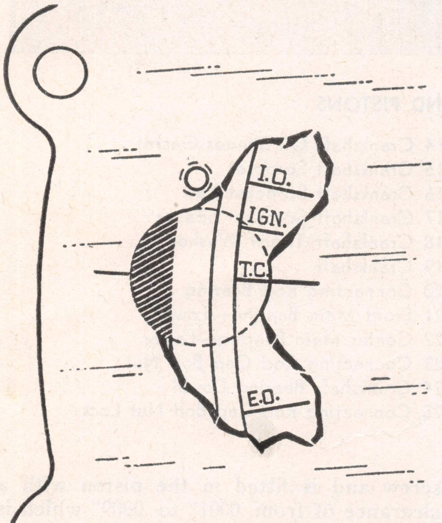


SIDE SECTIONAL VIEW OF ENGINE

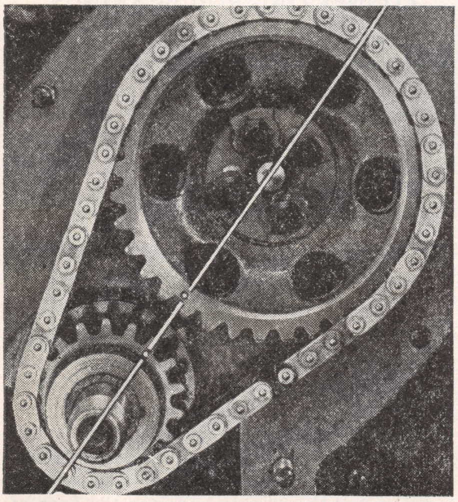
1 Camshaft Sprocket
2 Camshaft Thrust Washer
3 Camshaft Front Bushing
4 Camshaft Thrust Plunger
5 Fuel Pump Eccentric
6 Fan and Generator Drive Pulley
7 Crankshaft Packing
8 Fan and Generator Drive Belt
9 Crankshaft Sprocket
10 Camshaft Drive Chain
11 Chain Cover
12 Crankshaft Thrust Washer
13 Crankshaft Oil Passages
14 Crankshaft Front Main Bearing
15 Connecting Rod Bolt Nut Lock
16 Connecting Rod
17 Center Main Bearing
18 Floating Oil Intake
19 Floating Oil Intake Support
20 Connecting Rod Cap Bolt
21 Oil Pump and Distributor Drive Gear
22 Crankshaft
23 Valve Tappet
24 Rear Main Bearing
25 Rear Main Bearing Oil Drain
26 Crankshaft Packing
27 Flywheel Ring Gear
28 Camshaft
29 Valve Tappet Clearance Spring
30 Valve Tappet Adjusting Screw
31 Valve Spring
32 Exhaust Manifold
33 Cylinder Head
34 Intake Valve
35 Exhaust Valve
36 Water Outlet
37 Piston Pin
38 Piston
39 Water Pump Impeller
40 Water Pump Seal
41 Water Pump Seal Washer
42 Water Pump Bearing and Shaft
43 Fan



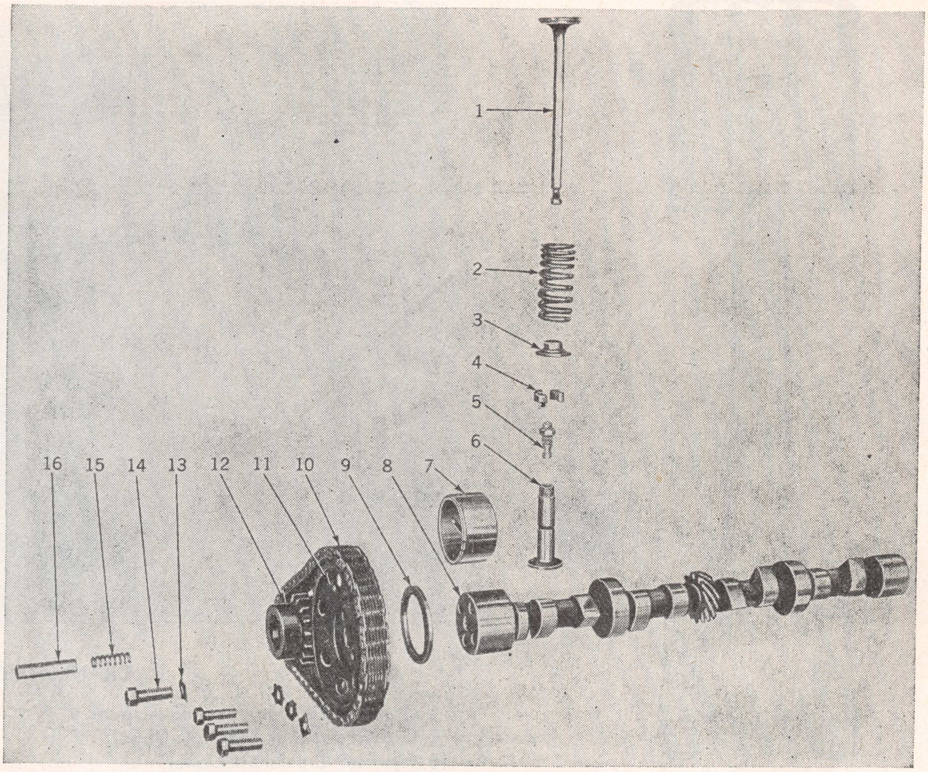
POSITION VALVE GUIDES AS SHOWN



FLYWHEEL TIMING MARKS



SPROCKET POSITIONS FOR CORRECT VALVE TIMING



VALVE MECHANISM

1 Exhaust Valve
2 Valve Spring
3 Valve Spring Retainer—Lower
4 Valve Spring Retainer Lock
5 Valve Tappet Adjusting Screw
6 Valve Tappet
7 Camshaft Bushing—Front
8 Camshaft
9 Camshaft Thrust Washer
10 Camshaft Drive Chain
11 Camshaft Sprocket
12 Crankshaft Sprocket
13 Camshaft Sprocket Screw lockwasher
14 Camshaft Sprocket Screw
15 Camshaft Thrust Plunger Spring
16 Camshaft Thrust Plunger

should be in the center of the inspection hole in the flywheel housing.

NOTE—Before replacing the valve cover —after checking the valve timing—be sure to adjust the tappets to proper running clearance which is given in "Engine Specifications."

TIMING CASE COVER & SEAL

The stationary pin in the timing case cover is so located that it bears against the plunger in the end of the camshaft which controls the end play of the camshaft.

The crankshaft oil seal is of woven asbestos impregnated with graphite and oil. When a new oil seal is to be installed, the steel retainer should also be renewed.

PISTONS & RODS, REMOVE

Pistons and rods are removed and installed from the top of the cylinder block. Although regular production rods are marked with the cylinder number in which they are installed, replacement rods are not; therefore, unmarked rods should be suitably identified with punch marks as they are removed so they may be replaced in the original cylinder.

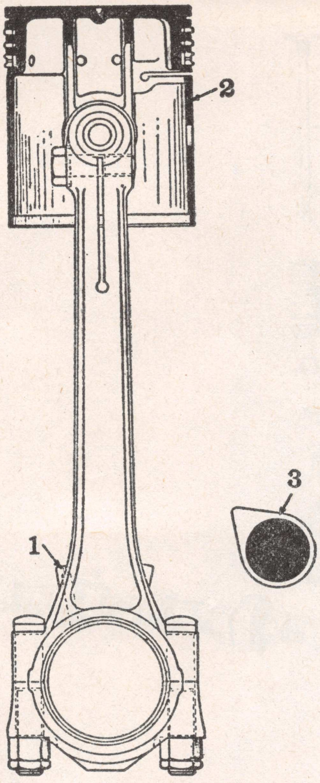
PISTONS & RODS, ASSEMBLE

When correctly assembled, the slotted side of the piston should be opposite the oil spray hole in the bearing end of the connecting rod. When the rod is installed in the engine, be sure that the offset of the rod is facing away from the nearest main bearing, which will bring the oil spray hole in the bearing end of the rod on the follow side or away from the camshaft.

PISTONS, RENEW

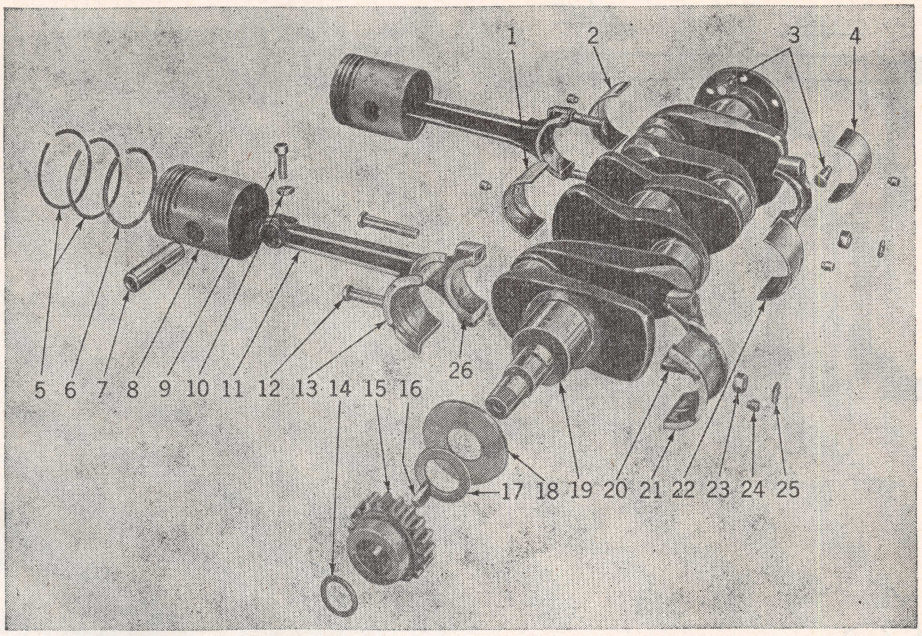
NOTE—A variation of 10 degrees between the temperature of the pistons and cylinder bores is sufficient to produce a difference of .0005". Therefore, both the pistons and cylinder bores should be at normal room temperature (about 70 degrees) when fitting pistons. This is particularly important because the clearances given in the "Engine Specifications" are minimum and pistons must not be fitted with less clearance than specified.

Before any attempt is made to fit new pistons, cylinder bores should be carefully indicated with a micrometer or a dial gauge and refinished if necessary. If bores do not require refinishing, be sure to remove the



ASSEMBLE ROD AND PISTON AS SHOWN

1 Oil Spray Hole
2 Slotted Side of Piston
3 Camshaft



CRANKSHAFT AND PISTONS

1 Crankshaft Center Bearing—Upper
2 Crankshaft Rear Bearing—Upper
3 Flywheel Crankshaft Dowel
4 Crankshaft Rear Bearing—Lower
5 Piston Ring—Compression
6 Piston Ring—Oil Regulating
7 Piston Pin
8 Piston
9 Piston Pin Lock Screw
10 Piston Pin Lock Screw Lockwasher
11 Connecting Rod
12 Connecting Rod Cap Bolt
13 Front Main Bearing—Upper
14 Crankshaft Oil Slinger Gasket
15 Crankshaft Sprocket
16 Crankshaft Sprocket Key
17 Crankshaft Sprocket Spacer
18 Crankshaft Thrust Washer
19 Crankshaft
20 Connecting Rod Bearing
21 Front Main Bearing—Lower
22 Center Main Bearing—Lower
23 Connecting Rod Cap Bolt Nut
24 Crankshaft Bearing Dowel
25 Connecting Rod Cap Bolt Nut Lock

ridge at the top of each bore. If refinishing is required, it is good practice to do so in alternate cylinders due to the localized temperature build-up. When refinished, cylinder bores should not be out-of-round or tapered more than .0005".

Before fitting pistons, wipe the cylinder walls and pistons to remove all chips, dirt or other foreign matter. Check the clearance with a .003" feeler gauge ¾" wide and which extends the entire length of the piston. Insert the piston in the bore upside down and in its running position (slotted side facing away from the camshaft). Place the feeler ribbon between the cylinder wall and the thrust side of the piston (opposite the slotted side) in a position at right angles to the piston pin hole. When fitted correctly, it should require a pull of from 5 to 10 pounds to withdraw the feeler—the pull being indicated on a spring scale hooked to the end of the feeler.

PISTON RINGS

NOTE—To prevent the possibility of breaking or bending the second ring land after the engine is operated with new rings, the ridge at the top of the cylinder bores should be carefully cut away. If the available ridge reamer has no provision to control the depth of the cut, it is good practice to cut away the ridges before removing the piston and rod assemblies. When performing the operation, bring the piston far enough up into the cylinder to allow the reamer to rest on top of the piston. This will serve to prevent cutting down into the ring travel area.

CAUTION—Never cut down into the ring travel area more than 1/32"—or more than half the depth of the top ring.

New rings should be fitted with end gaps and groove clearances as given in the "Engine Specifications." Ring grooves must be clean and free from carbon and must show no perceptible wear.

NOTE—The upper compression ring is installed with the inside beveled edge up. The face of the lower compression ring is tapered .005"; the letters "TOP" on the upper edge of this ring indicates how the ring should be installed.

Install rings with gaps staggered around the piston circumference but with no gaps over the piston pins.

Piston rings are available in .010", .020" and .030" oversizes. Standard rings should be used in cylinder bores which are not more than .010" oversize.

PISTON PINS

The pin is anchored in the rod with a lock screw and is fitted in the piston with a clearance of from .0001" to .0009" which is equivalent to a light thumb push fit at normal room temperature—about 70 degrees F.

Pins are available in oversizes of .001", .002" and .003".

CONNECTING ROD BEARINGS

When bearings become worn they can be replaced without removing the rod by simply taking off the bearing cap and replacing the upper and lower halves. Bearings should be replaced in sets and under no circumstances should rods or caps be filed, altered or mutilated in any way in an attempt to fit bearings.

NOTE—When replacing the upper halves, be sure that the oil spray holes line up with the spray hole in the connecting rod.

CAUTION—Before replacing bearings, make sure that the crankpins are not nicked or scored and that all parts are thoroughly clean. This is particularly important because the presence of one small particle of metal, carbon or other foreign matter, lodged between the back of the bearing and the rod, or between the face of the bearing and the crankpin, will very likely cause a hot spot due to the elimination of the oil clearance at that point, eventually resulting in a bearing failure or a scored crankpin.

To check the fit of new bearings, use a piece of brass shim stock ¼" wide, the length of which should be ¼" less than the length of the bearing, while the thickness should be about the same as the minimum allowable clearance which is given in the "Engine Specifications."

To avoid damaging the bearing material, smooth down the edges of the shim stock on an oil stone so that no sharp edges remain. Install the shim between the bearing and the crankpin, then tighten the cap bolts to the recommended tension as given in the "Engine Specifications." When fitted properly, it should not be possible to move the rod endwise by hand, but a light tap with a hammer should cause the rod to move endwise. If the fit is satisfactory, remove the checking shim and install the cap again, tightening the cap bolts to the recommended tension, after which, the rod should be loose enough to be moved endwise by hand.

NOTE—If the rod is loose enough to be moved by hand with the checking shim in place, the crankpin should be turned down and undersize bearings—which are available in undersizes of .010", .020" and .030"—should be fitted.

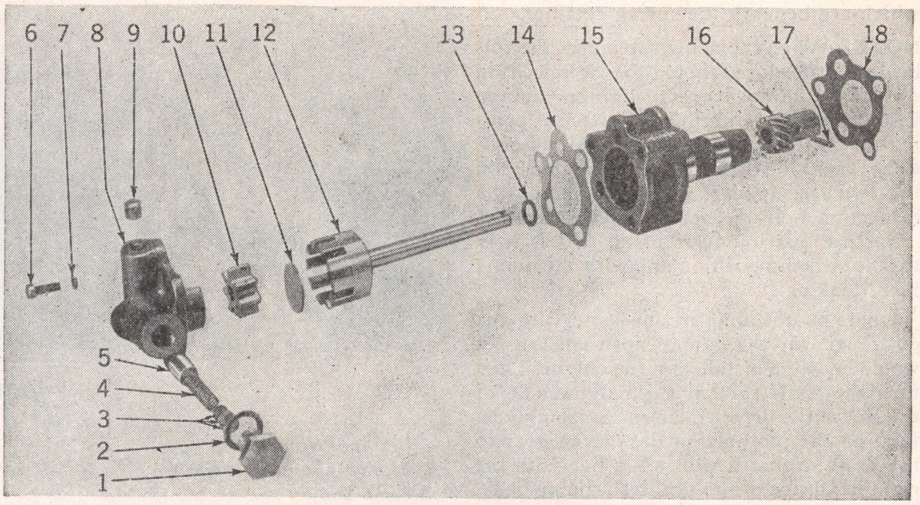
It is good practice to check the connecting rod bore for roundness. A special tool with an indicator gauge is available for this operation. Before using this instrument, be sure there are no nicks, burrs or dirt on the contacting surfaces to prevent a true reading. If the rod bore is out-of-round more than .002" or .003", the rod should be replaced.

MAIN BEARINGS & CRANKSHAFT

The crankshaft rotates on three steel-backed babbitt-lined bearings, manufactured to exact size and are interchangeable without reaming. Whenever it becomes necessary to remove the crankshaft or install new bearings, the engine must be removed from the chassis because the bearings are held in place by dowels.

Before replacing bearings, make sure the crankshaft journals are not nicked or scored and that all parts are thoroughly clean. Be sure the face of the bearing seat is absolutely clean and that no particles of grit or carbon are allowed to become lodged between it and the back of the bearing shell because a hot spot will result due to the elimination of the oil clearance at that point, resulting in premature bearing failure.

The fit of main bearings may be checked in the same manner as already described for checking rod bearings except that with the checking shim in place between the bearing and the journal and the bearing caps tightened to the recommended tension as given in the "Engine Specifications," the bearing may be considered to be fitted properly if the crankshaft can be rocked through an arc of 2" (not more than 1" in either direction) with a fairly heavy drag.



OIL PUMP

1 Oil Pump Oil Relief Spring Retainer
2 Oil Relief Spring Retainer Gasket
3 Oil Pump Relief Spring Shim
4 Oil Pump Relief Plunger Spring
5 Oil Relief Plunger
6 Oil Pump Cover to Body Screw
7 Pump Cover to Body Screw Gasket
8 Oil Pump Cover Assembly
9 Oil Pump Cover Plug
10 Oil Pump Pinion
11 Oil Pump Rotor Disc
12 Oil Pump Shaft Assembly
13 Oil Pump Shaft Gasket
14 Oil Pump Cover Gasket
15 Oil Pump Body
16 Oil Pump Driven Gear
17 Oil Pump Driven Gear Pin
18 Oil Pump to Cylinder Block Gasket

If the fit is too loose, the crankshaft should be turned down and undersize bearings (available in .010", .020" and .030") should be fitted.

NOTE—As bearing replacement involves the exposure and removal of so much of the oiling system, it is recommended that a complete check up of the latter be done at this time. If available, use a rifle brush and poke through all oil passages in the crankcase, crankshaft, connecting rods and oil tubing to remove all sludge and carbon which may be present. Finally, apply compressed air—if convenient—to each passage to clear it of any remaining loose carbon chips or other abrasives.

CRANKSHAFT END THRUST

End thrust of the crankshaft is controlled by a thrust washer in front of the front main bearing. Through normal wear, the end play will seldom become excessive but whenever new bearings are fitted, the clearance should be carefully checked and if not within the limits given in the "Engine Specifications," the crankshaft sprocket will have to be removed with a gear puller and a new thrust washer installed.

To check the end play, force the crankshaft back to the limit of its end play and slip a feeler ribbon between the rear flange of the front main bearing and the crankshaft cheek.

REAR MAIN BEARING OIL SEAL

The rear main bearing is sealed by a wick type packing, installed in a groove machined in the crankcase, and the rear main bearing cap.

NOTE—If it is necessary to replace the packing in the upper half of the bearing, the engine must be removed from the chassis, the crankshaft removed and the packing installed in the same manner as described below for the lower half of the bearing.

To install, insert the packing in the groove of the bearing cap and use a smooth rounded tool to work the packing from each end towards the center of the cap to force and shape the packing in the groove. Then cut off the overlapping ends of the packing flush with the surface of the cap.

NOTE—Make sure that the packing is not pulled out of the groove when cutting off the ends. A special seal compressor or a round block of wood of the same diameter as the crankshaft flange may be used to hold the packing firmly in position during the cutting operation.

ENGINE OILING

OIL PUMP

To remove the oil pump, take off the three nuts from the studs holding the pump to the crankcase and slide the pump from the studs.

To disassemble, take out the screw from the oil pump cover plate which will permit the cover to be separated from the housing. To remove the driven gear, file off one end of the straight pin and with a small drift, drive the pin from the shaft. The oil pump shaft and rotor can then be removed from the pump housing as an assembly.

When removing the oil relief valve parts, care must be exercised to be sure not to lose any of the oil pressure adjusting shims which are beneath the spring retainer.

NOTE—When replacing the pump, the following procedure should be followed in order to obtain correct ignition timing. Crank the engine until No. 1 piston is coming up on its compression stroke and continue cranking until the "IGN" mark on the flywheel appears in the center of the inspection hole in the flywheel housing.

Set the distributor rotor so that it is in the No. 1 firing position and with the points just breaking.

Hold the oil pump in one hand with the oil relief valve retainer positioned as it would be when installed in the engine. Then turn the shaft so that the narrow side of the slot in the driven gear end is facing you. Line up the pin holding the driven gear to the shaft so that it will fall in line with the right hand side of the slot in the pump body. Slide the assembly on the studs in the crankcase, and before installing the retaining nuts, check the position of the distributor rotor. If it has shifted from its original position, remove the oil pump and turn one tooth to obtain the correct setting.

OIL PRESSURE REGULATOR

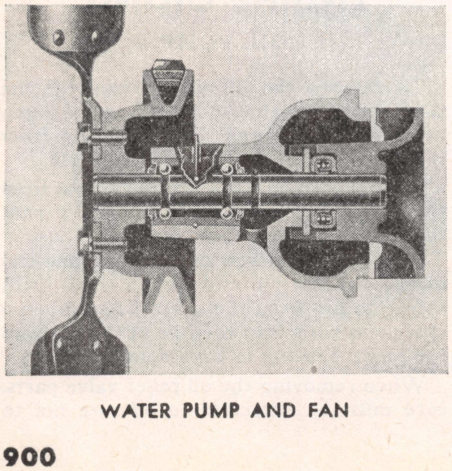
Oil pressure is controlled by shims under the relief valve spring retainer. Adding shims increases pressure, and removing shims decreases pressure.

FLOATING OIL INTAKE

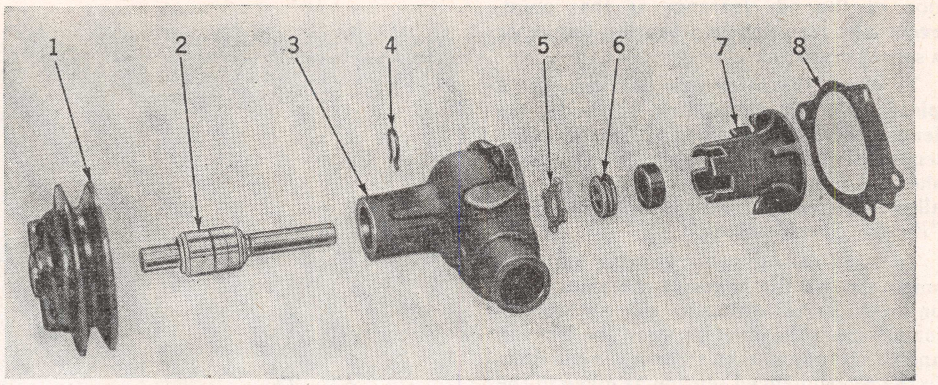
The floating oil intake is attached to the crankcase with two cap screws. Whenever the assembly is removed or when the oil pan is down, the float, screen and tube should be cleaned thoroughly in a suitable cleaning fluid to remove any accumulation of dirt.

OIL FILTER

Whenever the oil on the level indicator in the engine filler tube becomes dark, remove the oil filter cover and drain plug and allow the filter to drain. Remove the element and install a new one. Install a new gasket, replace the cover, start the engine and check for leaks. If the installation is satisfactory, check the oil level and add oil as required.



WATER PUMP AND FAN



WATER PUMP

1 Fan and Water Pump Pulley
2 Bearing and Shaft Assembly
3 Pump Body
4 Bearing Retainer Wire
5 Pump Seal Washer
6 Pump Seal Spring
7 Pump Impeller
8 Pump to Cylinder Block Gasket

COOLING SYSTEM SPECIFICATIONS

COOLING CAPACITY	11 Quarts
RADIATOR	Jamestown
Radiator Filler Cap	A C
FAN—4 Blade—15" Dia.	Hayes
FAN BELT	
Type	"V"
Length	45.65"-44.43"
Width	11/16"
Angle of Vee	45°
WATER PUMP	
Type	Centrifugal
Location	Front of Cylinder Block
Drive	Belt
Bearing	Permanently Sealed-Lubricated Ball
THERMOSTAT	
Location	Water Outlet Top Cylinder Head
Starts To Open At	145°-155°
Fully Open	170°

WATER PUMP

To overhaul the water pump, take out the bearing retaining wire and place the pump body on the face plate of an arbor press and press the shaft through the impeller and pump body. Remove the seal washer and seal. Place the pump shaft and fan pulley on the press in such a position so that the bearing will clear in the opening and press the shaft from the pulley.

To reassemble the pump, install the long end of the shaft in the pump body from the front end until the outer end of the bearing is flush with the front end of the pump body.

Dip the seal and seal washer in brake fluid and install in the impeller. Place the impeller on the bed of the press and press the long end of the shaft into the impeller until the end of the shaft is flush with the impeller.

Support the assembly on the impeller end of the shaft and press the fan pulley on the shaft so that the end of the shaft is flush with the face of the fan pulley. Move the shaft in the body so that the grooves in the bearing and pump body line up, then lock in position with the bearing retaining wire.

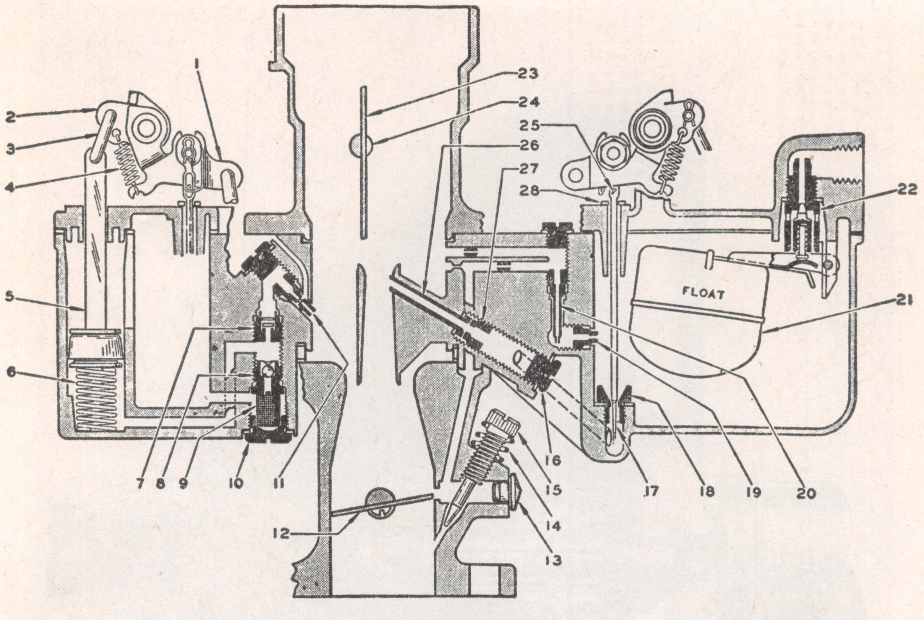
NOTE—The double row ball bearing is integral with the shaft, packed with grease at the time of manufacture and requires no further lubrication. The ends of the bearing are sealed to retain the lubricant and prevents dust and dirt from entering. Whenever the bearing and shaft assembly is removed, it should never be immersed in cleaning fluid because if any of this fluid enters the bearing, it will dissolve the lubricant and ruin the bearing. If cleaning is required, merely moisten a cloth with cleaning fluid and wipe away any foreign matter which may be present.

ENGINE THERMOSTAT

The thermostat is located in the water outlet on top of the cylinder head. The temperature at which the thermostat should open is set by the manufacturer and cannot be altered. To test the thermostat, heat sufficient water in a suitable vessel to 170 degrees F., at which time, the thermostat valve should be open to the limit. If it does not, the thermostat should be replaced.

FUEL SYSTEM SPECIFICATIONS

CARBURETOR	
Make	Carter
Model	WO596S
Flange	1"
Primary Venturi	11/32" I.D.
Main Venturi	1" I.D.
Float Setting	3/8"
FUEL INTAKE	Square Vertical Spring Loaded Needle No. 53 Drill Size in Needle Seat.
FUEL LINE	
Connection	1/8" pipe thread—3/16" inverted flared tube elbow.



CARBURETOR

1	Pump Operating Lever Assembly
2	Pump Arm and Collar Assembly
3	Pump Connecting Link
4	Pump Arm Spring
5	Pump Plunger and Rod Assembly
6	Pump Plunger Spring
7	Discharge Disc Check Assembly
8	Intake Ball Check Assembly
9	Pump Check Strainer
10	Pump Check Strainer Nut
11	Pump Jet
12	Throttle Valve
13	Idle Port Rivet Plug
14	Idle Adjustment Screw Spring
15	Idle Adjustment Screw
16	Pump Jet and Nozzle Passage Plug and Gasket Assembly
17	Metering Rod
18	Metering Rod Jet and Gasket Assembly
19	Idle Well Jet
20	Low Speed Jet Assembly
21	Float and Lever Assembly
22	Needle, Pin, Spring and Seat Assembly
23	Choke Valve Assembly
24	Choke Shaft and Lever Assembly
25	Metering Rod Spring
26	Nozzle
27	Nozzle Retainer Plug
28	Metering Rod Disc

LOW SPEED JET TUBE

Jet Size	No. 71 Drill
Idle Well Jet	No. 61 Drill

IDLE SCREW SEAT .... No. 46 Drill

MAIN NOZZLE DISCHARGE JET

.096" Diameter

METERING ROD No. 75-547

Jet Size	.076" Diameter
Setting (Use gauge No. T-109-26)	2.718"

ACCELERATING PUMP

Discharge Jet	No. 73 Drill
Intake Ball Check	No. 40 Drill
Discharge Disc Check	No. 40 Drill
Relief Passage to Outside	No. 42 Drill
Adjustment (Use gauge T-109-117 S)	17/64"

AIR CLEANER

Make	Oakes
Model	613300
Type	Oil Bath
Oil Capacity	1¼ Pints

FUEL PUMP

Make	AC
Model	AF
Type	Camshaft

Pressure 4½ lbs. at 16" above outlet @ 1800 R.P.M.

FUEL TANK

Make	Own
Capacity	15 Gals.
Location	Under Driver's Seat
Filler Cap	Pressure Type

FUEL FILTER

Make	AC
Model	T-2
Type	Disc
Mounting	Mounted on Dash

CARBURETOR

LOW SPEED SYSTEM

The low speed jet is inserted through the top and is reached by taking out the plug. Gasoline for the low speed system does not come through the main metering jet, but through the well jet, the opening of which is carefully calibrated, and if damaged should be replaced. Make sure the well jet is always seated tightly.

HIGH SPEED SYSTEM

The high speed system carries a vented nozzle. The vent is a small opening which must always be kept clean. The metering rod is adjusted by the nut which holds the pump pin securely fastened to the pump arm. Do not bend the connector rod to adjust the metering rod.

PUMP SYSTEM

To adjust the pump stroke, bend the connector rod. Always adjust the pump stroke setting before the metering rod setting. The pump is the wet type and the pump arm spring prolongs the pump discharge.

CHOKE SYSTEM

The choke connector link connects the choke and throttle levers, and causes the throttle to be opened slightly when the choke valve is closed, or partly closed, thus insuring quick starting and prevents stalling during warm-up periods.

FAST IDLE ADJUSTMENT

With the choke fully closed, bend the choke connector link at the offset to give the proper throttle valve opening. Be sure the bending is done at the offset and the ends of the link are parallel so that no binding occurs at either end.

FLOAT LEVEL ADJUSTMENT

In adjusting the float level, first turn the bowl cover gasket around to get it out of the way. Use the proper gauge as specified in the specifications. To make a change in the float level, press down with a screwdriver on the brass lip of the float while holding up on the float assembled to the cover of the carburetor. Bending the lip in this way allows it to retain its curvature which is necessary for the correct operation of the float valve.

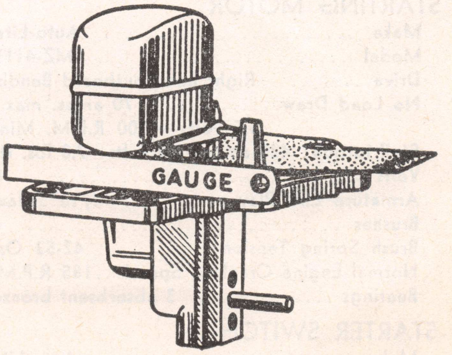
Be sure that the pin and spring are in position and that the spring has not been stretched.

PUMP TRAVEL ADJUSTMENT

In gauging the pump stroke, place the gauge on top of the bowl cover. Seat the throttle valve by backing out the throttle adjusting screw. Bend the pump connector rod at the offset until the upper surface of the shaft is at the height indicated in the specifications. Always adjust the pump travel before setting the metering rod.

METERING ROD ADJUSTMENT

Remove the metering rod and insert the metering rod gauge in its place. With the



FLOAT LEVEL SETTING

throttle closed tightly, loosen the nut and move the pin until it seats in the gauge notch. Tighten the nut securely, remove the gauge and install the metering rod, spring and disc. Lubricate the pump arm shaft with graphite grease.

MANIFOLDS & HEAT CONTROL

The intake and exhaust manifolds make a unit in which the hot exhaust gases are thermostatically controlled and directed around the intake manifold to assist in vaporizing the fuel when the engine is cold.

When the engine is cold, the counterweight lever closes the valve and directs the hot exhaust gases against the intake manifold. As the engine warms up, the bimetal spring (thermostat) expands and opens the valve, directing the exhaust gases into the exhaust pipe.

When assembling the manifolds to the engine, new gaskets should be installed and the nuts drawn up evenly until they are all tight. When using a torque indicating wrench, the nuts should be tightened to from 31 to 35 pounds feet.

FUEL PUMP

NOTE—For complete service information covering the AF model fuel pump, see page 569.

FUEL GAUGE

NOTE—For complete service information covering the Auto-Lite fuel gauge, see page 576.

ELECTRICAL SYSTEM SPECIFICATIONS

BATTERY

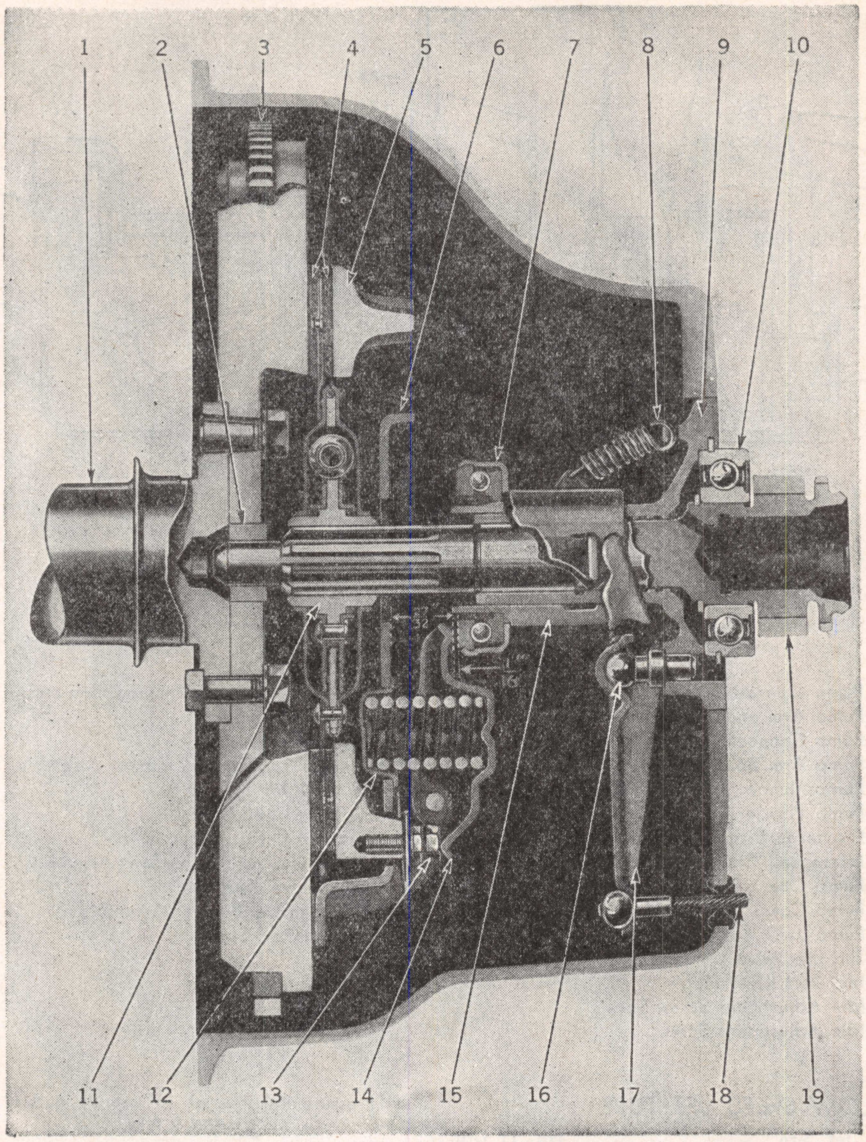
Make	Auto-Lite or U. S. L.
Model	TS-2-15 or PN-15
Plates per Cell	15
Capacity	116 Amp. Hr.
Volts	6
Length	Approx. 8 15/16"
Width	Approx. 7 1/8"
Height	Approx. 8 5/8"
Specific Gravity	
Fully Charged	1225-1300
Recharge at	1175
Ground Terminal	Negative
Location	Under Hood Right Side

STARTING MOTOR

Make	Auto-Lite
Model	MZ-4113
Drive	Right hand outboard Bendix
No Load Draw	70 amps. max.; 5.5 volts—4300 R.P.M. Min.
Stall torque	420 amps.; 3.0 volts—7.8 lbs. ft.
Volts	6
Armature End Play	1/16" Max.
Brushes	4
Brush Spring Tension	42-53 Oz.
Normal Engine Cranking Speed	185 R.P.M.
Bearings	3 absorbsent bronze

STARTER SWITCH

Make	Auto-Lite
Model	SW-4015



CLUTCH AND CONTROL

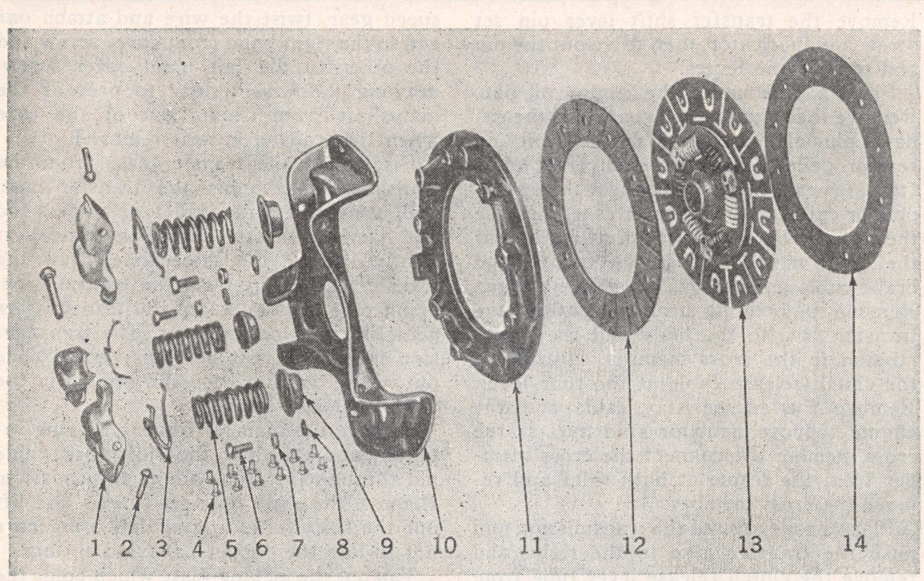
1 Crankshaft
2 Clutch Shaft Bushing
3 Flywheel Ring Gear
4 Clutch Facings
5 Pressure Plate
6 Clutch Bracket
7 Clutch Release Bearing
8 Release Bearing Retracting Spring
9 Main Drive Gear Bearing Retainer
10 Main Drive Gear Bearing
11 Clutch Driven Plate and Hub
12 Clutch Pressure Spring
13 Clutch Adjusting Screw
14 Clutch Lever
15 Release Bearing Carrier
16 Clutch Control Lever Fulcrum
17 Clutch Control Lever
18 Clutch Control Lever Cable
19 Main Drive Gear

GENERATOR

Make	Auto-Lite
Model	GDZ-4817A
Volts	6-8
Ground Polarity	Negative
Controlled Output	40 Amps.
Rotation (Drive End)	Clockwise
Control	Current-voltage regulator
Air Cooled	Yes
Armature End Play	.010" Max.
Brushes	2
Brush Spring Tension	35-53 Oz.
Bearings	Ball
Field Coil Draw	1.60 to 1.78 Amps.—6.00 V.
Motorizing Draw	4.2 to 4.6 Amps.—6.0 volts (Have field and armature terminals connected).
Output	8.0 amps.; 7.6 volts; 1175 Max. R.P.M. 30-37 amps.; 7.6 volts; 1900 Max. R.P.M. 30-37 amps.; 8.0 volts; 1900 Max. R.P.M.

CURRENT—VOLTAGE REGULATOR

Make	Auto-Lite
Model	VRP-4007-02
Volts	7.2-7.5



EXPLODED VIEW OF CLUTCH

1 Clutch Lever
2 Clutch Lever Pivot Pin
3 Pressure Plate Return Spring
4 Clutch Facing Rivet
5 Clutch Pressure Spring
6 Clutch Adjusting Screw
7 Clutch Adjusting Screw Lock Nut
8 Clutch Adjusting Screw Washer
9 Clutch Pressure Spring Cup
10 Clutch Bracket
11 Clutch Pressure Plate
12 Clutch Facing—Rear
13 Driven Plate and Hub
14 Clutch Facing—Front

Amperes	35
Ground Polarity	Negative

VOLTAGE REGULATOR

Voltage Setting Open Circuit	7.20-7.41
Air Gap	.048"-.052"
Point Gap	.012"

CIRCUIT BREAKER

Points Close (Hot)	6.4-7-0 Volts
Points Open—Reverse Current	0.5-6.0 Amps.
Air Gap	.031"-.034"
Points Gap	.015"

CURRENT LIMITING REGULATOR

Air Gap	.048"-.052'
Point Gap	.012"

DISTRIBUTOR

Make	Auto-Lite
Model	IGW-4177-I
Type Advance	Centrifugal
Firing Order	1-3-4-2
Breaker Point Gap	.020"
Breaker Arm Spring Tension	17-20 Oz.
Cam Angle (Time points are closed)	41°
Max. Automatic Advance 1500 R.P.M. (dist.)	11°
Condenser Capacity	20-25 Mfd.
Timing—72 octane fuel (gasoline)	5° BTC Flywheel (.0103" Piston travel)
Timing—68 octane fuel (gasoline)	TC Flywheel (Zero Piston travel)
Timing Mark	Flywheel
Location	Right Side under Starter
Ignition Switch	Douglas No. 6282

COIL

Make	Auto-Lite
Model	IG-4314

Draw—Engine Stopped	5 Amps. @ 6.4 Volts
Draw—Engine Idle	2.5 Amps.

GAUGES

Fuel	Auto-Lite
Oil Pressure	Auto-Lite
Temperature	Auto-Lite
Ammeter	Auto-Lite

SPARK PLUGS

Size	14MM
Gap	.030"

RADIO FILTERS (Military only)

Generator Filter Unit	Solar SJ-194 Sprague JX-130 Tobe Deutschmann SC-33M-I Mallory B-115963
Regulator Filter	Solar EV-101 Sprague JX-112 Tobe Deutschmann 1126 Mallory FL-13
Filter Group	Solar EV-103 Sprague JX-17 Tobe Deutschmann 1107DEG Mallory C-134739

DISTRIBUTOR

NOTE—For complete information covering the service of the Auto-Lite Distributor, see page 609.

GENERATOR

NOTE—For complete information covering the service of the Auto-Lite Generator, see page 664.

GENERATOR REGULATOR

NOTE—For complete information covering the service of the Auto-Lite Current and Voltage Regulator, see page 678.

STARTING MOTOR

NOTE—For complete information covering the service of the Auto-Lite Starting Motor. see page 638.

IGNITION TIMING

To set the ignition timing, remove all spark plugs from the engine and reinstall No. 1 plug finger tight. Loosen the screw which holds the timing hole cover to the flywheel housing—located just under the starting motor on the right hand side of the engine—and slide it to one side.

Crank the engine to bring No. 1 piston up on its compression stroke and, after removing No. 1 spark plug, continue cranking until the "IGN" mark on the flywheel appears in the center of the opening in the flywheel housing.

Locate the distributor rotor so that it is ready to fire No. 1 cylinder—with the points just breaking. Mount the distributor on the engine, and when the end of the shaft enters the driving collar on the oil pump drive gear, rotate the distributor shaft—by means of the rotor—back and forth until the driving lug on the end of the distributor shaft enters the slot in the coupling, then push the distributor assembly down, after which, install the hold-down screw. Connect the primary wire from the coil to the distributor and rotate the distributor body until the points are just breaking, after which lock in place with clamp screw. Install the spark plugs and connect the ignition wires.

NOTE—For best results, check the timing with a Neon timing light or a conventional test lamp. Advance or retard the distributor to compensate for the grade of fuel being used. For best performance and fuel economy, the ignition setting should be one which will provide smooth engine performance with a slight "ping" on wide-open throttle at comparatively low vehicle speed.

CLUTCH SPECIFICATIONS

Type	Single, Dry Plate

DRIVEN PLATE

Make	Borg & Beck
Size	8½"
Facings	1 Woven and 1 Molded Asbestos
Diameter	Inside 5⅛"-Outside 8½"
Thickness	⅛"-(.125")
Torque Capacity	175 Lbs.-Ft.

PRESSURE PLATE

Make	Atwood
Number Springs	3
Spring Pressure at 1 9/16"	220-230 lbs.

CLUTCH RELEASE BEARING

Type	Sealed Ball Bearing—Prelubricated

CLUTCH SHAFT BUSHING

Location	In Flywheel
Material	Bronze Bushing (Impregnated with graphite)
Size	(Inside) .628"

CLUTCH PEDAL ADJUSTMENT

Pedal Adjustment	¾" Free Pedal Travel

CLUTCH SERVICE

NOTE—For complete information covering the service of this clutch, see page 704.

CLUTCH PEDAL, ADJUST

Lengthening or shortening the clutch control lever cable governs the clearance of the clutch release bearing to the clutch fingers, which should be maintained at 1/16", or equivalent to ¾" free clutch pedal travel. This also disengages the clutch release bearing and prevents any unnecessary wear while the engine is running.

To adjust the pedal, loosen the clutch control lever cable adjusting yoke lock nut. Screw the yoke in the desired direction until the adjustment is satisfactory and tighten the lock nut.

TRANSMISSION SPECIFICATIONS

TRANSMISSION

Make	Warner
Model	T90A
Type	Synchronous Mesh
Mounting	Unit Power Plant
Shift Lever Location	Steering Post
Speeds	3 Forward—1 Reverse
Ratio	
Low	2.798
Second	1.551
High	1:1
Reverse	3.780

BEARINGS

Transmission Main Gear Shaft (Flywheel)	Bushing
Clutch Release	Ball
Main Drive Gear (Clutch Shaft Rear)	Ball
Main Shaft Front	14 Rollers
Main Shaft Rear	Ball
Counter Shaft Gear	Roller Bearings
Reverse Idler Gear	Bushing

TRANSMISSION OIL

Capacity—(Pts.)	3

TRANSMISSION SERVICE

TRANSMISSION & TRANSFER CASE, REMOVE

Drain the radiator and remove the upper hose. Unscrew the ball handles from the shift levers and remove the transmission cover from the floor. Remove the transmission shift lever by unscrewing the retainer collar at the top of the shift housing. Remove the transfer shift lever pin set screw and lubricator, then drive out the pin and remove the levers.

Place a jack under the engine oil pan. Remove the exhaust pipe guard and the exhaust pipe clamp. Disconnect the front and rear propeller shafts at the universal joints (transfer case end). Disconnect the speedometer cable at the transfer case. Remove the transfer case support (snubber) bolt at the cross member. Disconnect the hand brake cable and remove the return spring. Remove the bonding straps which hold the transfer case to the body and the transmission to the cross member. Disconnect the clutch release cable at the tube lever. Remove the engine stay cable and the engine support insulator stud nuts at the cross member. Disconnect the cross member from the frame at both sides and remove the cross member.

Place a rope around the transmission and push the transfer case to the right, and remove the clutch release lever tube from the ball joint on the transfer case. Place a jack under the transmission and remove the transmission to bell housing bolts, inspection cover and clutch release fork.

Hold the weight of the transmission with the rope, remove the jack from under the transmission, lower the jack under the engine until the transmission cover can clear the floor pan, after which, pull the assembly to the rear until the transmission clutch shaft clears the bell housing, then lower the assembly and remove it from under the vehicle.

TRANSMISSION, OVERHAUL

Disassemble: After draining the lubricant and cleaning the outside of the case, remove the cover from the rear of the transfer case, and after removing the cotter pin, nut and washer, take out the mainshaft gear and oil slinger. Disconnect the shift control housing from the top of the transmission and lift it off. Remove the shifter plate and spring.

NOTE—Loop a piece of wire around the mainshaft, just to the rear of the second speed gear, twist the wire and attach one end to the right hand front cover screw and the other to the left hand cover screw, drawing the wire tightly to prevent the mainshaft from sliding out of the case when the transfer case is removed.

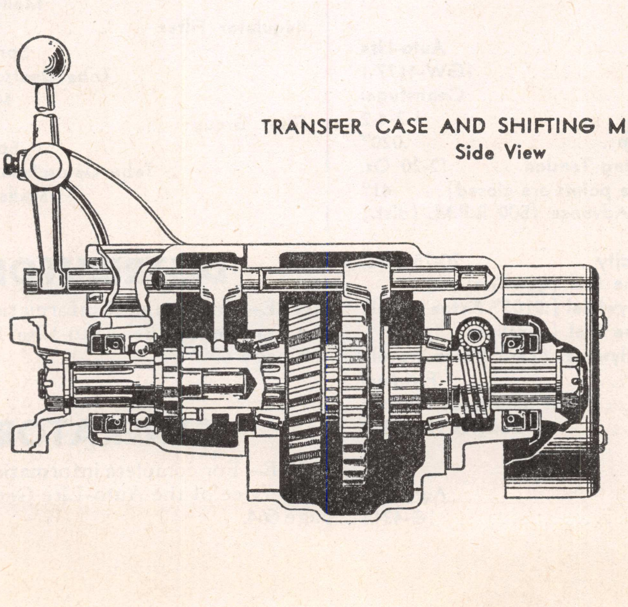
Disconnect the transfer case from the transmission. Support the transfer case, and, using a rawhide mallet, or a brass rod and hammer, tap the end of the mainshaft lightly and, at the same time, draw the transfer case away from the transmission, being careful not to lose the transmission gearshift interlock plunger. The transmission mainshaft rear bearings should slide out of the transfer case and remain in the transmission.

Remove the main drive gear bearing retainer, and take out the shift fork guide pin through the front of the transmission. Remove the shift fork set screws and lift out the shift forks and shafts, using care not to lose the poppet balls and springs.

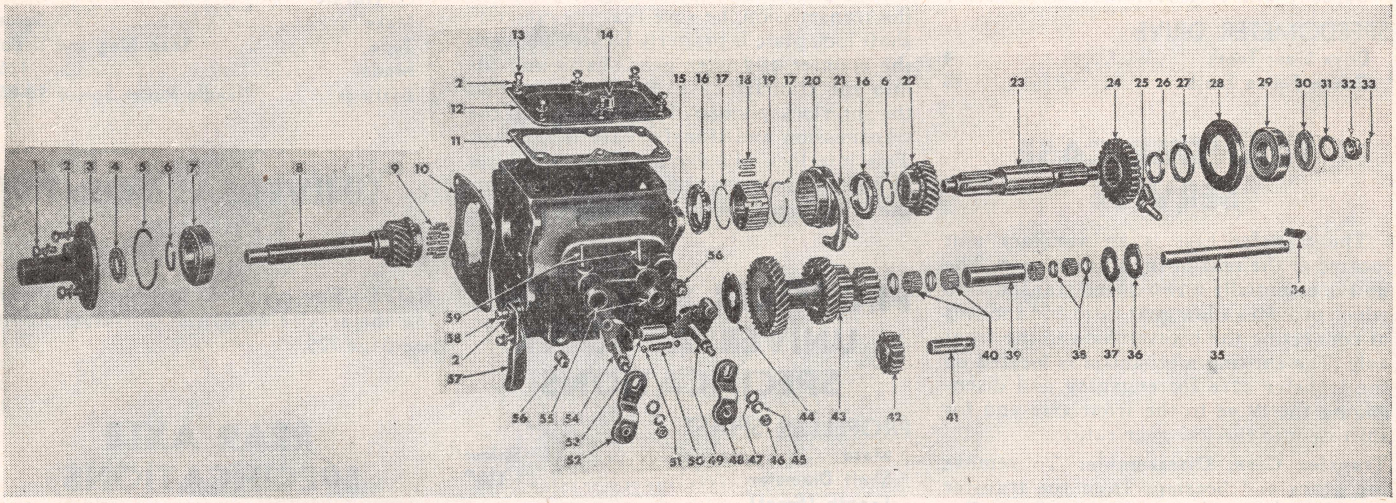
Tap out the locking plate which holds the countershaft and idler shaft in position, then, using a drift, drive out the countershaft. Remove the main drive gear bearing, shaft and synchronizer blocking ring. Release the snap rings from the main drive gear shaft and bearings, after which, take out the mainshaft assembly. Lift out the countershaft gear set with its thrust washers, bushings and spacer. Push out the reverse idler gear shaft and lift out the reverse idler gear.

To disassemble the mainshaft, release the snap ring which holds the second and high speed clutch hub, then remove the gears from the shaft. Complete the disassembly by pushing the synchronizer unit apart and finally, pull the mainshaft bearing and remove the oil slinger and spacer.

Assemble: The assembly operation should be performed in the reverse manner in which it was dismantled. First, install the reverse idler gear and shaft. Assemble the countershaft gearset and three thrust washers, two bushings and spacer in the case, using a ⅜" rod to permit the gear to hang below the correct position so as to



TRANSFER CASE AND SHIFTING MECHANISM
Side View



TRANSMISSION

1 Bearing Retainer Screw
2 Lockwasher
3 Main Drive Gear Bearing Retainer
4 Main Drive Gear Bearing Retainer Oil Seal
5 Main Drive Gear Bearing Snap Ring
6 Main Drive Gear Snap Ring
7 Main Drive Gear Bearing
8 Main Drive Gear
9 Mainshaft Pilot Roller Bearing
10 Main Drive Gear Bearing Retainer Gasket
11 Transmission Case Cover Gasket
12 Transmission Case Cover
13 Transmission Case Cover Bolt
14 Transmission Case Cover Breather Assembly
15 Transmission Case
16 Synchronizer Blocking Ring
17 Synchronizer Spring
18 Synchronizer Shifting Plate
19 High and Second Clutch Hub
20 Second and High Speed Clutch Sleeve
21 High and Intermediate Shift Fork
22 Mainshaft Second Speed Gear Assembly
23 Mainshaft
24 Low and Reverse Sliding Gear
25 Low and Reverse Shoe
26 Mainshaft Bearing Spacer
27 Oil Seal
28 Transmission Mainshaft Bearing Adapter
29 Mainshaft Bearing
30 Mainshaft Oil Retaining Washer
31 Mainshaft Washer
32 Mainshaft Nut
33 Cotter Pin
34 Countershaft Lock Plate
35 Countershaft
36 Countershaft Rear Thrust Washer, Steel
37 Countershaft Rear Thrust Washer, Bronze
38 Countershaft Rear Thrust Washer, Steel
39 Countershaft Bearing Spacer
40 Countershaft Gear Bearing Rollers
41 Countershaft
42 Reverse Idler Gear Assembly
43 Countershaft Gears
44 Countershaft Thrust Washer, Front
45 Lockwasher
46 Control Lever Nut
47 Control Lever Washer
48 Low and Reverse Control Lever Outer Assembly
49 Low and Reverse Shift Lever
50 Shift Lever Poppet Spring
51 Shift Lever Poppet Ball
52 High and Intermediate Control Lever Outer Assembly
53 Shift Lever Interlock Sleeve
54 High and Intermediate Shift Lever
55 Shift Shaft Oil Seal
56 Filler and Drain Plugs
57 Countershaft Gear Oil Collector
58 Screw
59 Shift Shaft Taper Pin

prevent interference with the mainshaft gears when they are installed.

NOTE—The countershaft bushings are of the floating type, being free to turn within the gear as well as on the shaft. Dip these bushings in gear lubricant when assembling and be sure the spacer is placed between the two bushings. The steel thrust washer at the rear of the countershaft is pinned in the case and the bronze washer should be installed between the steel washer and the gear. Only one washer (bronze) is used at the front end of the gear.

Assemble the mainshaft in the case, placing the oil slinger and bearing in position, being sure the open side of the bearing is in the transmission case.

When assembling the synchronizer unit, place the right end of a synchronizer spring in one shifting plate. Then turn the unit around and make exactly the same installation with the other spring in the same shifting plate.

Install the main drive gear bearing on the shaft and secure it with snap rings, after which, install the main drive gear assembly in the case and on the front end of the mainshaft with the synchronizer blocking ring.

Drive out the ⅜" rod, which is being used to hold the countergear assembly, by installing the regular countershaft, after which, lock the countershaft and idler gear shaft in position by tapping in the lock plate.

Complete the assembly of the cover, shift rails and forks in the reverse order of removal, and, if service to the transfer case is required, see "Transfer Case Service."

TRANSFER CASE SPECIFICATIONS

TRANSFER CASE

Make	Spicer
Model	18
Mounting	Unit with Transmission
Shift Lever	Floor
Ratio	High 1:1 Low 2.43:1

TRANSFER CASE BEARINGS

Transmission Mainshaft	Ball
Idler Gear	2 Roller
Output Shaft	Taper Roller
Front Axle Clutch Shaft	
Front Bearing	Ball
Rear Pilot in Output Shaft	Bronze Bushing I.D. .627"

TRANSFER CASE OIL

Capacity Pts.	3

SPEEDOMETER DRIVE

Drive Gear Teeth	4
Driven Pinion Teeth	15

TRANSFER CASE SERVICE

The transfer case is an auxiliary unit located at the rear of the transmission. The unit is essentially a two-speed transmission which provides a low gear ratio and a means of connecting the transmission to the front axle. The shifting mechanism is located on the transfer case for engaging and disengaging the drive to the front axle and for shifting into the low gear ratio.

Transfer Case, Disassemble: To remove the gears and bearings from the transfer case on the bench, proceed as follows: Remove the brake band assembly and linkage. Take out the cap screws and washers holding the lower cover. Remove the lock plate screw and lock plate. Drive the intermediate shaft out to the rear of the case and remove the intermediate gear, thrust washers and roller bearings through the bottom of the case.

Remove the poppet plugs, springs and balls on both sides of the output bearing cap and shift the front wheel drive to its engaged position (shaft forward). After removing the cap screws holding the output bearing cap, take off the cap as an assembly with the universal joint end yoke, clutch shaft bearing, clutch gear fork and shift rail, being sure not to lose the shift rail interlock.

Remove the output shaft snap ring and thrust washer. Unfasten the rear output bearing cap and remove the cap as an assembly with the universal joint flange, speedometer gears and bearing, and output shaft. This will allow the sliding gear and the output shaft gear to slide off the output shaft and come out through the bottom of the case.

Remove the set screw in the sliding gear shift fork and slide the shift rail through the fork and the hole in the case, then remove the fork through the bottom of the case.

Front Cap, Disassemble: Remove the universal joint yoke and oil seal. After removing the set screw and shifting rail, the clutch gear and fork can be removed together. Press the output shaft carefully through the bearing then release the snap ring and remove the bearing.

Rear Cap, Disassemble: Take off the companion flange, oil seal and speedometer driven gear, then remove the output shaft from the cap. Press the bearing cone and speedometer drive gear from the shaft.

NOTE—The shims which are provided between the rear cap and case are for the adjustment of the roller bearings. These bearings should be so adjusted to establish not more than .003" end play of the shaft.

CAUTION—Assembly of the transfer case is accomplished in the reverse order of disassembly but when installing the unit to the transmission, be sure that the countershaft lock plate is properly located between the counter and idler gear shafts and fits into the transfer case. Be sure also, that the interlock plunger, located between the transmission and transfer case is in place. This interlock plunger acts as a stabilizer on the transmission shift rails and prevents the rails from shifting out of position.

PROPELLER SHAFT AND UNIVERSAL JOINT SPECIFICATIONS

PROPELLER SHAFT

Make	Spicer
Shaft Diameter	1¼"
Length (Front) (Joint center to center)	22 31/32"
Length (Rear) (Joint center to center)	$20\frac{11}{32}$"

FRONT DRIVE UNIVERSAL JOINT—FRONT

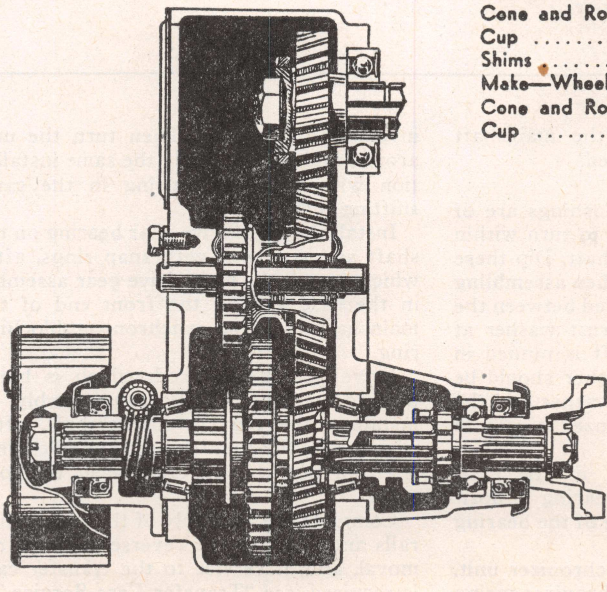
Make	Spicer
Type	Snap Ring and U Bolt
Model	1268
Bearings	Needle Roller Spicer 98-851

FRONT DRIVE UNIVERSAL JOINT—REAR

Make	Spicer
Type	Snap Ring and U Bolt
Model	1261
Bearings	Needle Roller Spicer 98-851

REAR DRIVE UNIVERSAL JOINT—FRONT

Make	Spicer
Type	Snap Ring
Model	1261
Bearings	Needle Roller Spicer 98-851



TRANSFER CASE
Top View

REAR DRIVE UNIVERSAL JOINT—REAR

Make	Spicer
Type	Snap Ring and U Bolt
Model	1268
Bearings	Needle Roller Spicer 98-851

UNIVERSAL JOINT SERVICE

NOTE—For complete information covering the service of Spicer Universal Joints, see page 775.

REAR AXLE SPECIFICATIONS

REAR AXLE

Type	Full floating
Make	Spicer
Drive	Through springs
Road Clearance	8⅝"

DIFFERENTIAL

Type	Hypoid
Ratio	5.38:1
Bearings	Timken Roller
Differential Pinion Gears	2
Oil Capacity	2½ Pts.
Adjustment	Shims .003", .005", .010", .030"

PINION SHAFT

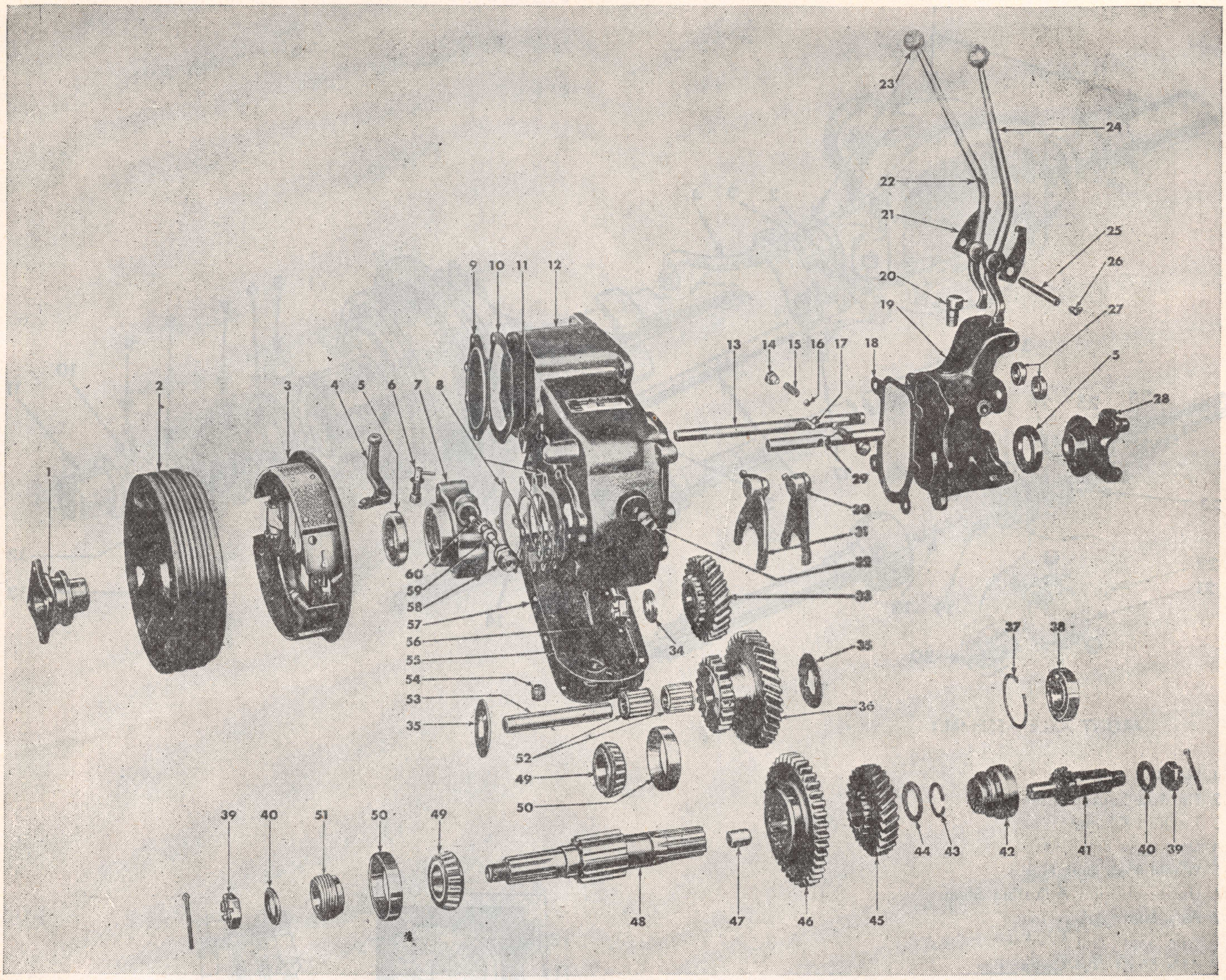
Bearings	Two Timken Roller
Adjustment	Shims .003", .005", .010"

BEVEL AND PINION GEAR

Back Lash	.005"—.007"
Adjustment	Shims .003", .005", .010", .030"

BEARINGS

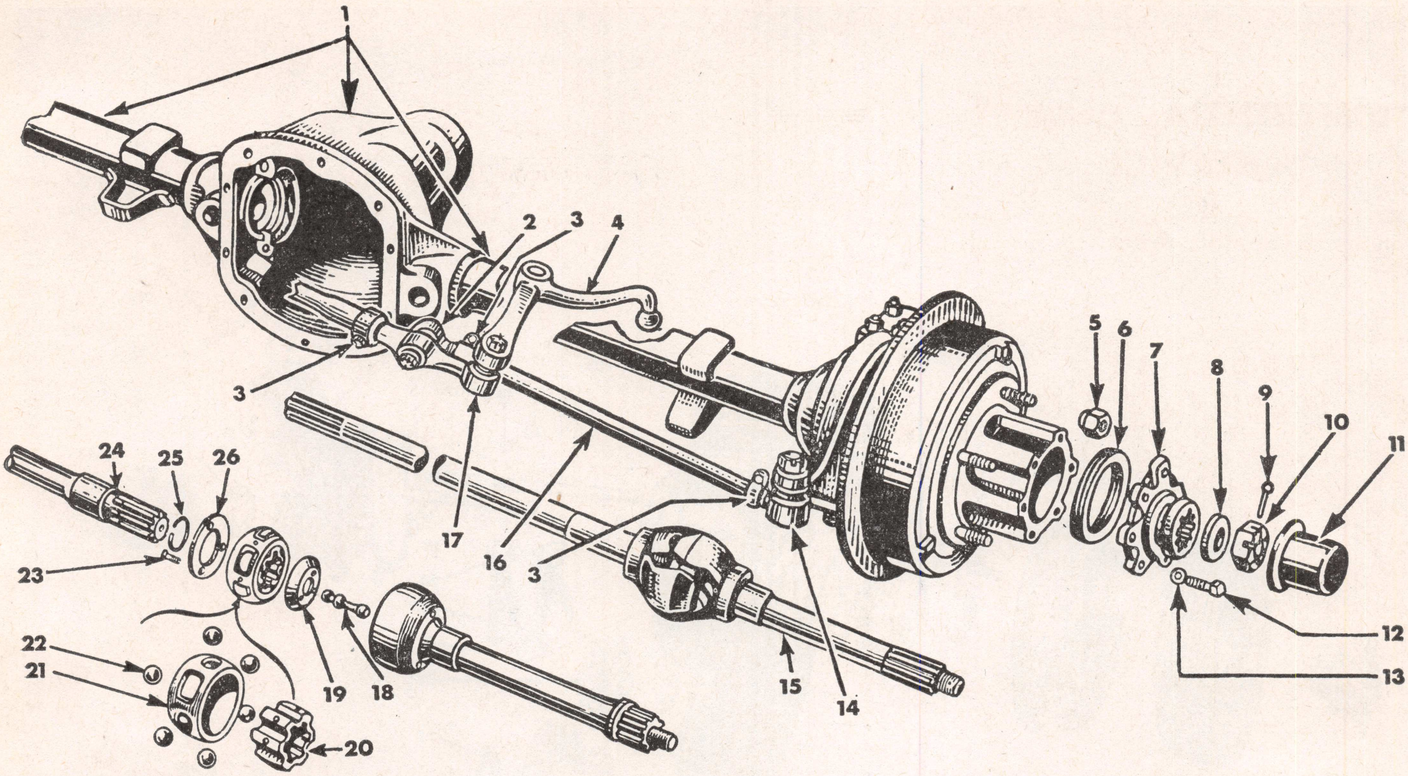
Make—Differential Side		Timken
Cone and Roller		24780
Cup		24721
Make—Pinion Shaft		Timken
Cone and Roller	Front 02872	Rear 31593
Cup	Front 02820	Rear 31520
Shims		.003", .005", .010", .030"
Make—Wheel Hub		Timken
Cone and Roller	Inner 18590	Outer 18590
Cup	Inner 18520	Oter 18520



TRANSFER CASE—Exploded View

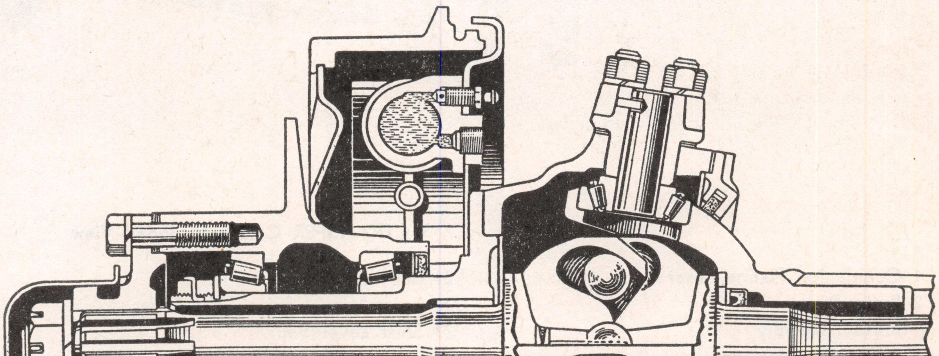
1 Companion Flange, Rear
2 Brake Drum
3 Brake Assembly
4 Lever Assembly
5 Output Shaft Oil Seal
6 Stud
7 Output Shaft Bearing Cap, Rear
8 Output Shaft Bearing Shim
9 Rear Cover
10 Rear Cover Gasket
11 Intermediate Shaft Lock Plate
12 Transfer Case
13 Front Wheel Drive Shift Rod
14 Shift Rod Poppet Plug
15 Shift Rod Poppet Spring
16 Shift Rod Poppet Ball
17 Shift Rod Interlock
18 Output Shaft Bearing Cap Gasket, Front
19 Output Shaft Bearing Cap, Front
20 Transfer Case Breather Assembly
21 Shift Lever Spring
22 Front Wheel Drive Shift Lever
23 Shift Lever Ball
24 Under Drive Shift Lever
25 Shift Lever Pivot Pin
26 Grease Fitting
27 Shift Rod Oil Seal
28 Universal Joint End Yoke, Front
29 Front Wheel Drive Shift Rod
30 Front Wheel Drive Shift Fork
31 Under Drive Shift Fork
32 Filler Plug
33 Mainshaft Gear
34 Mainshaft Washer
35 Intermediate Gear Thrust Washer
36 Intermediate Gear
37 Output Clutch Shaft Bearing Snap Ring
38 Output Clutch Shaft Bearing
39 Companion Flange Nut
40 Companion Flange Washer
41 Output Clutch Shaft
42 Output Clutch Shaft Gear
43 Output Clutch Shaft Gear Snap Ring
44 Output Shaft Gear Thrust Washer
45 Output Shaft Gear
46 Output Shaft Sliding Gear
47 Output Clutch Shaft Pilot Bushing
48 Output Shaft
49 Output Shaft Bearing Cone and Rollers
50 Output Shaft Bearing Cup
51 Speedometer Drive Gear
52 Intermediate Gear Bearing
53 Intermediate Shaft
54 Transfer Case Drain Plug
55 Transfer Case Cover Gasket, Bottom
56 Mainshaft Nut
57 Transfer Case Cover, Bottom
58 Speedometer Driven Gear Sleeve
59 Speedometer Driven Gear
60 Speedometer Drive Pinion Bushing

CIVILIAN JEEP



FRONT AXLE ASSEMBLY

1 Housing and Tube
2 Tie Rod Socket Assembly
3 Tie Rod Clamp
4 Drag Link Bell Crank
5 Wheel Hub Bolt Nut
6 Universal Joint Adjusting Shims
7 Axle Shaft Drive Flange
8 Axle Shaft Nut Washer
9 Axle Shaft Nut Cotter Pin
10 Axle Shaft Nut
11 Hub Cap
12 Axle Shaft Drive Flange Cap Screw
13 Lockwasher
14 Tie Rod Socket Assembly, Left
15 Axle Shaft and Universal Joint
16 Tie Rod Assembly, Left
17 Tie Rod Socket Assembly
18 Universal Joint Pilot Pin
19 Universal Joint Pilot
20 Universal Joint Inner Race
21 Axle Shaft Universal Joint Cage
22 Axle Shaft Retainer Universal Ball
23 Axle Shaft Retainer Screw
24 Axle Inner Shaft
25 Axle Shaft Retainer Snap Ring
26 Axle Shaft Retainer



FRONT WHEEL DRIVE

DIFFERENTIAL CARRIER SERVICE

NOTE—For complete information covering the service of the Spicer Axle, see page 803.

FRONT AXLE SPECIFICATIONS

FRONT AXLE	
Make	Spicer
Drive	Through springs
Type	Full floating
Road Clearance	8⅝″

DIFFERENTIAL (Same as Rear Axle)	
Drive	Hypoid
Gear Ratio	5.38:1
Bearings	Timken Roller 2
Adjustment	Shims
Gears (Pinion)	2

OIL CAPACITY (PTS.)	2½

STEERING KNUCKLE THRUST

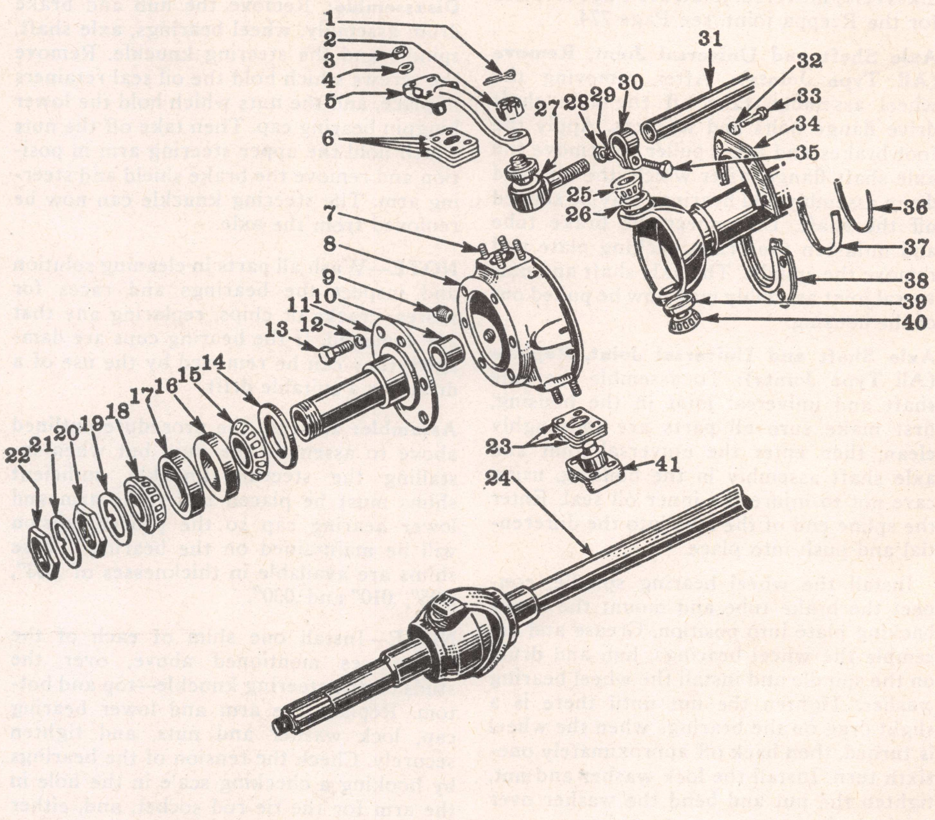
Adjusted by shims, should have 25 to 35 inch-pounds pull without oil seal assembly in position.

TURNING ANGLE	26°

TIE RODS	
Number	2
Right hand length—center to center	24¼″
Left hand length center to center	17 11/32″
Tie rod ends	Serviced as a unit

STEERING GEOMETRY	
King Pin inclination	7½°
Wheel camber	1½°
Wheel caster	3°
Wheel toe-in	3/64″-3/32″

BEARINGS	
Differential side	Timken
Cone and Rollers	24780
Cup	24721
Shims	.003″, .005″, .010″, .030″
Pinion Shaft	Timken
Cone and Rollers	Front 31593, Rear, 02872
Cup	Front 31520, Rear 02820
Shims	.003″, .005″, .010″, .030″
Wheel Hub	Timken
Cone and Rollers	Inner 18590, Outer 18590
Cup	Inner 18520, Outer 18520
Steering Knuckle	Timken
Cone and Rollers	Upper 11590, Lower 11590
Cup	Upper 11520, Lower 11520
Steering Bell Crank Bearing	Needle, Torrington B1210



FRONT AXLE, STEERING KNUCKLE AND WHEEL BEARINGS

1 Tie Rod Stud Nut Cotter Pin
2 Tie Rod Stud Nut
3 Steering Arm Nut
4 Steering Arm Nut Lockwasher
5 Upper Steering Arm
6 King Pin Adjusting Shims
7 Steering Arm Stud
8 Steering Knuckle
9 Steering Knuckle Filler Plug
10 Wheel Bearing Spindle Bushing
11 Wheel Bearing Spindle Assembly
12 Brake Disc Screw Lockwasher
13 Brake Disc Screw
14 Hub Oil Seal Assembly
15 Wheel Bearing Cone and Rollers
16-17 Wheel Bearing Cup
18 Wheel Bearing Cone and Rollers
19 Wheel Bearing Lockwasher
20 Wheel Bearing Nut
21 Wheel Bearing Nut Lockwasher
22 Wheel Bearing Nut
23 King Pin Adjusting Shims
24 Axle Shaft and Universal Joint
25 King Pin Bearing Cone and Rollers
26 King Pin Bearing Cup
27 Tie Rod Socket Assembly
28 Tie Rod Socket Clamp Nuts
29 Clamp Nut Lockwasher
30 Tie Rod Socket Clamp
31 Tie Rod Tube
32 Knuckle Oil Seal Screw Lockwasher
33 Knuckle Oil Seal Screw
34 Steering Knuckle Oil Seal Assembly
35 Tie Rod Socket Clamp Screw
36 Steering Knuckle Oil Seal Felt Pressure Strip
37 Steering Knuckle Oil Seal Felt
38 Steering Knuckle Oil Seal Assembly
39 King Pin Bearing Cup
40 King Pin Bearing Cone and Rollers
41 Lower King Pin Bearing Cap

FRONT AXLE SERVICE

The front axle assembly is a front wheel driving unit with specially designed steering knuckles and a conventional type differential with hypoid gears. The axle is the full-floating type and the shafts can be removed without dismantling the steering knuckles.

NOTE—For service information on both the front and rear differential carrier units, see Page 803. The front axle differential parts are interchangeable with those of the rear axle.

FRONT AXLE UNIVERSAL JOINTS

NOTE—For service procedure on the Bendix-Weiss universal joint, see Page 771, and for the Rzeppa joint, see Page 774.

Axle Shaft and Universal Joint, Remove (All Type Joints): After removing the wheel assembly, take off the axle shaft drive flange bolts and washers. Apply the foot brakes and use a puller to remove the axle shaft flange, after which, the hub and drum assembly and bearings may be slipped off the shaft. Disconnect the brake tube and unfasten the brake backing plate and remove the spindle. The axle shaft and universal joint assembly may now be pulled out of the housing.

Axle Shaft and Universal Joint, Replace (All Type Joints): To assemble the axle shaft and universal joint in the housing, first make sure all parts are thoroughly clean, then enter the universal joint and axle shaft assembly in the housing, using care not to injure the inner oil seal. Enter the spline end of the axle into the differential and push into place.

Install the wheel bearing spindle, connect the brake tube and mount the brake backing plate into position. Grease and assemble the wheel bearings, hub and drum on the spindle and install the wheel bearing washer. Tighten the nut until there is a slight drag on the bearings when the wheel is turned, then back off approximately one-sixth turn. Install the lock washer and nut, tighten the nut and bend the washer over on the lock nut.

NOTE—If equipped with Bendix joint, install the axle drive flange on axle splines without shims. Measure the space between the outer end of the wheel hub and the inner face of the drive flange with a feeler gauge, which will determine the amount of shims to be installed. In order to have proper clearance in the universal joint, it is necessary to add .035" shims to those required as measured by the feeler gauge. If no clearance is present between the axle flange and hub, add .010" shim for both Tracta and Bendix joints. After installing the correct amount of shims, replace the driving hub on the spline shaft and install the six screws.

NOTE—If equipped with the Rzeppa universal, install the same quantity of shims as were removed when the axle drive flange was dismantled. There should be .060" shims on each side with this type joint.

After replacing the wheel, check the front wheel alignment according to "Front Axle Specifications," bleed the brake, and be sure to lubricate the universal joint through the filler plug in the knuckle housing.

CAUTION—An excessively hot steering knuckle housing or center housing may indicate lack of lubricant or a leaky seal.

STEERING KNUCKLE

Disassemble: Remove the hub and brake drum assembly, wheel bearings, axle shaft, spindle and the steering knuckle. Remove the screws which hold the oil seal retainers in place, and the nuts which hold the lower kingpin bearing cap. Then take off the nuts which hold the upper steering arm in position and remove the brake shield and steering arm. The steering knuckle can now be removed from the axle.

NOTE—Wash all parts in cleaning solution and inspect the bearings and races for scores, cracks or chips, replacing any that are damaged. If the bearing cups are damaged, they can be removed by the use of a driver or a suitable drift.

Assemble: Reverse the procedure outlined above to assemble the unit, but when installing the steering knuckle, sufficient shims must be placed under the arm and lower bearing cap so the proper tension will be maintained on the bearing. These shims are available in thicknesses of .003", .005", .010" and .030".

NOTE—Install one shim of each of the thicknesses mentioned above, over the studs on the steering knuckle—top and bottom. Replace the arm and lower bearing cap, lock washer and nuts, and tighten securely. Check the tension of the bearings by hooking a checking scale in the hole in the arm for the tie rod socket, and, either remove or add shims until the load is approximately 25 to 35 inch pounds without the oil seal assembly in position. Make sure there are the same thickness of shims between the arm and the knuckle as there are between the lower cap and knuckle.

Steering Knuckle Oil Seal: To remove the oil seal, take off the eight screws which hold the oil seal in place. Before installing a new seal, examine the spherical surface of the axle for scores or scratches which might damage the seal. Roughness of any kind should be smoothed down with emery cloth.

Install both upper and lower halves of the oil seal, making sure that the felt fits snugly at the points where the upper and lower halves come together.

CAUTION—After driving in wet, freezing weather, swing the front wheels from right to left and remove any moisture adhering to the oil seal and spherical surface of the axle housing. This will prevent freezing with resulting damage to oil seal felts. Should the vehicle be stored for any long period of time, coat these surfaces with light grease to prevent rusting.

BRAKE SPECIFICATIONS

SERVICE BRAKES

Type	4-Wheel Hydraulic
Size	9" x 1¾"
Fluid Capacity	¾ Pt.

MASTER CYLINDER

Size	1"
Mounted	L.H. Frame Side Rail

WHEEL CYLINDER

Size	Front 1" Rear ¾"

BRAKE SHOES

	Bendix
Size	9" x 1¾"
Lining area	117.8 Sq. In.
Length Lining-Forward shoe	10 7/32"
Length Lining-Reverse shoe	6 39/64"
Width	1¾"
Thickness	.206"-.216"

HAND BRAKE

Type	Mechanical
Size	8"
Lining	Woven
Length (Each shoe)	8⅛"
Width	1¾"
Thickness	.206"-.216"
Brake Pedal Return Spring—Length	5⅞"
Load when extended to 7 9/16"	23 lbs.
Brake Shoe Return Spring—Length	5 13/16"
Load when extended to 6 3/16"	40 lbs.
Wheel Cylinder Spring Load when compressed to 1 7/16"	1 to 1¼ lbs.
Master Cylinder Spring— Load when compressed to 1 15/16"	6 lbs.

BRAKE SERVICE

NOTE—For complete information covering the service of the Bendix Hydraulic Brake, see page 845.

WHEEL SPECIFICATIONS

WHEELS

Make	Kelsey-Hayes
Rim 16x4.50 Drop Center	
Tires	16 x 6.00
Type	Mud and Snow Non-Directional Tread or Highway Type Tread
Tire Pressure	28 lbs.

BEARINGS—FRONT AND REAR

	Inner	Outer
Make	Timken	Timken
Cone and roller	18590	18590
Cup	18520	18520

CIVILIAN JEEP

STEERING SPECIFICATIONS

STEERING GEAR

Make	Ross
Type	Cam and Twin Pin Lever
Model	T-12
Ratio	Variable Ratio, 14-12-14 to 1
Wheel	3 spoke 17¼", Safety type

BEARINGS

Cam Upper	Ball
Cam Lower	Ball
Lever Shaft	Bushing
Steering Column Upper	Ball

LEVER SHAFT

Clearance to Bushing	.0005"-.0025"
End Play	.000"
Lash at Cam (Straight ahead)	Slight drag over high point

STEERING CONNECTING ROD

Make	Columbus Auto Parts
Type	Spring loaded
Adjustment	Threaded Plug

STEERING GEOMETRY

Toe-in	3/64"-3/32"
Camber	1½°
Caster	3°
Turning Radius	18 ft.
Toe out—On Turns	
Inside wheel	20°
Outside wheel	18°30'

STEERING GEAR SERVICE

NOTE—For complete information covering the service of Ross Steering Gear, see page 821.

FRAME SPECIFICATIONS

FRAME	SAE1025
Depth Maximum	4.186"
Thickness Maximum	.083"-.093"
Flange Width	1¾"
Length	122¾"
Width	
Front	29¼"
Rear	29¼"
Number Cross Members.	5-"K" member at Rear
Weight	140 lbs.
Wheel Base	80"

TREAD

Rear	48¼"
Front	48¼"

SPRING SPECIFICATIONS

FRONT SPRING

Make	Mather
Type Leaf	Parabolic
Length—Center to Center of Eye	36¼"
Width	1¾"
Number of Leaves	8
Rebound Clips	4
Eye—Center to Center Bolt	18⅛"
Left Camber under 525 lbs.	5/16"
Right Camber under 390 lbs.	5/16"
Rear Eye Bushed	1¾" long; .5655" I.D.

REAR SPRING

Make	Mather
Type Leaf	Parabolic
Length—Center to Center of Eye	42"
Width	1¾"
Number of Leaves	9
Rebound Clips	4
Eye—Center to Center Bolt	2:"
Camber under 800 lbs.	¼"
Front Eye Bushed	1¾" long; .5655" I.D.

SHOCK ABSORBER SPECIFICATIONS

Make	Front-Monroe	Rear-Monroe
Type	Hydraulic	Hydraulic
Action	Double	Double
Length Compressed	10 9/16"	11 9/16"
Length Extended	16⅛"	18⅛"
Adjustable	Yes	Yes
Refillable	Yes	Yes
Mountings	Rubber	Rubber

SHOCK ABSORBER SERVICE

NOTE—For complete information covering the service of Monroe Shock Absorbers, see page 836.

BUDA ENGINE TUNE UP CHART

Year	Engine Model	Firing Order	Spark Plug Gap	Breaker Gap	Cam Angle, Degrees	Timing Mark Location	Spark Timing, Degrees	Tappet Clearance For Running, Hot Int.	Tappet Clearance For Running, Hot Exh.	Tappet Clearance For Timing, Intake
1936–42	GF-638	153624	.025	①	②	Flywheel	½" After TDC	.010	.016	.010
1936–46	HP-205	1342	.025	①	②	Flywheel	½" After TDC	.006	.009	.006
1936–46	HP-217	1342	.025	①	②	Flywheel	½" After TDC	.006	.009	.006
1942–46	HP-234	1342	.025	①	②	Flywheel	½" After TDC	.006	.009	.006
1936–42	HP-260	153624	.025	①	②	Flywheel	½" After TDC	.006	.009	.006
1936–42	HP-298	153624	.025	①	②	Flywheel	½" After TDC	.006	.009	.006
1937–46	HP-326	153624	.025	①	②	Flywheel	½" After TDC	.006	.009	.006
1942–46	HP-351	153624	.025	①	②	Flywheel	½" After TDC	.006	.009	.006
1936–39	J-214	153624	.025	①	②	Flywheel	½" After TDC	.006	.009	.006
1936–39	K-325	153624	.025	①	②	Flywheel	½" After TDC	.006	.009	.006
1936–41	K-369	153624	.025	①	②	Flywheel	½" After TDC	.006	.009	.006
1936–46	K-393	153624	.025	①	②	Flywheel	½" After TDC	.006	.009	.006
1936–46	K-428	153624	.025	①	②	Flywheel	½" After TDC	.006	.009	.006
1936–40	L-468	153624	.025	①	②	Flywheel	½" After TDC	.006	.009	.006
1936–46	L-525	153624	.025	①	②	Flywheel	½" After TDC	.006	.009	.006
1937–40	LO-468	153624	.025	①	②	Flywheel	½" After TDC	.009	.018	.009
1937–46	LO-525	153624	.025	①	②	Flywheel	½" After TDC	.009	.018	.009
1937–40	M-707	153624	.025	①	②	Flywheel	½" After TDC	.010	.016	.010
1937–42	M-766	153624	.025	①	②	Flywheel	½" After TDC	.010	.016	.010

① ② Various makes and models of distributors are used on these engines, depending upon truck in which they are used. For correct breaker gap and cam angle, look up distributor model used on engine serviced in the Ignition System chapter of this Manual where the specifications will be found.

CONTINENTAL ENGINE TUNE UP CHART

Year	Engine Model ①	Firing Order	Spark Plug Gap	Breaker Gap	Cam Angle, Degrees	Timing Mark Location	Spark Timing, Degrees	Tappet Clearance For Running, Hot Int.	Tappet Clearance For Running, Hot Exh. ④	Tappet Clearance For Timing, Intake
1940–46	A6244, 25B	153624	.025	②	③	Flywheel	IGN Mark	⑤	⑤	⑤
1942–46	B6371, 41B	153624	.025	②	③	Flywheel	IGN Mark	.017	.025	.022
1940–46	B6405, 42B	153624	.025	②	③	Flyhweel	IGN Mark	.017	.025	.022
1936–37	C400	1342	.030	②	③	Flywheel	IGN Mark	.013	.013	.014
1936–46	E600, 29B	153624	.025	②	③	Flywheel	9° Before TDC	.018	.018	.018
1936–46	E601, 31B	153624	.025	②	③	Flywheel	9° Before TDC	.018	.018	.018
1936–46	E602, 32B	153624	.025	②	③	Flywheel	9° Before TDC	.018	.018	.018
1936–46	E603, 37B	153624	.025	②	③	Flywheel	9° Before TDC	.018	.018	.018
1938–46	F4124	1342	.025	②	③	Flywheel	IGN Mark	⑥	⑥	⑥
1937–46	F4140	1342	.028–.030	②	③	Flywheel	IGN Mark	⑥	⑥	⑥
1937–46	F4162	1342	.028–.030	②	③	Flywheel	IGN Mark	⑥	⑥	⑥
1936–46	F6170	153624	.025	②	③	Flywheel	IGN Mark	.014	.014	.017
1936–46	F6199	153624	.025	②	③	Flywheel	IGN Mark	.014	.014	.017
1936–46	F6209, 24B	153624	.025	②	③	Flywheel	IGN Mark	.014	.014	.017
1936–46	F6218	153624	.028–.030	②	③	Flywheel	IGN Mark	.014	.014	.017
1940	F6226	153624	.025	②	③	Flywheel	IGN Mark	.014	.014	.017
1940	M6253	153624	.025	②	③	Flywheel	IGN Mark	.022⑦	.022⑦	.022⑦
1938–46	M6271	153624	.025	②	③	Flywheel	IGN Mark	.022⑦	.022⑦	.022⑦
1938–46	M6290, 38B	153624	.025	②	③	Flywheel	IGN Mark	.022⑦	.022⑦	.022⑦
1938–46	M6330, 40B	153624	.025	②	③	Flywheel	IGN Mark	.022⑦	.022⑦	.022⑦

CONTINENTAL ENGINE TUNE UP CHART

Year	Engine Model ①	Firing Order	Spark Plug Gap	Breaker Gap	Cam Angle, Degrees	Timing Mark Location	Spark Timing, Degrees	Tappet Clearance For Running, Hot Int.	Tappet Clearance For Running, Hot Exh. ④	Tappet Clearance For Timing, Intake
1937–46	Y4069	1342	.025	②	③	Flywheel	IGN Mark	.012	.012	.014
1936–46	Y4091	1342	.025	②	③	Flywheel	IGN Mark	.012	.012	.014
1940–46	Y4112	1342	.025	②	③	Flywheel	IGN Mark	.012	.012	.014
1936–46	20R, 33B	153624	.025	②	③	Flywheel	IGN Mark	.014	.020	.013
1936–46	21R, 34B	153624	.025	②	③	Flywheel	IGN Mark	.014	.020	.013
1936–46	22R, 35B	153624	.025	②	③	Flywheel	IGN Mark	.014	.020	.013

① Engine models having the letter "B" following the number are Brockway models.

② ③ Various makes and models of distributors are used on these engines, depending upon truck in which they are used. For correct breaker gap and cam angle, look up distributor model used on engine serviced in the Ignition System chapter of this Manual where the specifications will be found.

④ If engine is equipped with Stellite exhaust valves, clearance should be increased .003″.

⑤ With camshaft Nos. A6001A–433 and A6001–425, running clearance, intake .017″, exhaust .022″; for timing, intake and exhaust .017″. With camshaft No. A6001–217, running and timing clearance .014″.

⑥ With camshaft No. F1401–300, clearance for running and timing .014″. With camshaft No. F4001–403, clearance for running and timing .017″.

⑦ If equipped with Roto valves, set clearance at .018″.

HERCULES ENGINE TUNE UP CHART

Year	Engine Model	Firing Order	Spark Plug Gap	Breaker Gap	Cam Angle, Degrees	Timing Mark Location	Spark Timing, Degrees	Tappet Clearance For Running, Hot Int.	Tappet Clearance For Running, Hot Exh.	Tappet Clearance For Timing, Intake
1936–46	HX	153624	.025	①	②	Flywheel	DC1-6 Mark	.010	.016	.008
1936–46	IX	1243	.025	①	②	Flywheel	SPARK Mark	.006	.008	.006
1936–46	IX	1243	.025	①	②	Flywheel	SPARK Mark	.006	.008	.006
1936–46	JXA	153624	.025	①	②	Flywheel	1⅞″ Before	.008	.010	.008
1936–46	JX	153624	.025	①	②	Flywheel	1⅞″ Before	.008	.010	.008
1936–44	OO	1243	.025	①	②	Flywheel	DC Mark③	.008	.012	.008
1936–43	OX	1243	.025	①	②	Flywheel	DC Mark③	.008	.012	.008
1936–46	OXC	1243	.025	①	②	Flywheel	DC Mark③	.008	.012	.008
1936–46	QX	153624	.025	①	②	Flywheel	1⅝″ Before	.008	.010	.008
1936–46	RXB	153624	.025	①	②	Flywheel	DC1-6 Mark④	.006	.010	.006
1936–46	RXC	153624	.025	①	②	Flywheel	DC1-6 Mark④	.006	.010	.006
1940–46	RXLC	153624	.025	①	②	Flywheel	DC1-6 Mark④	.006	.010	.006
1940–46	RXLD	153624	.025	①	②	Flywheel	DC1-6 Mark④	.006	.010	.006
1936–46	WXC	153624	.025	①	②	Flywheel	DC1-6 Mark④	.006	.010	.006
1936–46	WXC–2	153624	.025	①	②	Flywheel	DC1-6 Mark④	.006	.010	.006
1936–46	WXC–3	153624	.025	①	②	Flywheel	DC1-6 Mark④	.006	.010	.006
1936–46	WXLC	153624	.025	①	②	Flywheel	DC1-6 Mark④	.006	.010	.006
1936–46	WXLC–3	153624	.025	①	②	Flywheel	DC1-6 Mark④	.006	.010	.006
1936	YXB	153624	.025	①	②	Flywheel	DC1-6 Mark④	.006	.010	.006
1936–45	YXC	153624	.025	①	②	Flywheel	DC1-6 Mark④	.006	.010	.006
1936–45	YXC–2	153624	.025	①	②	Flywheel	DC1-6 Mark④	.006	.010	.006
1936–45	YXC–3	153624	.025	①	②	Flywheel	DC1-6 Mark④	.006	.010	.006

① ② Various makes and models of distributors are used on these engines depending upon the truck in which they are used. For correct breaker gap and cam angle, look up distributor model used on the engine being serviced in the Ignition System Chapter of this Manual where the specifications will be found.

③ SPARK Mark when engine is fitted with magneto.

④ 20° Before when engine is fitted with magneto.

WAUKESHA ENGINE TUNE UP CHART

Year	Engine Model	Firing Order	Spark Plug Gap	Breaker Gap	Cam Angle, Degrees	Timing Mark Location	Spark Timing, Degrees	Tappet Clearance		
								For Running, Hot		For Timing, Intake
								Int.	Exh.	
1936–39	6BA	153624	.025	①	②	Flywheel	DC Mark	.010–.012	.014–.016	.004
1936–46	6BK	153624	.025	①	②	Flywheel	DC Mark	.010–.012	.014–.016	.004
1936–46	6BL	153624	.025	①	②	Flywheel	DC Mark	.010–.012	.014–.016	.004
1936–46	6BM	153624	.025	①	②	Flywheel	DC Mark	.010–.012	.014–.016	.004
1937–46	6BZ	153624	.025	①	②	Flywheel	DC Mark	.010–.012	.014–.016	.004
1941–46	6BZR	153624	.025	①	②	Flywheel	DC Mark	.010–.012	.014–.016	.004
1936–46	FC	1342	.025	①	②	Flywheel	DC Mark	.005–.007	.009–.011	.005
1936–40	FL	1342	.025	①	②	Flywheel	DC Mark	.005–.007	.009–.011	.005
1936–46	FCL	1342	.025	①	②	Flywheel	DC Mark	.005–.007	.009–.011	.005
1936–46	FCS	1342	.025	①	②	Flywheel	DC Mark	.005–.007	.009–.011	.005
1936–40	FS	1342	.025	①	②	Flywheel	DC Mark	.005–.007	.009–.011	.005
1937–46	6GAK	153624	.025	①	②	Flywheel	DC Mark	.015–.017	.024–.026	.011
1936–41	6GAL	153624	.025	①	②	Flywheel	DC Mark	.015–.017	.024–.026	.011
1936–37	6MK	153624	.025	①	②	Flywheel	DC Mark	.008–.010	.016–.018	.004
1938–46	6MKR	153624	.025	①	②	Flywheel	DC Mark	.008–.010	.016–.018	.004
1937–38	6ML	153624	.025	①	②	Flywheel	DC Mark	.008–.010	.016–.018	.004
1937–38	6MS	153624	.025	①	②	Flywheel	DC Mark	.008–.010	.016–.018	.004
1936–39	6MZ	153624	.025	①	②	Flywheel	DC Mark	.008–.010	.016–.018	.004
1938–46	6MZR	153624	.025	①	②	Flywheel	DC Mark	.008–.010	.016–.018	.004
1936–37	6RB	153624	.025	①	②	Flywheel	DC Mark	.006–.008	.010–.012	.008
1938–41	6RBR	153624	.025	①	②	Flywheel	DC Mark	.006–.008	.010–.012	.008
1936–37	6SRK	153624	.025	①	②	Flywheel	DC Mark	.008–.010	.018–.020	.004
1938–46	6SRKR	153624	.025	①	②	Flywheel	DC Mark	.008–.010	.018–.020	.004
1936–37	6SRL	153624	.025	①	②	Flywheel	DC Mark	.008–.010	.018–.020	.004
1938–46	6SRLR	153624	.025	①	②	Flywheel	DC Mark	.008–.010	.018–.020	.004
1937–39	6SRS	153624	.025	①	②	Flywheel	DC Mark	.008–.010	.018–.020	.004
1939–46	6WAK	153624	.025	①	②	Flywheel	DC Mark	.013–.015	.022–.024	.012
1939–46	6WAL	153624	.025	①	②	Flywheel	DC Mark	.013–.015	.022–.024	.012
1936–46	XAH	1243	.025	①	②	Flywheel	DC Mark	.009–.011	.009–.011	.010
1936–39	XAK	1243	.025	①	②	Flywheel	DC Mark	.004	.006–.008	.004
1936–39	6-110	153624	.025	①	②	Flywheel	DC Mark	.012	.016	.010
1936–39	6-125	153624	.025	①	②	Flywheel	DC Mark	.012	.016	.010

① ② Various makes and models of distributors are used on these engines depending upon truck in which they are used. For correct breaker gap and cam angle, look up distributor model used on engine being serviced in the Ignition System chapter of this Manual where the specifications will be found.

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CONTINENTAL ENGINE

ENGINE SPECIFICATIONS

Engine model (Brockway 48B)	R6572
Engine type	6 cyl. Overhead valves
Bore	4¾"
Stroke	5⅜"
Piston displacement, cu. in.	571.7
Compression ratio	5.97
Taxable horsepower	52.4
Brake horsepower	175 @ 2600 RPM
Maximum torque	436 @ 1250 RPM
Oil capacity	16 qts.

TUNE UP DATA

Firing order	153624
Spark plug gap	.025"
Timing mark location	Flywheel
Spark timing mark	IGN

VALVE SYSTEM

Valve stem clearance, intake	.002"
Exhaust	.004"
Tappet guide clearance	.0015"
Tappet clearance:	
For runinng	.020"
For timing	.013"
Valve seat angle; degrees:	
Intake	30
Exhaust	45
Valve spring length, valve closed	2¼"
Valve spring pressure:	
Outer	70 lbs. @ 2¼"
Inner	35 lbs. @ 2¼"
Valve timing:	
Intake opens	12° BTDC
Exhaust closes	15° ATDC

PISTON & RING CLEARANCES

Piston skirt clearance	.006"
Piston fitted with ½ inch feeler with 5 to 10 pounds pull on spring scale.	
Ring end gap	.013" to .018"
Ring and groove clearance	.002"

ENGINE BEARING SPECIFICATIONS

Camshaft journal diameter	2.1220-2.1225"
Camshaft bearing clearance	.0015-.0025"
Connecting rod journal diameter	2.999-3.000"
Rod bearing clearance	.002-.0046"
Main bearing journal diameter	3.249-3.250"
Main bearing clearance	.002-.0046"

CUMMINS ENGINES

MODELS NH and NHS

NOTE—For service on these engines, follow procedure given for the H models on pages 236 through 266. This also applies to the service on the Cummins Fuel Injection System on pages 391 through 427.

SPECIFICATIONS

Type	Valve in head diesel
No. of cylinders	6
Bore	5⅛"
Stroke	6"
Piston displacement	743 cu. in.
Compression pressure:	
NH	500-525 lbs.
NHS	600-625 lbs.
Cylinder head material	Alloy cast iron
Cylinder head nut tension	430-450 ft. lbs.
Firing order	1-5-3-6-2-4
Compression ratio:	
NH	15.5:1
NHS	13.5:1
Head gaskets—material.	Special steel asbestos

VALVES—NH AND NHS

Intake—angle of valve seat	30°
CLEARANCE—Set valves with engine oil temperature at 140°F. and with injectors adjusted	.017"
Exhaust—angle of valve seat	30°
CLEARANCE—Set with engine oil temperature at 140° F. and with injectors adjusted	.027"

VALVE SRINGS—Intake and Exhaust

Spring pressure:	
Valve open	102 lbs.
Valve closed	72 lbs.
Free length	3¼"

PISTONS

Material	Aluminum
Clearance	.010"

PISTON PINS

Diameter	1.9988" to 1.9990"
Oversize available	.005" to .010"
Fit in piston.	Shrink fit—Heat piston in boiling water before inserting pin
Method of fastening	Lock rings

PISTON RINGS

Gap clearance:	
Compression rings	.010" to .020"
Oil ring	.010" to .018"

CONNECTING RODS

Bearing clearance: copper lead—lead plated	.003" to .005"
End clearance	.006" to .010"
Length (center to center)	11.998" to 12.000"
Undersize replacement bearings available:	

MAIN BEARINGS

Type .... Precision type—steel backed

Undersize replacement bearings available:
.... .010″, .020″, .030″, .040″

End thrust .... .006″ to .008″

Bearing clearance: copper lead—lead plated .... .004″ to .006″

Nut tension .... 310 to 330 ft. lbs.

CAMSHAFT

Material .... Steel forging

Journal diameter .... 1.997″ to 1.998″

Bearing clearance .... .0015″ to .004″

End thrust—taken on thrust washer behind cam gear and thrust plate in gear cover .... .008″ to .010″

CAMSHAFT BEARINGS

Diameter inside .... 1.9995″ to 2.001″

Length:

No. 1 .... 2¼″

Nos. 2, 4, 6 .... 1⅞″

Nos. 3, 5 .... 2⅜″

No. 7 .... 2¹¹⁄₁₆″

CRANKSHAFT

Main Journals .... 4.499″ to 4.500″

Connecting rod journals ... 3.124″ to 3.125″

Supercharger and generator run at
.... 1.8 crankshaft speed

INTERNATIONAL

RED DIAMOND ENGINES

Year	Engine Model	Number Cylinders and Valve Arrangement	Bore and Stroke	Displacement Cubic Inches	Compression Ratio	Taxable H. P.	Brake H. P. at R. P. M.	Maximum Torque at R. P. M. Pounds Feet	Oil Capacity Quarts
1942–46	RED-361 (A)	6-I	4⅛x4½	361	6.3	40.8	129 @ 3000	282 @ 1200	8
1942–46	RED-401 (A)	6-I	4⅛x5	401	6.3	40.8	141 @ 2800	318 @ 1200	8
1942–46	RED-450 (A)	6-I	4⅜x5	450	6.3	45.9	148 @ 2600	360 @ 1000	8

ENGINE BEARING SPECIFICATIONS

Year	Engine Model	Camshaft		Connecting Rod			Mains				
		Journal Diameter	Clearance	Journal Diameter	Clearance	Bearing Bolt Tension Lb. Ft.	Journal Diameter	Clearance	Bearing Bolt Tension Lb. Ft.	Thrust on No.	End-play
1942–46	RED-361 (A)	①	.001–.0035	2.751–2.752	.002–.0045	56–70	3.2495–3.2505	.002–.0045	⑥	7	.004–.012
1942–46	RED-401 (A)	①	.001–.0035	2.751–2.752	.002–.0045	56–70	3.2495–3.2505	.002–.0045	⑥	7	.004–.012
1942–46	RED-450 (A)	①	.001–.0035	2.751–2.752	.002–.0045	56–70	3.2495–3.2505	.002–.0045	⑥	7	.004–.012

① No. 1—2.109″–2.110″. No. 2—2.089″–2.090″. No. 3—2.069″–2.070″. No. 4—1.499″–1.500″.

⑥ For ½″ and ⁹⁄₁₆″ bolts, 75 to 85 pounds feet; for ⅝″ bolts, 90 to 100 pounds feet.

TUNE UP CHART

Year	Engine Model	Firing Order	Spark Plug Gap	Breaker Gap	Cam Angle, Degrees	Timing Mark Location	Spark Timing, Degrees	Tappet Clearance For Running, Hot		Tappet Clearance For Timing, Intake	Battery Terminal Grounded
								Int.	Exh.		
1942–46	RED-361 (A)	153624	.028–.032	.018–.024	35	Vib. Damp.	4BTDC	.018	.018	.023	Positive
1942–46	RED-401 (A)	153624	.028–.032	.018–.024	35	Vib. Damp.	TDC	.018	.018	.023	Positive
1942–46	RED-450 (A)	153624	.028–.032	.018–.024	35	Vib. Damp.	TDC	.018	.018	.023	Positive

VALVE SYSTEM

Year	Engine Model	Stem Clearance		Tappet Guide Clearance	Tappet Clearance				Valve Spring Pressure Test		Valve Seat Angle, Degrees
					Running Hot		Timing				
		Intake	Exhaust		In-take	Ex-haust	In-take	Ex-haust	Free Length, Inches	Pounds at Inches, Length	
1942–46	RED-361 (A)	.0015–.0035	.002–.004	.001–.003	.018	.018	.023	.023	I 2 11/32 O 2 9/16	I 86 @ 1 33/64 O 136 @ 1 45/64	Int. 15 Exh. 45
1942–46	RED-401 (A)	.0015–.0035	.002–.004	.001–.003	.018	.018	.023	.023	I 2 11/32 O 2 9/16	I 86 @ 1 33/64 O 136 @ 1 45/64	Int. 15 Exh. 45
1942–46	RED-450 (A)	.0015–.0035	.002–.004	.001–.003	.018	.018	.023	.023	I 2 11/32 O 2 9/16	I 86 @ 1 33/64 O 136 @ 1 45/64	Int. 15 Exh. 45

I—Inner spring. O—Outer spring.

PISTON AND RING CLEARANCES

Year	Engine Model	Piston Skirt, Inches		Fitting Pistons with Shim and Spring Scale		Ring End Gap, Inch ①		Ring and Groove, Inch	
		Top	Bottom	Shim Thickness	Pounds Pull on Scale	Com-pression	Oil	Com-pression	Oil
1942–46	RED-361 (A)	.0035–.004	.0015–.002	.003	3 to 6	.013–.023	.013–.021	.0015–.003	.0015–.003
1942–46	RED-401 (A)	.0035–.004	.0015–.002	.003	3 to 6	.013–.023	.013–.021	.0015–.003	.0015–.003
1942–46	RED-450 (A)	.0035–.004	.0015–.002	.003	3 to 6	.013–.023	.013–.021	.0015–.003	.0015–.003

① Fit rings in tapered bores for minimum clearance in tighest portion of ring travel.

⑤ For top ring only; 2nd and 3rd rings, .002″–.0035″.

CYLINDER HEAD

RED—Tighten cylinder head in the order shown on page 117, using a torque wrench to a specified tension of 80 pounds feet.

ROCKER ARMS & SHAFTS

RED—See page 117 for instructions, and refer to FBC engine for details.

VALVE SPRINGS

RED—Install valve springs with close-coiled ends against cylinder head. Valve springs should be checked with valve spring tester and replaced if they do not come within the specifications given in the **Valve System** table.

VALVE CLEARANCE ADJUSTMENT

RED—See page 123 for instructions.

VALVE SEAT INSERTS

RED—See page 123 for instructions.

VALVE STEM GUIDES

RED—See page 124 for instructions but ream guides to .437".

VALVE TAPPETS & GUIDES

RED—Follow instructions given on page 123 for FBC engines.

VALVE TIMING

RED—Check valve timing with engine at normal room temperature and adjust valve lash to the clearance for timing as given in the **Valve System** table. Intake opens 8 degrees before top dead center and exhaust closes 15 degrees after top dead center.

TIMING GEARS

RED—See page 125 for instructions and illustration for correct setting.

CAMSHAFT & BEARINGS

RED—Follow instructions given for FAB engines on page 125.

PISTONS & RODS, REMOVE

RED—See page 125 for instructions. Pistons are removed from top of block.

PISTONS & RODS, ASSEMBLE

RED—Pistons are assembled to connecting rods with the vertical slot toward the camshaft. Piston heads are marked with an arrow, indicating that the piston shall be installed with the **arrow toward the front.**

CYLINDER BORES, SLEEVES & LINERS

RED—See instructions starting on page 125 and follow specific procedure given for FBC engines.

PISTONS, RENEW

RED—See page 126 for instructions.

PISTON RINGS, RENEW

RED—Follow instructions given on page 126.

PISTON PINS, RENEW

RED—See page 126 for instructions.

PISTON PIN BUSHINGS

RED—See page 126 for instructions.

CONNECTING ROD BEARINGS

RED—See page 126 for instructions.

MAIN BEARINGS, RENEW

RED—See page 128 for instructions.

CRANKSHAFT & END THRUST

RED—See page 128 for instructions. End thrust is taken on the rear bearing.

VIBRATION DAMPER

RED—Follow instructions given for FBC engines on page 128.

FLYWHEEL & CLUTCH HOUSING ALIGNMENT

RED—See page 130 for instructions.

FLYWHEEL MOUNTING

RED—Follow instructions given for FAB engines on page 130.

ENGINE MOUNTINGS

RED—Front engine mounting attaching screws should be tightened so that the mounting screw springs are compressed to 3⅛ inches.

When assembling the rear mounting trunnion, tighten the nut while rotating the trunnion slowly. When tightening of the trunnion shaft unit just stops the trunnion, back the nut off 1/6 turn or to the next cotter pin hole. The trunnion should be free to move on the trunnion shaft but should not be too loose.

OIL PUMP

RED—See instructions given for FAB engines on page 132.

OIL PRESSURE REGULATOR

RED—Oil pressure is controlled by the pressure valve spring located in the oil pressure regulator.

OIL FILTER

RED—See page 134 for instructions as given for FBB engines.

WATER PUMP, OVERHAUL

RED—The pump used on these engines is similar to the FAC pump shown on page 135. It is equipped with a ball bearing at each end and is mechanically sealed. The seal is held in place by spring pressure and, therefore, the pump requires no adjustment.

Should the pump leak, either the seal is worn or the thrust surface of the pump housing is worn. Regardless of the cause, however, the pump must be dismantled to repair the leak.

To overhaul the pump, remove the fan pulley, being careful not to damage its flanges. Release the snap ring from the front bearing. Take off the rear cover plate. Press the shaft out of the impeller **from the rear** and remove the shaft and bearings as a unit. Press the shaft from the bearings, sleeve and slinger, and remove the lock rings. Release the lock ring from the impeller and take out the seal washer, seal and spring, noting carefully the arrangement of these parts so that no difficulty will be experienced when assembling.

NOTE—Before assembling the pump, check the thrust face of the housing for wear. If the surface is not true and smooth, a special facing cutter (SE-1278) must be used to reface the housing.

To assemble the pump, apply a liberal amount of grease to the bearings and to the shaft between the bearings. Then install the shaft and bearings in the housing as a unit. Press the impeller and seal assembly **down onto the shaft,** pressing it down just **flush** with the end of the shaft. Complete the assembly by installing the cover plate and fan pulley.

FAN BELT

RED—Proper tension of the belt is obtained when the belt can be depressed approximately ½ inch between the fan and generator pulleys.

Fan belts are furnished in matched sets and it is recommended that when replacement is necessary, both belts be replaced.

WATER THERMOSTAT

RED—See page 136 for instructions.

EXHAUST PIPE SEAL RING

RED—Follow instructions given for FAB engines on page 136.

EXHAUST MANIFOLD SEALS

RED—Follow instructions given for FBB engines on page 137.

IGNITION TIMING

RED—Follow instructions given on page 137.

WAUKESHA GASOLINE ENGINES

SPECIFICATIONS:	140-GK	145-GK	6-MZA
Number of cylinders	6	6	6
Valve arrangement	In head	In head	L head
Bore and stroke	4½ x 5½	5¼ x 6	4¼ x 4¾
Piston displacement, cu. in.	525	779	404
Compression ratio	6	6.2	5.6
Taxable horsepower	160 @ 2400	186 @ 2000	126 @ 2650
Max. torque, RPM, lbs. ft.	410 @ 1200	590 @ 1000	290 @ 1200
Oil capacity, qts.	10	18	8
Firing order	153624	153624	153624
Spark plug gap, inches	.025-.030	.025-.030	.025-.030
Valve setting, cold:			
Intake	.012-.014	.012-.014	.012-.014
Exhaust	.018-.020	.023-.025	.020-.022
Valve setting for timing, intake	.010	.010	.010
Piston clearance, bottom skirt:			
Cast iron pistons	.005	.005	......
Aluminum pistons	.005	.006	......
Piston ring end gap	.015-.025	.015-.025	......
Piston ring groove clearance	.001-.007	.002-.008	......
Crankshaft bearing journal diameters:			
Connecting rod	2.624-2.625	2.999-3.000	2.249-2.250
Main bearing	3.249-3.250	3.499-3.500	2.624-2.625
Crankshaft bearing clearances:			
Connecting rods	.001-.003	.001-.003	.001-.003
Main bearings	.0015-.004	.0025-.005	.0015-.004
Main bearing which takes thrust	Rear	Rear	Rear
Crankshaft end play	.003-.007	.003-.007	.003-.007

NOTE—In servicing these engines, follow the instructions given on pages 190 through 197.

CARTER CARBURETOR WE SERIES

STUDEBAKER 1946, M5, M15

The Carter WE carburetor is essentially the same as the Carter WA-1 described on page 491. However, there are several changes in the location of the parts in the climatic control mechanism. The fast idle cam assembly, choke trip lever, unloader mechanism, etc., are located in the climatic control housing. In this way, all these parts are protected from dirt and other foreign matter.

The by-pass in the low speed circuit (see cut) is extended to a point above the closed choke valve. This produces a richer calibration for part throttle operation while the choke is closed or partly closed. Check to see that the air horn gasket does not leak at this point and the calibrated hole in the upper surface of the body is clean.

CLIMATIC CONTROL ASSEMBLY

When assembling the parts, slide the fast idle cam assembly onto the choke shaft. Install the choker shaft into the air horn and revolve the cam to allow the piston to slide freely into the cylinder. Then lock the fast idle cam spring ends around the nib of the cam and the projecting nib of the chocker shaft assembly.

Install the choker valve with the trademark to the top, seating the valve before tightening the screws. The valve must not bind in any position, but must fall free of its own weight. Install the fast idle link and choke trip lever. Place washer on the choke connector rod before attaching to the fast idle link. Install the spring and retainer.

Fast idle and unloader adjustments should be made at this point before the balance of the climatic control is assembled. After making the adjustments in the manner described below, install the baffle plate and attaching screw, and the coil housing gasket. With the choke wide open, hold the coil housing with the notch revolved ¼ turn clockwise from the index mark on the housing. Place against the housing and revolve counter-clockwise to center the index mark. Lock the housing in place with screws and retainer.

CARBURETOR ADJUSTMENTS

Float Setting—With bowl cover inverted and float lip resting on seated needle, the distance from soldered seam of float to small projection on machined surface of bowl cover should be ¼". Adjustment should be made by bending lip of float lever. Use gauge T109-31. After making float adjustment, adjust stops on float bracket so the free end of the float can move ½", plus or minus 1/32".

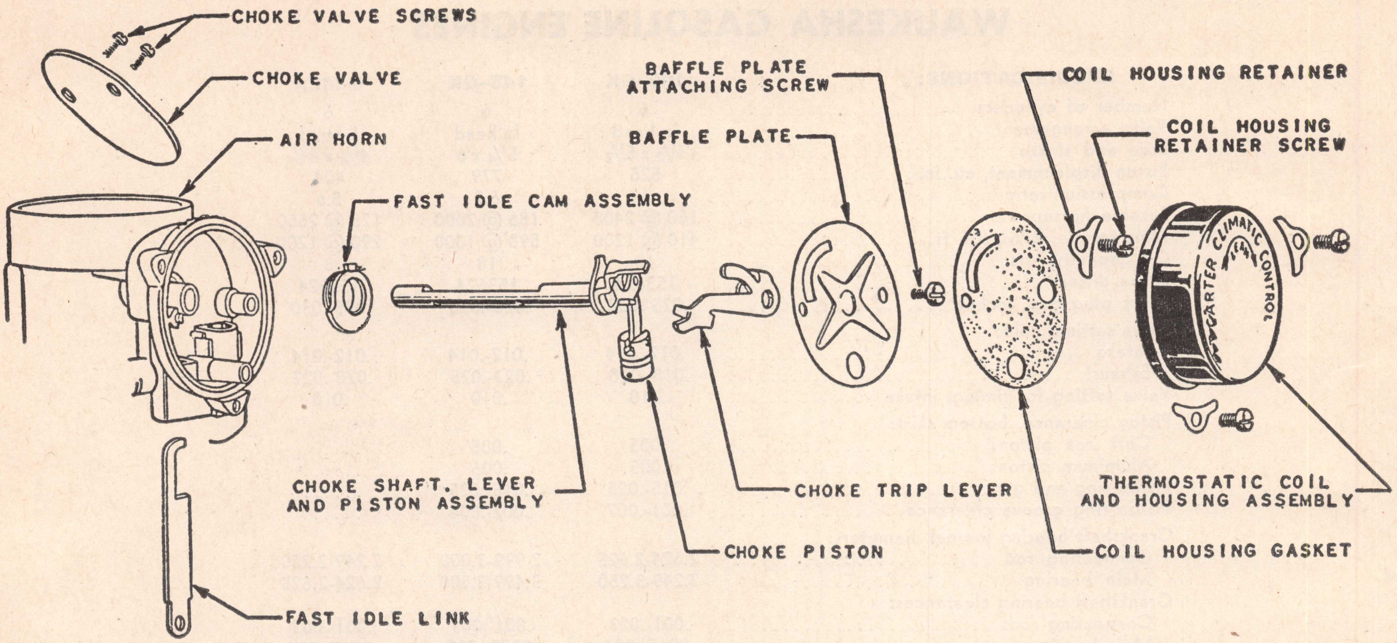
Pump Adjustment—This adjustment should be made each time the carburetor is serviced and must be made before the metering rod and anti-percolator settings.

To make the adjustment, back out the throttle lever adjusting screw to allow the throttle valve to seat in the bore of the carburetor. Place the pump travel gauge (T109-117S) on the bowl cover with the lip of the gauge extending over the top of the plunger shaft. Turn the knurled nut of the gauge until the lip rests on top of the plunger shaft, **with throttle valve seated.** Read the number on the gauge as indicated by the notch in the knurled nut. Now repeat the preceding operation with the throttle valve wide open and read the number on the gauge. The difference in the readings obtained at closed and at wide-open throttle should be "17" (17/64"). Adjustment is made by bending the throttle connector rod at the lower angle.

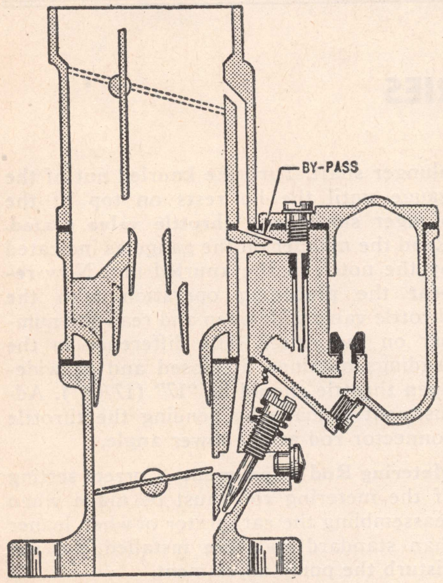
Metering Rod Adjustment—Correct setting of the metering rod must be made when reassembling the carburetor or when leaner than standard rods are installed. Do not disturb the pump adjustment.

To make the adjustment, remove the metering rod and disc, and install gauge T109-102 in place of metering rod, making sure lower end of gauge seats in metering rod jet. Back out the throttle lever set screw so throttle valve seats in carburetor or bore. Make sure fast idle cam does not hold throttle valve open, as it **must** be seated. Press lightly on top of the metering rod arm until the **upper** lip of the arm contacts the pin in the pump arm. There should be less than .005" clearance between shoulder in notch of gauge and metering rod pin. Adjust by bending upper lip on metering arm, using tool T109-105.

NOTE—This carburetor provides an added economy measure by means of the second lip on the metering rod arm which extends


CHOKE VALVE SCREWS
CHOKE VALVE
AIR HORN
FAST IDLE CAM ASSEMBLY
BAFFLE PLATE ATTACHING SCREW
BAFFLE PLATE
COIL HOUSING RETAINER
COIL HOUSING RETAINER SCREW
CARTER CLIMATIC CONTROL
CHOKE SHAFT, LEVER AND PISTON ASSEMBLY
CHOKE TRIP LEVER
CHOKE PISTON
THERMOSTATIC COIL AND HOUSING ASSEMBLY
COIL HOUSING GASKET
FAST IDLE LINK

CARTER WE. Climatic control housing parts

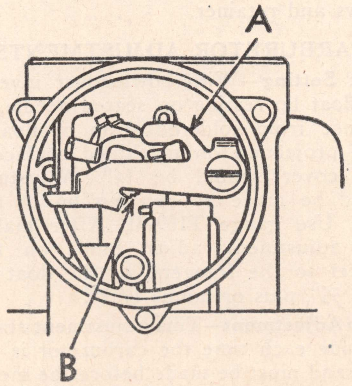


CARTER WE
Low speed circuit

below the pin in the pump arm, and should **be** adjusted as follows: With the throttle valve seated and finger pressing down on metering rod arm so that upper lip contacts pin on pump arm, adjust lower lip for **3/16"** clearance between **bottom** of pump **arm** pin and **upper** surface of lower lip. Use gauge T109-28.

Anti-Percolator Adjustment—Do not disturb pump or metering rod adjustments. Insert .030" gauge (T109-29) between throttle valve and bore of carburetor on the side opposite the idle port. Bend the anti-percolator rocker arm to allow .005" to .015" clearance between rocker arm lip and pump arm.

Fast Idle Adjustment—Remove thermostatic coil housing gasket and baffle plate. Crack the throttle valve, hold the choke valve fully closed, then close throttle. This will allow the fast idle cam to revolve to the fast idle position. With choke valve held tightly closed and slight tension on throttle lever, loosen lock nut on choke connector rod and turn sleeve until there is .054" (gauge T-109-88) clearance between throttle valve and carburetor bore—side opposite idle port. Hold the sleeve in position and secure lock nut.



CARTER WE
"**A**". Choke trip lever
"**B**". Showing fast idle cam in fast idle position

Unloader Adjustment—This must be made after the fast idle adjustment. Hold the throttle valve in wide open position and close choke valve as far as possible without forcing. There should be 3/16" clearance between lower edge of choke valve and inner wall of carburetor (gauge T109-28). Adjust by bending arm on choke trip lever ("A" in cut), using tool T109-187).

CARBURETOR SPECIFICATIONS

Part number	532S
Vent, outside	10
Vent, inside	None
Gasoline intake	46
Low speed jet tube:	
Low speed jet	64
By-pass	50
Economizer	.0755-.0765"
Idle bleed	50
Idle ports:	
Length	.200"
Width	.030"
Port opening, valve closed	.010-.014"
Idle screw seat	46
Main nozzle:	
Inside diameter	30
Discharge jet	44
Metering rod:	
Economy step	.068"
Middle step tapers to	.060"
Power step	.043"
Length	3-9/64"
Metering rod jet	.098"
Accelerating pump:	
Pump discharge jet	71
Relief passage to outside	42
Intake ball check seat	40
Discharge ball check seat	32

HOLLEY
MODEL AA-1G

This carburetor is a dual downdraft carburetor of the plain tube type. It may be considered as being two carburetors built into one unit. There are separate sets of venturi tubes and throttle plates, and a separate main metering system and idle system, one set for each side of the carburetor.

The carburetor is "balanced and sealed" and all vents and bleeds are taken from the main air entrance of the carburetor, thus only air which has passed through the air cleaner is admitted into the carburetor.

The governor throttle actuated mechanism is an integral part of the carburetor and is designed to provide the needed power required for moving the throttle to governing speeds as controlled by a separately driven governor rotor.

In the following explanation, one side of the carburetor is generally referred to, unless otherwise noted.

IDLE SYSTEM

(Fig. A.) Fuel from the carburetor bowl (12) passes through the main metering jet (13) into the idle tube (10). Air is introduced into the fuel stream by the idle air bleed (8). This fuel and air mixture then travels through the idle passage (1), through the chamber around the bleeder plug (16) and to the continuation of passage (1) then discharges at the idle holes (2 and 3).

When the engine is set to idle at approximately 350 R.P.M., the mixture is discharged out of the lower hole (3) only. As the throttle plate (5) is opened and the engine speed and air flow increases, the upper hole (2) starts discharging in addition to the lower hole at about 450 R.P.M. The action and timing are such that the discharge from the upper hole reaches a maximum at about 750 R.P.M. and then gradually becomes less effective as the main nozzle (15) starts to flow.

MAIN FUEL SYSTEM

As the throttle is opened and the idle system becomes less effective, the main discharge nozzle (15) in Fig. A starts to deliver fuel. This occurs about 900 R.P.M. road load. Between 900 and 1200 R.P.M. there is a definite blending of the idling and main metering systems. In the above range, all the fuel passes through the main jet (13) up through the main well (6) to angle channel (9). Here the fuel is atomized by the high speed bleed (7) and an additional supply of air is introduced to this mixture by the bleeder plug (16) before being discharged through the vertical passage (14) into the venturi.

POWER SYSTEM

(Fig. B) A power valve (30) and spring (31) is actuated by the vacuum below the throttle plate which communicates with the valve diaphragm (32).

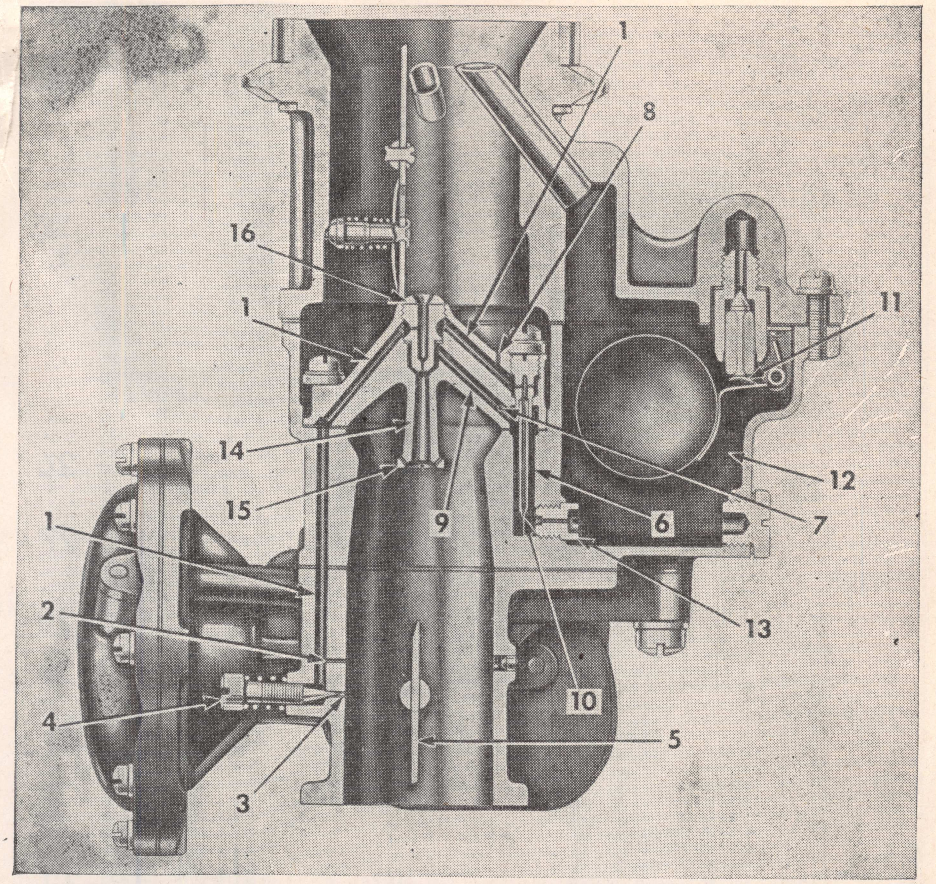


Fig. A. Model AA-1G Main Fuel System

1. Idle passage
2. Idle discharge port (upper)
3. Idle discharge port (lower)
4. Idle adjusting needle
5. Throttle plate
6. Main well
7. High speed bleed
8. Idle air bleed
9. Angle channel
10. Idle tube
11. Float arm
12. Carburetor bowl
13. Main metering jet
14. Vertical passage
15. Main nozzle
16. Bleeder plug

At idle, the vacuum is the highest and is decreases as the load of the engine increases. The valve and spring is held in the closed position until the vacuum drops to between 7.5 to 6.5 inches of mercury. Below this vacuum the compressed load of the spring overcomes the diaphragm power, allowing the valve to open.

Under load, as in climbing hills, the vacuum drops because it becomes necessary to open the throttle wider in order to maintain speed. When the vacuum drops below 7.5 inches of mercury, the power valve is opened by the spring. The fuel then flows into the power valve chamber and through the power jet restrictions (29) into the main well (6). This gives the additional power required for high speeds and for heavy pulling at full throttle low speeds.

ACCELERATION PUMP

(Fig. B) The accelerating pump is directly connected to the throttle and its function is temporarily to enrich the mixture for rapid acceleration. The fuel is drawn into the pump chamber (19) through the pump inlet check valve (21) on the upward stroke of the pump piston (20) when closing the throttle. When the throttle is opened, the pump piston moves downward, closing the pump check valve and forcing the displaced fuel through passages (24) to raise the ball check (28) and compress the spring (27). The accelerating fuel is then forced out of the pump discharge nozzle (26). A slot in the pump piston stem allows the pump operating rod (18) to over-run the pump piston when the throttle is opened suddenly. This over-run causes the pump piston to be subjected to the pressure of the spring (17) thereby giving a prolonged discharge of the accelerating fuel.

The accelerating pump is provided with an adjustment for varying the quantity of the accelerating charge. This adjustment is made by changing the position of the

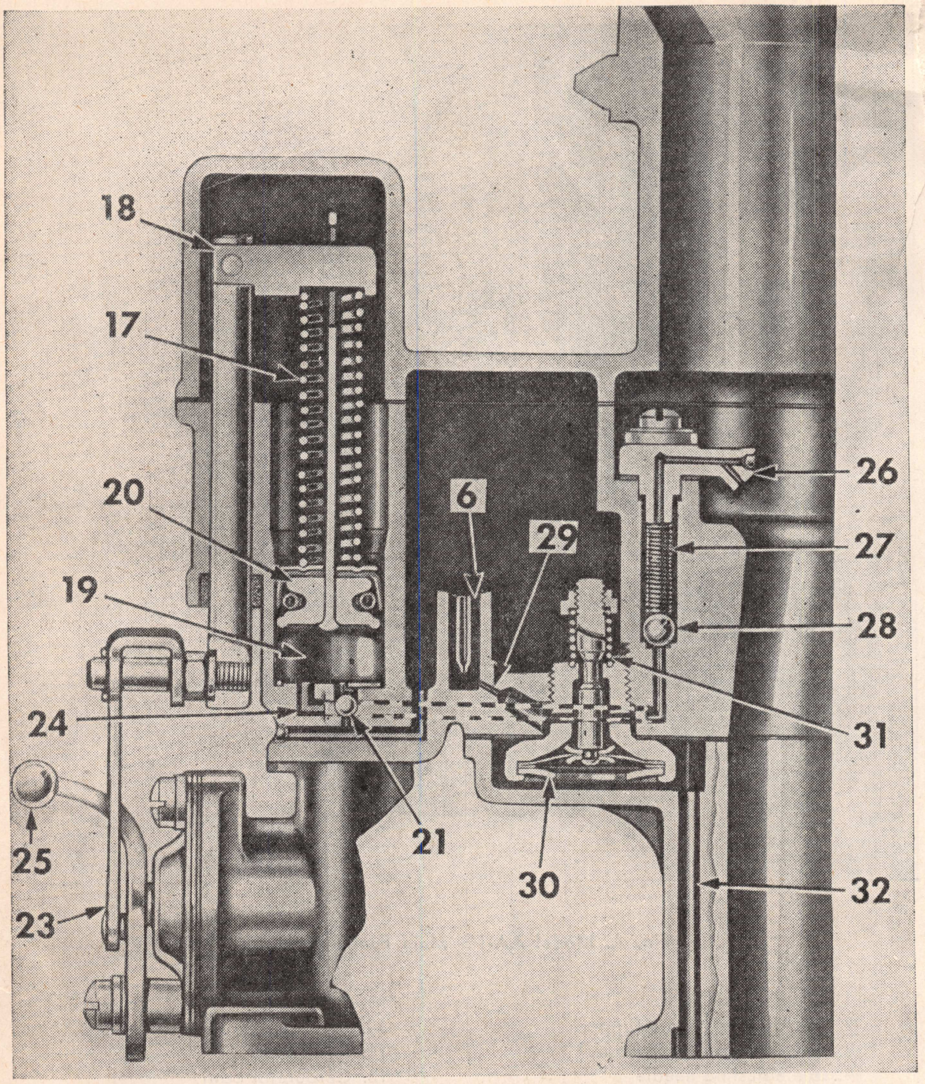


Fig. B. Model AA-1G Power and Accelerating Systems

6. Main well
17. Pump spring
18. Pump operating rod
19. Pump chamber
20. Pump piston
21. Pump inlet check valve
23. Pump link
24. Fuel passages
25. Throttle lever
26. Pump discharge nozzle
27. Ball check spring
28. Ball check
29. Power jet restrictions
30. Power valve
31. Power valve spring
32. Power valve diaphragm

pump link (23) in the holes in the throttle lever (25). The positions are marked No. 1, No. 2 and No. 3. Number 2 position is the average setting. Number 1 position displaces the smallest quantity of fuel, and number 3 position, the greatest quantity.

ADJUSTMENTS & SERVICE

Before making any adjustments, it is important that the breaker points and spark plugs be properly spaced, the ignition timing correct and the valve tappets set to proper clearance. Check all carburetor assembly screws and manifold flange bolts, being sure that they are thoroughly tightened and that there are no leaks at the gaskets.

FUEL LEVEL

When checking the fuel level in an open vessel, under three pounds fuel pump pressure, the level should measure $\frac{19}{32}$ inch below the surface of the float chamber cover with the gasket in place. The level may be corrected by bending the float arm.

When using a glass tube as a level indicator, care must be exercised because the reading will be approximately $\frac{1}{16}$ of an inch higher in the glass than in the carburetor bowl, due to capillary attraction. The float level can be set accurately when the air horn is off by gauging the distance between the bottom of the float and the flange surface of the air horn. Holding the air horn upside down and with the float in the closed position, measure the distance from the flange surface of the air horn to what would normally be the bottom side of the float (not the soldered seam). The correct distance should measure 1¼ inches. To correct the float setting, the float lever arm should be bent up or down to bring the float within the established limits and thus correct the fuel level for best operation. Pushing the float toward the float chamber cover raises the level; away from the cover lowers the level.

IDLE ADJUSTMENT

First set the idling speed by adjusting the throttle stop screw. The idle adjusting needles should be screwed in until they just touch the seats then back off one full turn.

When the engine has warmed up, turn both needles in until the engine starts to slow down, then turn both needles out until the engine again starts to slow down. A point midway between these two slowdowns will be very close to the correct idle mixture.

After arriving at the correct mixture, it may be necessary to reset the throttle stop screw to obtain the correct idle speed. Changing the speed may make a slight change in the idling mixture. If this occurs, readjust the needles as outlined above. It is important that both idle needles be set at approximately the same number of turns open, otherwise the off-idle performance may be erratic.

NOTE—If the engine fails to idle properly, check the fuel level. See that the idle tubes (10) in Fig. A are tight on the seat in the nozzle bar casting. Check the vacuum power valve. If this valve is not tight on its seat or if the gasket is leaking, an additional supply of fuel is being admitted to the engine beyond the control of the idle adjustment needles.

ACCELERATING PUMP

When the engine does not accelerate properly, check the accelerating pump system for dirt. If the pump inlet check valve (21) Fig. B, does not seat, fuel will be found to return to the float bowl instead of discharging through the pump discharge nozzle (26). This can be checked by removing the main body cover and operating the pump with a small amount of fuel in the bowl. If the ball check valve (21) is leaking, air or fuel will bubble back into the float bowl through the inlet hole. When cleaning this seat, extreme care should be taken when reinstalling the pump piston to be sure the piston leather is not damaged and that it contacts the cylinder wall. If the leather is not a good fit against the cylinder wall, fuel will leak by the piston, causing a weak discharge on acceleration.

To clean the accelerating pump system, remove the pump assembly, check ball retainer and check ball from the bottom of the cylinder. Remove the pump discharge nozzle, spring and ball check. All channels can then be cleaned of any foreign matter by blowing out with compressed air. The small holes in the discharge nozzle should be checked and, when working properly, should deliver a fine, solid and round stream. When system is in good condition, a quick steady stream will flow from the discharge outlet the instant the throttle is opened.

To check for trouble at intermediate speeds, be sure all gaskets are tight. Remove the main jets and check the size according to specifications. Clean the main jets, main jet passages and main discharge nozzle with compressed air. Never attempt to pass a wire or drill through holes or jets to clean them as there is danger of enlarging the opening, thus rendering them useless.

For high speed complaints, check the power valve and the high speed restrictions, as well as the main jets in accordance with the above instructions. Clean all passages with compressed air. Check the fuel pump pressure to be sure there is sufficient to maintain fuel level in the bowl. Check the float level to insure full opening of the inlet valve.

ALTITUDE OPERATION

In high altitudes, it may be necessary in some cases to use leaner metering jets. Usually 5% or 10% leaner jet will take care of any variation in altitude. The metering jets are marked in thousandths of an inch of hole diameter; thus, the smaller the hole, the smaller the number on the jet. Do not try to change the size of the power valve restrictions or pump discharge holes as this may cause erratic performance.

ECONOMY COMPLAINTS

Changing jets rarely increases economy more than slightly and often ruins performance. Make a thorough check on the condition of the engine with a compression gauge and make sure valves are in good condition. Check fuel level in carburetor bowl and make sure fuel pump pressure is not excessive. If these checks fail to uncover the cause, the various points outlined above should be checked over.

MODEL 885 JJSG

The Holley Model 885 JJSG is a plain tube dual concentric carburetor of the down-draft type. All the metering jets and passages are located in the center of the float bowl, which provides for correct metering of fuel and air at all practical operating angles.

The governor throttle actuated mechanism is an integral part of the carburetor and has been designed to provide the needed power required for moving the throttle to governing speeds as controlled by a separately driven governor rotor.

The carburetor is of the balanced type and vents and bleeds are taken from the air passage located in the float bowl and main body cover which, in turn, communicates through the balance tube to the main air entrance of the carburetor. Thus, only air which has passed through the air cleaner is taken into the carburetor.

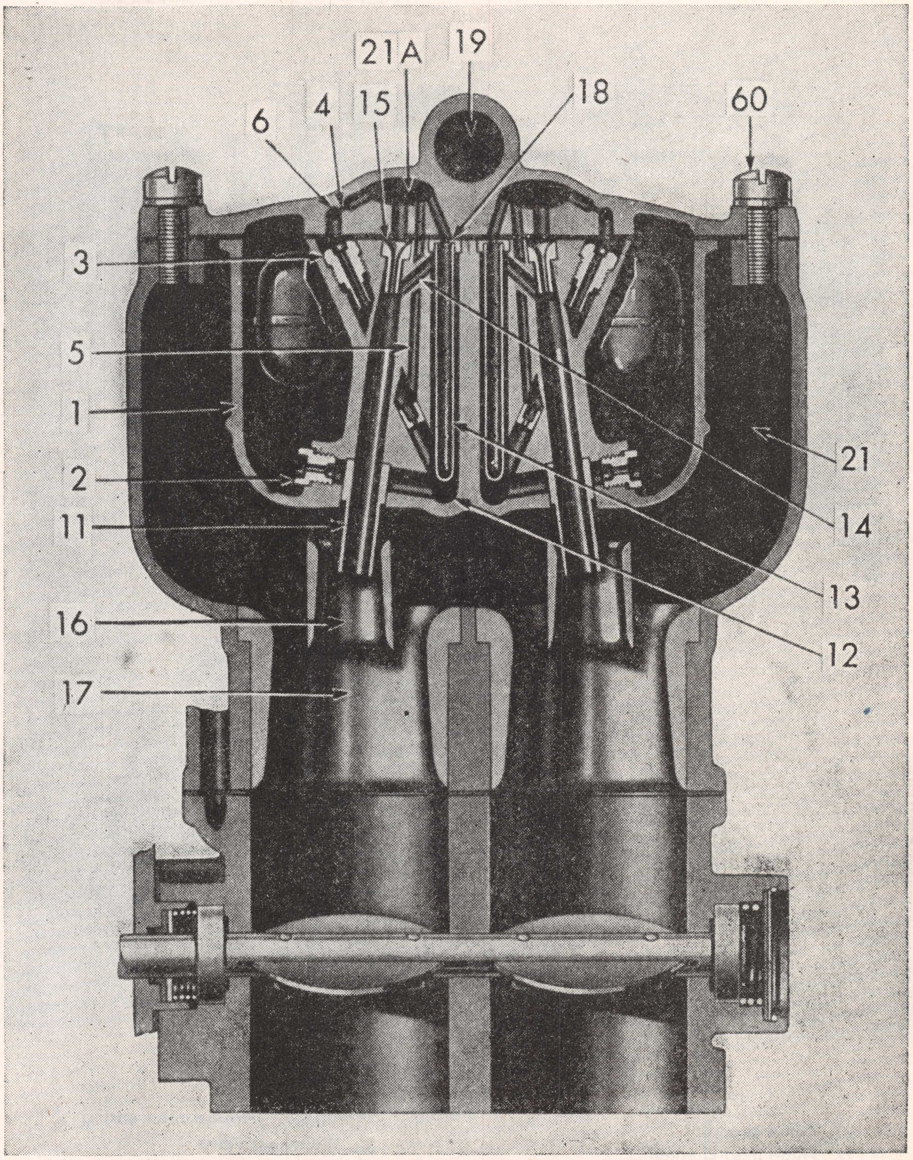


Fig. C. Model 885-JJSG Main Fuel System

1. Carburetor bowl
2. Main metering jet
3. Idle tube
4. Idle air bleed
5. Channel
6. Idle passage
11. Main discharge passage
12. Main well
13. Main well tube
14. Fuel passage
15. Nozzle tube jet
16. Secondary venturi
17. Primary venturi
18. Main air bleed
19. Horizontal air passage
21. Main air passage
21A. Air passaage

This carburetor can be considered as being two carburetors built into one unit. There are separate sets of venturi tubes, idle tubes, throttle plates, and a separate main metering system and idling system, one on each side. A throttle actuated pump provides accelerating fuel which is divided at the pump discharge nozzle. A single air chamber and one fuel chamber supply the twin mixing chambers. A single power valve takes the fuel from the fuel chamber through one passage and divides the fuel evenly to each side. In the following explanation, the operation of one side is referred to, unless otherwise mentioned.

IDLING SYSTEM

Fuel from the carburetor bowl (1) passes through the main metering jet (2) into the idle tube (3) as shown in Fig. C. Air is introduced into the fuel stream by idle air bleed (4) and channel (5). This fuel and air mixture then travels through idle passage (6) to the idle discharge holes (7 and 8. Fig. E).

When the engine is set to idle at about

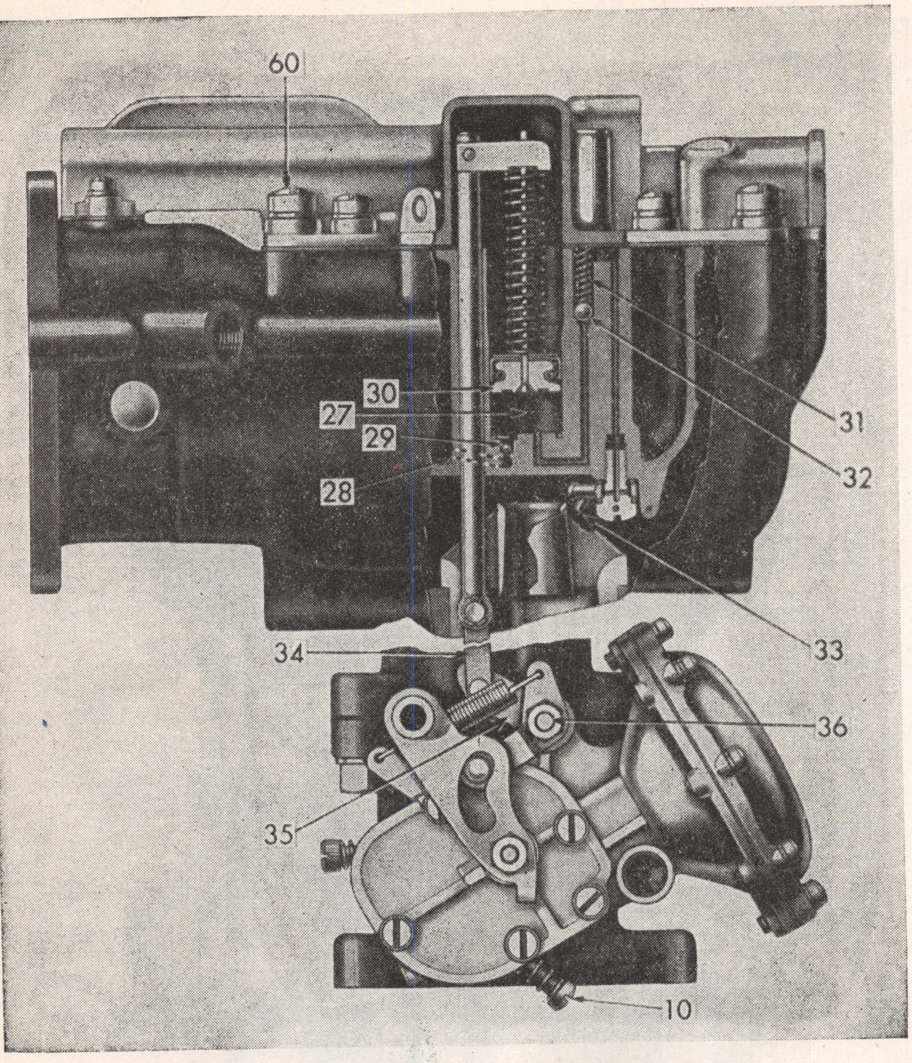


Fig. D. Model 885-JJSG Accelerating System

27. Pump chamber
28. Pump inlet channel
29. Pump check valve
30. Pump piston
31. Pump discharge valve spring
32. Ball check valve
33. Pump discharge nozzle

400 R.P.M., the mixture is discharged out of the lower hole (8) only. As the throttle plate is opened and the speed increases, the upper hole (7) starts discharging, in addition to the lower hole at 600 R.P.M. The action and timing are such that the discharge from the upper hole reaches a maximum at approximately 800 R.P.M. and then gradually becomes less effective as the main nozzle starts to flow.

MAIN FUEL SYSTEM

As the throttle is opened and the idle system becomes less effective, the main discharge passage (11) in Fig. C starts to deliver fuel. Between 800 and 1000 R.P.M. there is a definite blending of the idle and main metering systems. In the above range, all the fuel passes through the main jet (2) up through the main well (12) and around the main well tube (13) through passage (14) to the main discharge passage (11). The mixture is aspirated here by the nozzle tube jet (15) and carried through the secondary venturi (16) to the primary venturi (17).

Air from the aspirating nozzle (15) and the main air bleed (18) is taken from the air passage (21A) in the cover which communicates directly to the main air channel (21).

The float bowl is vented to the atmosphere through a hole drilled to the horizontal air passage (19) which communicates with the balance tube (20). The main air supply for the secondary and primary venturi is carried through the main body (21) where it circulates around and under the float bowl. Thus, the fuel is kept cool by the circulation of air through the main body and the fact that the float bowl is attached to the main body cover.

POWER SYSTEM

A power valve vacuum piston (22), Fig. E, and spring (23) is actuated by the vacuum below the throttle plate which communicates with the top of the piston through passages.

At idle the vacuum is the highest and it decreases as the load of the engine increases. The piston and the spring is held in the up position which allows the valve (25) to remain closed until the vacuum drops to approximately 7 to 5 inches of mercury. Below this vacuum, the piston force is not high enough to resist the compressed load of the spring and thus opens the power valve. The underside of the piston is vented to the horizontal air channel (19) to insure positive action.

Under load, as in climbing hills, the vacuum drops because it becomes necessary to open the throttle wider in order to maintain speed. When the vacuum drops to about 7 to 5 inches of mercury, the power valve is opened by the action of the spring and piston. The fuel then flows into the power valve chamber and through the high speed restriction into the main well (12). This gives the additional fuel required for high speeds and for heavy loads at full throttle at low speeds.

ACCELERATING PUMP

The accelerating pump is directly connected to the throttle and its function is temporarily to enrich the mixture for rapid acceleration. The fuel is drawn into the pump chamber (27), Fig. D, through the pump inlet channel (28) and check valve (29) on the upward stroke of the pump piston (30) when the throttle is closed. When the throttle is opened, the pump piston moves downward, closing the pump check valve and overcoming the tension of the pump discharge valve spring (31). The accelerating fuel then goes around the ball check valve (32) and out the pump discharge nozzle (33). A slot in the pump piston stem allows the pump operating rod to over-run the pump piston when the throttle is opened suddenly. This over-run causes the pump piston to be subjected to the spring pressure, thereby giving a prolonged discharge of the accelerating fuel.

FLOAT MECHANISM

The float mechanism is supported by a coil spring which increases the buoyancy of the float. This spring action against the float eliminates any increase in fuel level due to jarring which would affect the engine performance when the vehicle is traveling over rough terrain.

NOTE—When assembling the float, make sure that the float balancer spring (37) is between the float stop arm (38) and the float needle seat housing, as shown in the insert in Fig. E.

SERVICE & ADJUSTMENTS

This carburetor can be cleaned and serviced (with the exception of the idle discharge holes) without breaking the air cleaner connection or removing the carburetor from the manifold. It is only necessary to remove the gasoline line and fitting from the carburetor. And by removing

1. Carburetor bowl
6. Idle passage
7. Idle discharge port (upper)
8. Idle discharge port (lower)
9. Idle adjusting needle
19. Horizontal air passage
20. Balance tube
21. Main air passage
22. Power valve piston
23. Power valve spring
25. Power valve
37. Float balancer spring
38. Float stop arm
39. Float needle

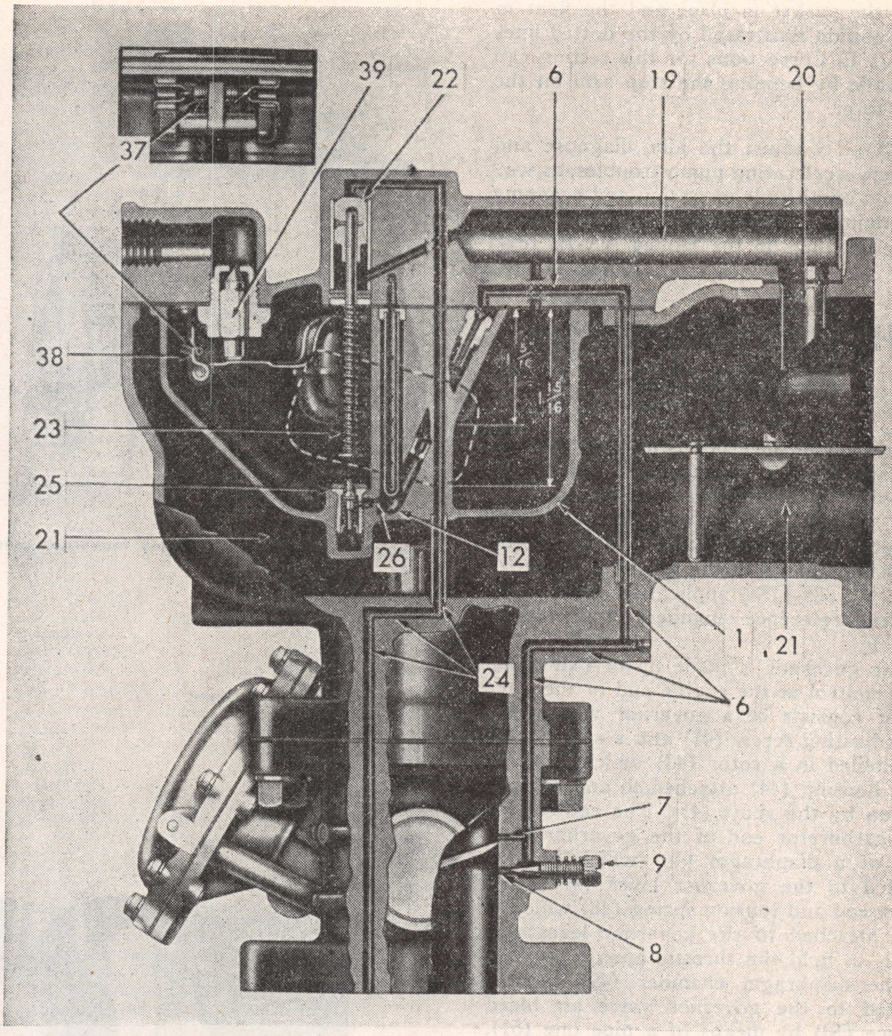


Fig. E. Model 885-JJSG Power System and Float Mechanism

the accelerating pump link and six assembly screws, the main body cover and float bowl assembly can be removed from the air horn.

NOTE—Precaution should be taken to close the throttle plates when removing the float bowl to prevent the acceleration pump rod seal, washer and spring from falling into the intake manifold.

FUEL LEVEL

When checking the fuel level in an open vessel under five pounds pump pressure, the fuel level should measure $\frac{19}{32}$ inch, plus or minus $\frac{1}{32}$ inch, below the surface of the float chamber cover with the **cover gasket in place.** However, the float level can be set accurately by gauging the distance between the bottom of the floats and the chamber cover surface.

When setting the float level, it is important that both the "open" and "closed" position of the floats be checked (see Fig. E). To gauge the "closed" position of the floats, hold the float chamber cover upside down and measure the distance from the float chamber gasket to what would normally be the bottom side of the free end of the floats. The distance should be $1\frac{5}{16}$ inches with the fuel inlet valve in the "closed" position and with the gasket in place. To correct the float setting for this position, the float lever arms should be bent up or down to bring the floats within the correct limits and thus correct the fuel level for best operation. Pushing the floats up or toward the float chamber cover raises the fuel level; down or away from the cover, lowers the level.

The "open" position is gauged by raising the floats up until the float stop arm comes to rest against the inlet needle seat housing and measuring the float setting in the same manner as done in the "closed" position. This distance should be 1 15/16 inches

40. Governor valve
41. Adjusting screw
42. Adjusting screw spring
43. Governor rotor
44. Rotor housing
45. Governor shaft
46. Diaphragm
47. Governor lever
48. Tension spring
49. Diaphragm chamber
50. Governor valve air bleed
51. Pipe line
52. Pipe line

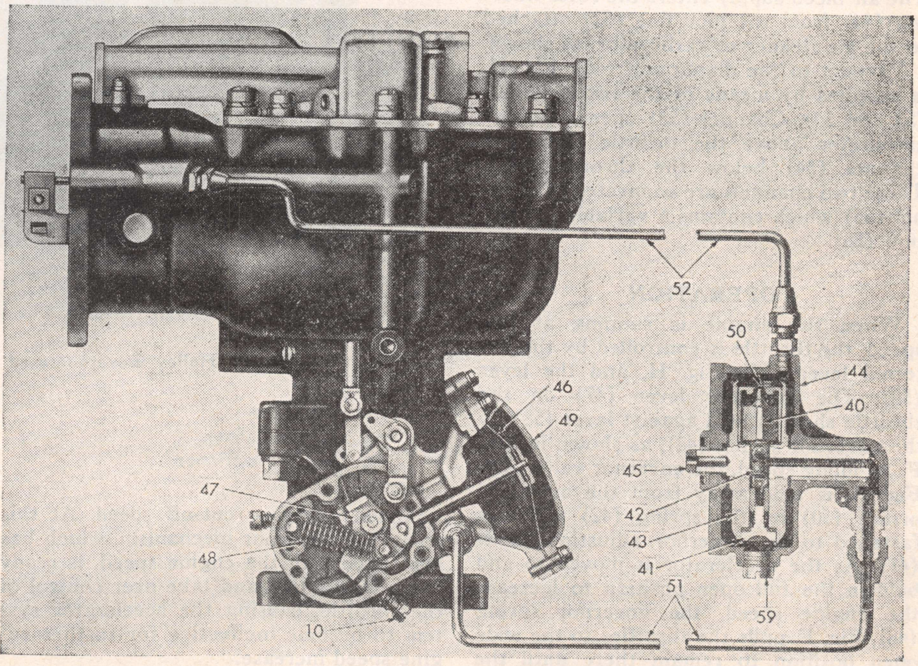


Fig. F. Holley Governor used on Carburetor Model 885-JJSG with the gasket in place and the float in the position illustrated by the dotted lines in Fig. E. Corrections for this setting can be made by bending the stop arm on the float lever.

NOTE—To adjust the idle, diagnose and correct accelerating pump troubles, as well as data on altitude operation and economy complaints, see instructions given under these headings in the Holley AA-1G text.

HOLLEY GOVERNOR MODEL 1174

This model governor is an integral part of both the AA-1G and 885-JJSG Holley carburetors. As shown in the illustrations, Figs. F and G, the two applications differ in detail but the operating principle is the same. Therefore, in the following explanation, the 885-JJSG application will be discussed, reference numbers applying to Fig. F.

The governor is made up of two units. The control at the engine end of the governor consists of a governor valve (40), an adjusting screw (41) and a spring (42) assembled in a rotor (43) which revolves in a housing (44) attached to and engine-driven by the shaft (45). The controls at the carburetor end of the governor consist of a diaphragm (46) which is connected to the governor lever (47) by a short rod and tension spring (48) which is also attached to the governor lever and tends to hold the throttle open.

The diaphragm chamber (49) is connected to the governor valve air bleed orifice (50) by means of a pipe line (51). The other side of the diaphragm is vented to the atmosphere at the engine air cleaner. The air bleed supply enters the rotor housing (44) from the pipe line (52) attached to the air cleaner or carburetor, as shown.

Vacuum to the diaphragm (46), Fig. H, is supplied by means of the two channels (53 and 54). Channel (53) opens into the carburetor above the throttle plate and channel (54) below the throttle plate. These two channels are connected to channel (55) which contains a variable restriction (56).

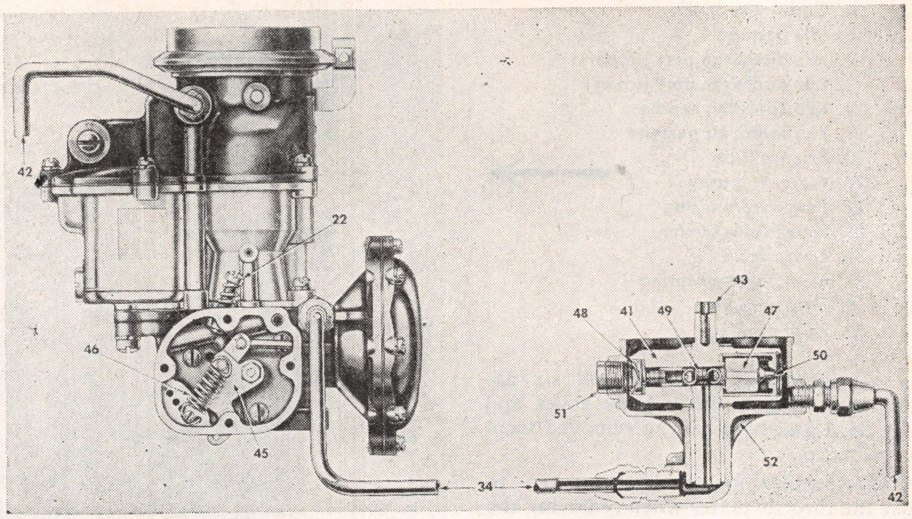


Fig. G. Holley Governor used on Carburetor Model AA-1G

34. Pipe line
41. Governor rotor
42. Pipe line
43. Governor shaft
45. Throttle shaft lever
46. Tension spring
47. Governor valve
48. Governor adjusting screw
49. Adjusting screw spring
50. Governor valve air bleed
51. Screw
52. Rotor housing

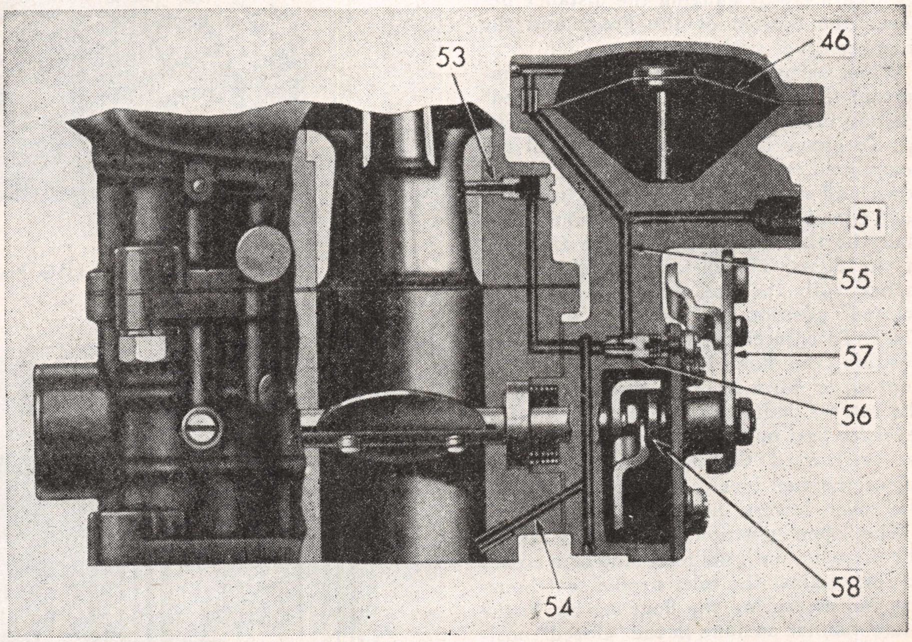


Fig. H. Holley Governor used on Carburetor Model 885-JJSG

46. Diaphragm
53, 54, 55. Channels
56. Variable restriction
57. External lever
58. Internal lever

OPERATION

When the engine is running at idle speed, the throttle is controlled by the external lever (57), Fig. H, and the lever (58). The governor lever (47) on the throttle shaft is held against lever (58) by the governor spring (48), as shown in Fig. F. At idling speed, the governor valve (40), Fig. F, is held away from the air bleed orifice (50) by the spring (42) which is fastened to the governor adjusting screw (41). As the accelerator is moved to and held in the full open position to increase the engine speed, the governor spring (48), Fig. F, pulls the throttles to the wide open position to remain there until the engine R.P.M. has reached the predetermined governor cut-off speed. At this point, the governor mechanism, which has kept pace with the engine speed, is ready to go into action and take over control of the throttle, causing the accelerator system to become ineffective for further engine speed increase.

The action of the mechanism is that when the engine speed increases, the governor valve (40), Fig. F, stretches the spring (42) and moves toward the air bleed orifice (50) thus restricting the bleed to the diaphragm (46). As the air bleed to the diaphragm is reduced, it permits the suction supplied by the orifices (53 and 54), Fig. H, to operate the diaphragm. As this suction increases, the diaphragm power overcomes the tension of the governor spring (48), Fig. F, and takes over full control of the throttles. The engine governed speed is then held constant by the valve (40) being balanced between the pull of centrifugal force actuated by the rotation of the shaft (45) and the tension of the spring (42).

Any slight change in speed or engine load will cause the governor valve (40) to act immediately either to increase or decrease the amount of air bled through orifice (50), which in turn causes an instant response from the diaphragm to increase or decrease the throttle opening.

When the accelerator is released, the control is taken away from the governor by the spring action of the external throttle lever and closes the throttle to bring the engine to any desired lower speed.

ADJUSTMENTS & SERVICE

To adjust the governor cut-off speed, remove the seal from the screw which will be found on the side of the housing. After removing the screw from the housing, rotate the engine until the end of the governor rotor which carries the adjusting screw is in line with the hole from which the screw was removed. With a suitable screw driver, turn the adjusting screw to the **right** to **increase** the engine governor speed, or to the **left** to **decrease** the speed.

Where the governor has been disassembled and serviced, after reassembling, turn the adjusting screw to the right until it stops, then turn the screw to the **left three full turns.** Final adjustment is then made after the governor has been assembled to the engine as outlined above.

The vacuum adjusting screw (56), Fig. H, regulates the R.P.M. spread between the full-load governor cut-off speed and the no-load engine speed. Turning the screw in (to the right) will decrease the R.P.M. spread. Turning the screw to the left (out) will increase the spread.

NOTE—Changing the position of the vacuum adjusting screw will change the average governor speed and this should be corrected by the governor adjusting screw as outlined above.

CAUTION—Never apply compressed air to an assembled carburetor as there is danger of rupturing the governor diaphragm.

ZENITH

SPECIFICATIONS

NOTE—These are in addition to the specifications given on pages 518 through 543.

NOTE—See page 543 for table for converting jet sizes into Zenith numbers and millimeters.

Engine Model	Carburetor Model	Outline Number ①	Carburetor Size, Inches	Main Venturi Diameter, Inches	Main Jet, Inch	Compensator, Inch	Idling Jet, Inch	Power and Accelerating Jet, Inch	Power Jet, Inch	Accelerating Jet, Inch	Main Discharge Jet, Inch	Economizer Jet, Inch
AUTOCAR												
377	28ADA10	S1036	1¼	1.023	.0472	None	.0275	None	.0354	.0393	.1475	None
BUDA												
HP205	455-2	8231	1¼	.866	.0393	.0433	.0275	None	None	None	None	None
HP351	62AJ9	9699	1¼	.984	.0491	None	.0314	None	None	None	.1181	.0354
HP326	63AW10	9864	1¼	.984	.0373	None	.0295	None	.0393	.0255	.1278	None
LO525	IN167SJ	S70	1¾	1.496	.0708	None	.0295	None	.0255	.0491	.0787	None
M766	457-2	S116	1¾	1.259	.0648	.0629	.0295	.0314	None	None	None	None
LO525	457-2	S136	1¾	1.377	.0688	.0609	.0314	.0314	None	None	None	None
LO525	IN167SJ	S456	1¾	1.338	.0669	None	.0334	None	.0334	.0373	.1278	None
LO525	457-2	S693	1¾	1.396	.0688	.0609	.0314	.0393	None	None	None	None
HP234	124½TO	S715	1	.866	.0412	.0433	.0236	None	None	None	None	None
HP326	456-2	S729	1½	.944	.0452	.0393	.0275	.0255	None	None	None	None
K428	IN-167	S56	1¾	1.456	.0551	.0511	.0255	.0393	None	None	None	None

continued on next page

Engine Model	Carburetor Model	Outline Number ①	Carburetor Size, Inches	Main Venturi Diameter, Inches	Main Jet, Inch	Compensator, Inch	Idling Jet, Inch	Power and Accelerating Jet, Inch	Power Jet, Inch	Accelerating Jet, Inch	Main Discharge Jet, Inch	Economizer Jet, Inch

CONTINENTAL

Engine Model	Carburetor Model	Outline Number ①	Carburetor Size, Inches	Main Venturi Diameter, Inches	Main Jet, Inch	Compensator, Inch	Idling Jet, Inch	Power and Accelerating Jet, Inch	Power Jet, Inch	Accelerating Jet, Inch	Main Discharge Jet, Inch	Economizer Jet, Inch
A6244	62AJX9	S559	1¼	.944	.0708	None	.0275	None	None	None	.0984	.0275
B6427	63AW16	S833	2	1.652	.0688	None	.0134	None	.0393	.0648	.1770	None
F4140	161X7	10005	1	.708	.0412	None	.0236	None	None	None	.1181	None
F4162	63AW10	10206	1¼	1.102	.0491	None	.0255	None	None	.0236	.1574	None
F4162	161X7	S569	1	.748	.0433	None	.0236	None	None	None	.1181	None
F4162	28BXV9R	S678	1¼	.944	.0433	None	.0295	None	.0215	.0236	.0984	None
R6513	29W16	10238	2	1.574	.0708	None	.0354	None	.0727	.0314	.2162	None
R6572	29W14	10087	1¾	1.456	.0688	None	.0275	None	.0551	.0314	.1770	None
R6572	29W14	10088	1¾	1.456	.0688	None	.0275	None	.0551	.0314	.1770	None
22R	458	S845	2	1.377	.0708	.0669	.0314	.0373	None	None	None	None
22R	458	S900	2	1.377	.0727	.0737	.0314	.0314	None	None	None	None
22R	458	S444	2	1.377	.0708	.0669	.0314	.0373	None	None	None	None
F6209	63AW10R	10068	1¼	1.023	.0412	None	.0275	None	.0236	.0354	.1377	None
M6290	63AW12	S468	1½	1.181	.0629	None	.0275	None	.0239	.0433	.1377	None
M6271	63AW12	S528	1½	1.181	.0491	None	.0275	None	.0314	.0472	.1475	None
F6209	28BXV9R	S662	1¼	.944	.0433	None	.0295	None	.0255	.0236	.0984	None
B6427	63AW16	10124	2	1.574	.0688	None	.0314	None	.0314	.0491	.1978	None
M6330	63AW14	10227	1¾	1.377	.0570	None	.0314	None	.0275	.0433	.1770	None
F6218	63AW10	9499	1¼	1.023	.0412	None	.0255	None	.0236	.0354	.1377	None
F6218	63AW10	S394	1¼	1.023	.0433	None	.0255	None	.0236	.0354	.1377	None
B6427	63AW16R	10142	2	1.652	.0688	None	.0373	None	.0393	.0648	.1770	None
22R	63AW16R	S867	2	1.652	.0748	None	.0314	None	.0354	.0511	.1770	None

DODGE

Engine Model	Carburetor Model	Outline Number ①	Carburetor Size, Inches	Main Venturi Diameter, Inches	Main Jet, Inch	Compensator, Inch	Idling Jet, Inch	Power and Accelerating Jet, Inch	Power Jet, Inch	Accelerating Jet, Inch	Main Discharge Jet, Inch	Economizer Jet, Inch
T124	29BBW12R	9996	1½	1.220	.0590	None	.0275	None	.0393	.0275	.1574	None

HERCULES

Engine Model	Carburetor Model	Outline Number ①	Carburetor Size, Inches	Main Venturi Diameter, Inches	Main Jet, Inch	Compensator, Inch	Idling Jet, Inch	Power and Accelerating Jet, Inch	Power Jet, Inch	Accelerating Jet, Inch	Main Discharge Jet, Inch	Economizer Jet, Inch
HXE	63AW16	S970	2	1.417	.0669	None	.0314	None	.0314	.0472	.1770	None
IX	193½	8552	⅞	.590	.0334	.0314	.0255	None	None	None	None	None
IXB	161–7	10117	⅞	.590	.0452	None	.0196	None	None	None	.1081	None
IXB3	193½P	10119	⅞	.748	.0373	.0373	.0177	None	None	None	None	None
IXB	161-7	10123	⅞	.590	.0412	None	.0196	None	None	None	.1081	None
IXB	161J7	10132	⅞	.590	.0373	None	.0196	None	None	None	.1181	None
IXB	161–7	10149	⅞	.590	.0412	None	.0236	None	None	None	.1081	None
IXB	193½	S382	⅞	.590	.0295	.0314	.0255	None	None	None	None	None
IXB	193½	S130	⅞	.590	.0334	.0314	.0255	None	None	None	None	None
IXB3	161J7	S902	⅞	.748	.0491	None	.0255	None	None	None	.1181	None
JXC	455	S266	1¼	1.023	.0511	.0472	.0275	.0275	None	None	None	None
JXD	457	S537	1¾	1.338	.0688	.0629	.0295	.0354	None	None	None	None
JXD	63AW10	S956	1¼	1.062	.0472	None	.0275	None	.0295	.0393	.1377	None
JXD	63AW10	S986	1¼	1.062	.0472	None	.0275	None	.0295	.0393	.1377	None
OOA	124½TOX	S49	1¼	.669	.0334	.0354	.0236	None	None	None	None	None
RXC	457	S530	1¾	1.377	.0708	.0688	.0275	.0255	None	None	None	None
RXLD	IN158	S199	2	1.574	.0787	.0708	.0314	.0334	None	None	None	None
RXLD	457	S461	1¾	1.338	.0669	.0688	.0236	.0354	None	None	None	None
WXC2	28BV12	S151	1½	1.220	.0609	None	.0255	None	.0275	.0275	.1475	None
WXLC3	28BV12	S880	1½	1.141	.0570	None	.0255	None	.0295	.0236	.1475	None

Engine Model	Carburetor Model	Outline Number ①	Carburetor Size, Inches	Main Venturi Diameter, Inches	Main Jet, Inch	Compensator, Inch	Idling Jet, Inch	Power and Accelerating Jet, Inch	Power Jet, Inch	Accelerating Jet, Inch	Main Discharge Jet, Inch	Economizer Jet, Inch
HERCULES (Cont.)												
JXD	457–2	9610	1¾	1.181	.0472	.0570	.0295	.0433	None	None	None	None
RXC	457–2	9932	1¾	1.299	.0629	.0629	.0314	.0491	None	None	None	None
RXC	457–2	S276	1¾	1.299	.0629	.0629	.0314	.0491	None	None	None	None
HXC	IN158	S79	2	1.496	.0748	.0727	.0295	.0314	None	None	None	None
HXD	29W16	S921	2	1.810	.0845	None	.0354	None	.0688	.0314	.2162	None
HXC	IN158	S500	2	1.496	.0748	.0727	.0295	.0314	None	None	None	None
OOB	63AW16R	S936	2	.984	.0433	None	.0275	None	.0275	.0255	.1181	None
QXB3	28BVX9	S936	1¼	.984	.0433	None	.0275	None	.0275	.0255	.1181	None
JXD	28AV12	S66	1½	1.141	.0530	None	.0255	None	.0314	.0236	.1377	None
WXLC3	IN167SJ	S111	1¾	1.338	.0708	None	.0255	None	.0393	.0433	.0984	None
RXLD	29W14	10143	1¾	1.338	.0727	None	.0314	None	.0373	.0334	.1770	None
RXC	29W14	10143	1¾	1.338	.0727	None	.0314	None	.0373	.0334	.1770	None
INTERNATIONAL												
RED361	63AW12R	10094	1½	1.259	.0551	None	.0295	None	.0236	.0433	.1574	None
RED361	28AV12R	10111	1½	1.259	.0530	None	.0275	None	.0491	.0275	.0255	None
RED401	29W14R	10103	1¾	1.417	.0669	None	.0314	None	.0648	.0314	.1574	None
RED401	29W14R	10104	1¾	1.456	.0688	None	.0314	None	.0491	.0314	1978	None
RED450	63AW14R	10076	1¾	1.496	.0669	None	.0295	None	.0452	.0551	.1770	None
RED450	29W14R	S1031	1¾	1.456	.0727	None	.0314	None	.0491	.0314	.1978	None
MACK												
EY	63AW16	10008	2	1.652	.0767	None	.0275	None	.0295	.0412	.1978	None
EN354	63AW14	10073	1¾	1.417	.0570	None	.0275	None	.0275	.0373	.1978	None
EP	63AW14	S589	1¾	1.496	.0648	None	.0295	None	.0236	.0393	.1978	None
EP	63AW16	S886	2	1.574	.0688	None	.0275	None	.0295	.0393	.1978	None
EN471	63AW14	S1075	1¾	1.496	.0669	None	.0295	None	.0275	.0373	.1978	None
EN510	63AW14	S1076	1¾	1.496	.0648	None	.0295	None	.0295	.0412	.1978	None
EN354	28ADA10	10245	1¼	.984	.0354	None	.0275	None	.0412	.0255	.1181	None
REO												
288	28BV12	S404	1½	1.141	.0551	None	.0314	None	.0314	.0275	.1475	None
WAUKESHA												
6BK	455	10070	1¼	.944	.0472	.0472	.0255	.0255	None	None	None	None
6BK	63AW10	10216	1¼	1.102	.0530	None	.0236	None	.0236	.0314	.1377	None
FC	161–7	10099	⅞	.629	.0433	None	.0275	None	None	None	.0984	None
HOGK	IN167SJ	S979	1¾	1.338	.0590	None	.0255	None	.0393	.0472	.1475	None
140GK	63AW14	S980	1¾	1.338	.0590	None	.0314	None	.0295	.0412	.1770	None
140GK	63AW14	S981	1¾	1.496	.0748	None	.0314	None	.0236	.0334	.1978	None
145GK	IN167SJ	S526	1¾	1.259	.0590	None	.0255	None	None	.0393	.1475	None
145GK	20AV16	S596	2	1.574	.0688	.0708	.0295	None	.0609	.0255	None	None
145GK	63AW16	S982	2	1.436	.0866	None	.0314	None	.0275	.0412	.1978	None
145GZ	29BW14	10083	1¾	1.338	.0648	None	.0295	None	.0373	.0334	.1978	None
145GZ	29BBW14	10084	1¾	1.338	.0648	None	.0295	None	.0373	.0334	.1978	None
6MS	63AW10	S974	1¼	1.062	.0511	None	.0275	None	.0295	.0373	.1377	None
6MZ	23AV12	S175	1½	1.259	.0412	.0491	.0275	None	.0334	.0255	None	None

Engine Model	Carburetor Model	Outline Number ①	Carburetor Size, Inches	Main Venturi Diameter, Inches	Main Jet, Inch	Compensator, Inch	Idling Jet, Inch	Power and Accelerating Jet, Inch	Power Jet, Inch	Accelerating Jet, Inch	Main Discharge Jet, Inch	Economizer Jet, Inch
WAUKESHA (Cont.)												
6MZR	63AW12	S843	1½	1.102	.0530	None	.0354	None	.0236	.0452	.1278	None
6MZR	28AV12	S1023	1½	1.259	.0609	None	.0275	None	.0314	.0255	.1475	None
6MZR	29W14	S1063	1¾	1.496	.0767	None	.0295	None	.0452	.0334	.1770	None
6WAK	63AW16	10097	2	1.850	.0963	None	.0314	None	.0334	.0491	.1978	None
6MZR	456	S619	1½	1.062	.0530	.0530	.0295	.0255	None	None	None	None
140GK	457	S657	1¾	1.181	.0570	.0609	.0295	.0295	None	None	None	None
145GK	457	S767	1¾	1.456	.0767	.0767	.0295	.0295	None	None	None	None
6BK	455	S817	1¼	.944	.0530	.0511	.0255	.0255	None	None	None	None
6MZR	29W14	S975	1¾	1.338	.0570	None	.0295	None	.0433	.0334	.1978	None
6MZR	IN167SJ	S248	1¾	1.220	.0551	None	.0255	None	.0255	.0373	.0984	None
6SRKR	IN167SJ	S1026	1¾	1.377	.0688	None	.0255	None	.0314	.0491	.1475	None
6MZR	IN167SJ	S504	1¾	1.259	.0609	None	.0354	None	.0354	.0433	.1377	None
145GK	29W14	10100	1¾	1.299	.0648	None	.0295	None	.0412	.0295	.1978	None
145GK	IN167SJ	S271	1¾	1.259	.0551	None	.0255	None	.0236	.0393	.1475	None
6MZR	IN167SJ	S285	1¾	1.220	.0590	None	.0295	None	.0354	.0433	.1377	None
6WAL	63AW16	S701	2	1.652	.0885	None	.0275	None	.0275	.0530	.1770	None
145GK	63AW16	S339	2	1.535	.0669	None	.0314	None	.0354	.0491	.1770	None
6MZR	63AW12	S1034	1½	1.102	.0530	None	.0354	None	.0236	.0452	.1278	None
6SRK	63AW14	S1035	1¾	1.417	.0609	None	.0354	None	.0275	.0452	.1978	None
145GZ	63AW16	S1052	2	1.574	.0688	None	.0314	None	.0314	.0491	.1978	None
WHITE												
21A	28AV10	10225	1¼	1.023	.0452	None	.0275	None	.0354	.0255	.1181	None
25A	457	S492	1¾	1.377	.0609	.0708	.0236	.0295	None	None	None	None

① Outline number stamped on small metal disc, usually on fuel bowl cover.

ZENITH CARBURETORS

29 SERIES

This series is a downdraft carburetor with a concentric float bowl design. This design assists in the proper metering of the air and fuel to the engine without flooding when the vehicle is operated on extreme angles. The fuel chamber can be tipped at an angle to any position within a circle up to 45 degrees. This feature is very helpful when the vehicle is operated in hilly country, in and out of excavations, on ramps, or when operated at side angles.

The carburetor is a "sealed and balanced" unit in that all air for fuel bowl chamber ventilation and idling must come through the air cleaner, and air cleaner restrictions have a minimum influence on fuel-air ratio.

Two venturi are employed to aid in the complete vaporization of the fuel. This removable double venturi measures the volume of air which passes through the carburetor. In selecting the venturi, it is best to use the smallest size which will permit full power development.

The power jet and accelerating pump systems are operated by engine vacuum and are completely enclosed and protected from dirt.

The main discharge tube is centrally located directly above the venturi. The metering well completely surrounds the upper portion of the discharge tube and is in the center of the fuel bowl assembly.

The float assembly is of the duplex type consisting of two float bodies assembled to a double ended float lever. When installed in the carburetor, the float bodies operate on all sides of the centrally located metering system.

FUEL SUPPLY SYSTEM

Fuel, under normal fuel pump pressure, entering the float chamber through the fuel valve seat is controlled by the float which, moving on its axle, closes the needle valve when the fuel reaches the proper level in the bowl.

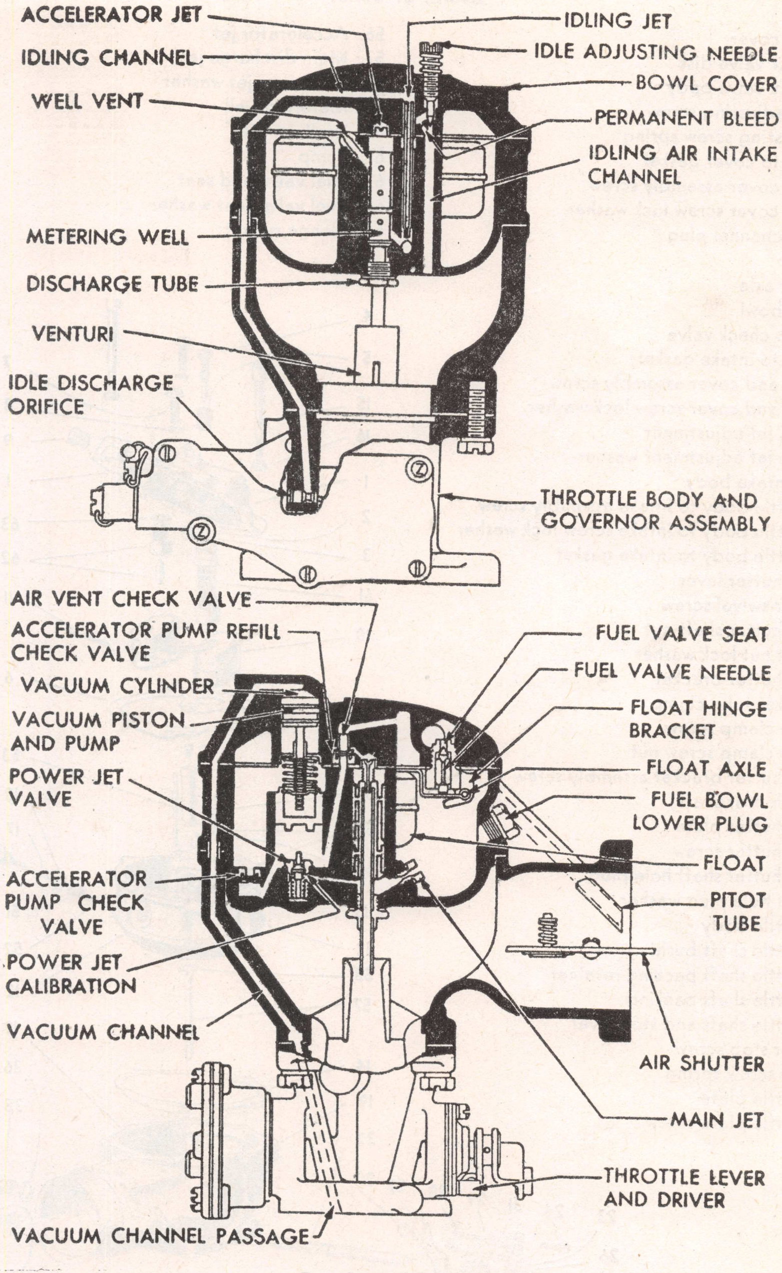
IDLING SYSTEM

At idling speeds, the throttle plate is slightly advanced from a completely closed position, leaving about ½ the area of the idle discharge port in the side of the throttle body bore revealed to the suction of the engine manifold. This suction is transmitted through the idling jet through a passage running through the air intake, fuel bowl, and fuel bowl cover bodies.

All fuel for part throttle operation is ordinarily supplied through the main jet. In some cases this is supplemented by a by-pass in the power jet valve. Fuel from the float chamber flows from the main jet into the metering well. Fuel for idling is drawn from this well through the metering orifice in the lower end of the idling jet. As the fuel reaches the idling channel, it is mixed with air which is admitted from the air intake channel through the permanent bleed plus that which is admitted by the idling adjusting needle. The mixture passes through the idling channel through the priming plug, at which point it is discharged into the air stream. The permanent bleed prevents the fuel from being syphoned into the intake manifold when, for any reason, the idle adjusting screw is bottoming on its seat.

MAIN JET SYSTEM

As the throttle is opened, the suction at the priming plug diminishes, but the increased volume of air entering the engine creates sufficient vacuum in the secondary venturi to draw fuel from the metering well up and over into the discharge tube. The flow characteristics from the main discharge tube are influenced by the size and number of holes used in the side of the metering well. Air from the float chamber, which is vented through a channel through a tube in the air intake, is admitted to the outer side of the metering well through the well vent.


ACCELERATOR JET
IDLING CHANNEL
WELL VENT
METERING WELL
DISCHARGE TUBE
VENTURI
IDLE DISCHARGE ORIFICE
IDLING JET
IDLE ADJUSTING NEEDLE
BOWL COVER
PERMANENT BLEED
IDLING AIR INTAKE CHANNEL
THROTTLE BODY AND GOVERNOR ASSEMBLY
AIR VENT CHECK VALVE
ACCELERATOR PUMP REFILL CHECK VALVE
VACUUM CYLINDER
VACUUM PISTON AND PUMP
POWER JET VALVE
ACCELERATOR PUMP CHECK VALVE
POWER JET CALIBRATION
VACUUM CHANNEL
VACUUM CHANNEL PASSAGE
FUEL VALVE SEAT
FUEL VALVE NEEDLE
FLOAT HINGE BRACKET
FLOAT AXLE
FUEL BOWL LOWER PLUG
FLOAT
PITOT TUBE
AIR SHUTTER
MAIN JET
THROTTLE LEVER AND DRIVER

Zenith 29 Series

POWER JET SYSTEM

The power jet, also called an economizer, controls the additional fuel necessary for maximum power at wide-open throttle. This part of the high speed system consists of a power jet valve which restricts the flow of fuel to the power jet calibration, a vacuum-controlled piston assembly for operating the power jet valves, and an accelerating pump disc check valve located in the fuel bowl controlling the passage from the fuel bowl into the accelerating pump cylinder. The power jet valve, through which the fuel flows to the power jet calibration, is opened by the vacuum-operated accelerating pump piston when the throttle is from three-quarters to wide open. This arrangement makes it possible to run the engine on a lean and economical mixture at normal cruising speeds without sacrificing maximum power at wide-open throttle.

In operation, when the power jet valve is open, fuel flows from the fuel bowl through the pump check valve into the pump cylinder and past the power jet valve through the calibration in the side of the valve. This fuel passes through the passage connecting the pump cylinder with the metering well. The power jet fuel entering the metering well adds to that metered by the main jet and is discharged into the air stream through the main discharge jet.

When the throttle position, or the road and load condition, allows the manifold vacuum to rise above a pre-determined point, the pump assembly is lifted and the power jet valve closes, permitting the carburetor to deliver an economy mixture again.

ACCELERATING SYSTEM

A quick opening of the throttle produces a sudden drop in the manifold vacuum which, in turn, allows the pump piston to be forced down by the pump spring. The downward movement of the pump piston closes the pump check valve, opens the relay check valve, closes the air vent check valve and discharges the pump fuel through the accelerating jet into the main discharge tube. As soon as the pump stroke is completed, the air vent valve disc drops, opening the air vent and closing the pump refill valve. The pump check valve also opens (by gravity) to permit fuel to flow to the power jet or to refill the pump cylinder on the upward stroke of the pump.

The air vent supplies air from the float chamber to the accelerating jet to break the suction on the accelerating and power jet systems the instant the vacuum piston starts to lift the pump assembly.

NOTE—When a sandwich-type speed governor is installed between the standard model of this carburetor and the intake manifold, a hollow screw must be installed in the vacuum channel passage to close the opening. Then, too, there must be an opening in the flange gasket to coincide with the vacuum channel passage and a bypass channel in the governor body to permit direct communication of manifold vacuum to the vacuum cylinder in the carburetor, otherwise, the power jet and accelerating systems will not function properly. (This note does not apply to models having a built-in speed governor.)

ADJUSTMENTS

The throttle stop screw should be screwed in (clockwise) against the stop pin to hold the throttle just slightly open. Adjust the throttle stop screw to obtain the desired idling speed of the engine.

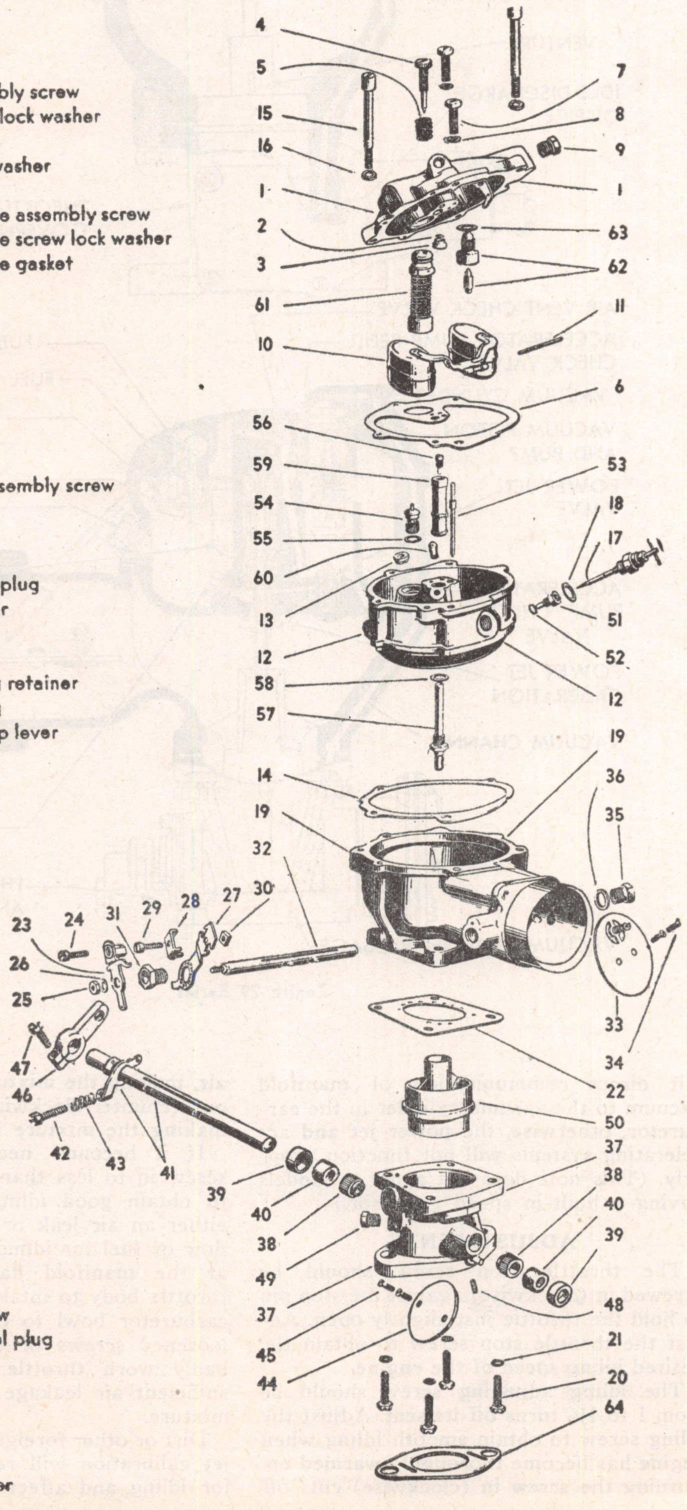
The idling adjusting screw should be from 1 to 1½ turns off its seat. Adjust the idling screw to obtain smooth idling when engine has become thoroughly warmed up. Turning the screw in (clockwise) cuts off air, making the mixture richer; turning it out (counter-clockwise) admits more air, making the mixture leaner.

If it becomes necessary to turn the screw in to less than ½ turn off its seat to obtain good idling, it would indicate either an air leak or a restriction of the flow of fuel for idling. Look for air leaks at the manifold flange; at carburetor throttle body to intake gasket, and at the carburetor bowl to cover gasket, due to loosened screws or damaged gaskets. A badly worn throttle shaft will produce sufficient air leakage to affect the idling mixture.

Dirt or other foreign matter in the idling jet calibration will restrict the fuel flow for idling and affect the mixture. If the

Zenith 29 Series

1. Bowl cover
2. Check valve disk
3. Check valve body
4. Idle adjusting screw
5. Adjusting screw spring
6. Bowl to cover gasket
7. Bowl cover assembly screw
8. Bowl cover screw lock washer
9. Fuel channel plug
10. Float
11. Float axle
12. Fuel bowl
13. Pump check valve
14. Bowl to intake gasket
15. Bowl and cover assembly screw
16. Bowl and cover screw lock washer
17. Main jet adjustment
18. Main jet adjustment washer
19. Air intake body
20. Throttle body to intake assembly screw
21. Throttle body to intake screw lock washer
22. Throttle body to intake gasket
23. Air shutter lever
24. Lever swivel screw
25. Air shutter shaft nut
26. Shaft nut lock washer
27. Air shutter bracket
28. Bracket tube clamp
29. Tube clamp screw
30. Tube clamp screw nut
31. Air shutter bracket assembly screw
32. Air shutter shaft
33. Air shutter plate
34. Air shutter screw
35. Air shutter shaft hole plug
36. Shaft hole plug washer
37. Throttle body
38. Throttle shaft bushing
39. Throttle shaft packing retainer
40. Throttle shaft packing
41. Throttle shaft and stop lever
42. Lever stop screw
43. Stop screw spring
44. Throttle plate
45. Throttle plate screw
46. Throttle clamp lever
47. Lever clamp screw
48. Vacuum channel screw
49. Vacuum spark channel plug
50. Venturi
51. Main jet
52. Main jet washer
53. Idling jet
54. Power jet valve
55. Power jet valve washer
56. Accelerator jet
57. Main discharge jet
58. Discharge jet washer
59. Metering well
60. Well vent jet
61. Pump
62. Fuel valve and seat
63. Fuel valve seat washer
64. Flange gasket



idling jet becomes completely clogged, it will be impossible to run the engine at idling speed regardless of the idling screw adjustment.

Some models of this series are supplied with a main jet adjustment which is installed in place of the fuel bowl lower plug (see cut). Turning the needle clockwise cuts off fuel, making the medium and high speed mixtures leaner. The needle should be adjusted to give highest manifold vacuum (or highest R.P.M. on a tachometer) for a set throttle position—which is usually about 1½ full turns (counterclockwise) from the seat. If the engine is equipped with a speed governor, set the throttle to hold the engine speed just below the governed speed while making the main jet adjustment. If the adjustment is set too lean, the engine will lack power and the fuel economy will be poor. If set too rich, the engine will be sluggish and the fuel economy will likewise be poor.

SERVICE

The disassembled view will identify the component parts of this series and shows the relation to the assembly. After disassembling the unit, clean all metal parts with carburetor cleaning solution and rinse in dry-cleaning solvent. Blow out all passages in the air intake assembly, fuel bowl assembly, and throttle body. Be sure all carbon deposits have been removed from the throttle bore and idle port. It is advisable to reverse flow with compressed air in all passages to be sure that all dirt is removed. Never use a wire or drill to clean out jets.

After disassembling the carburetor, inspect the following: 1—Replace float if loaded with gasoline, is damaged or crushed. Inspect top side of float lever for wear where it contacts the fuel valve needle.

2—Replace the float axle if any wear can be detected on the bearing surface.

3—Replace the fuel valve seat and needle because both parts wear and may cause improper float level.

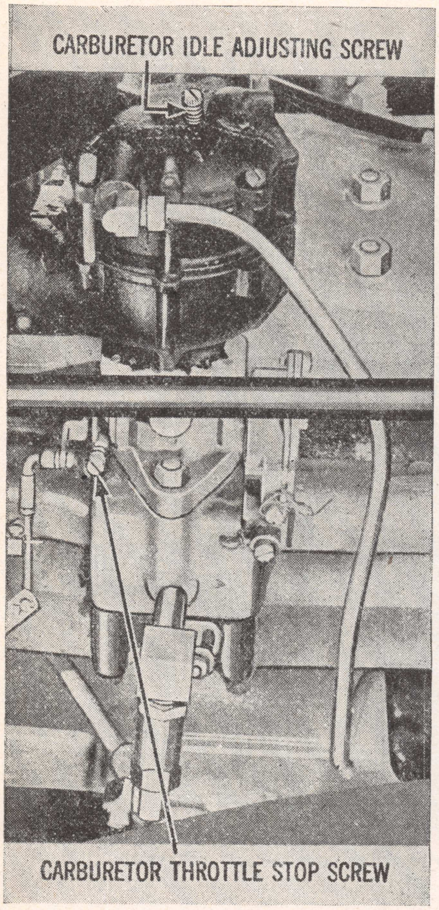
4—Inspect the point of the idle adjusting needle. This must be smooth and free of ridges.

5—Inspect the throttle plate for burrs or damaged edges. Never clean a throttle plate with a buffing wheel or a sharp instrument.

6—Replace the vacuum accelerating pump piston assembly because the extent of wear cannot be determined by visual inspection. Worn, scratched, or otherwise mutilated pistons result in poor idling, acceleration and power jet action. Vacuum piston head must be free of carbon, burrs, or damaged edges.

7—Replace the power jet valve because the extent of wear cannot be determined by visual inspection.

8—Inspect the air shutter plate for bends, burrs or damaged edges. See that the poppet valve is in good condition and works freely.


CARBURETOR IDLE ADJUSTING SCREW
CARBURETOR THROTTLE STOP SCREW

Zenith 29 Series Adjustments

9—Check the bearing surface of the air shutter shaft and lever for wear; see that the shaft is straight.

10—Replace the pump check valve and air vent check valve if these parts are removed because they have been damaged in removal.

11—Replace all gaskets and fibre washers every time a carburetor is disassembled.

12—Replace the throttle shaft if wear can be detected on the bearing surface.

13—Replace the throttle shaft bushings if the new shaft has more than .005 inch side play.

14—Examine the pump cylinder at the lower end for evidence of excessive wear, deep scratches or ridges. Desirable clearance between the pump piston and pump cylinder at the lower operating end is .001 inch. Any clearance in excess of .003 inch will reduce accelerating pump discharge and result in poor acceleration. Replace the fuel bowl if the above conditions are found.

15—Examine the vacuum piston cylinder in the fuel bowl cover for evidences of excessive wear, deep scratches, ridges or mutilation of cylinder head. Desired clearance between the vacuum piston and cylinder at the upper operating end is .001 inch. Any clearance in excess of .003 inch will allow air or fuel to be discharged into the engine manifold through the vacuum passage leading from the cylinder head into the throttle body bore. This condition results in poor idling, power jet and pump action.

FLOAT LEVEL

Hold the cover and float assembly upside down as shown in the illustration to observe the relation of the float to the cover. To obtain correct fuel level with normal pump pressure, dimension A should be 1¼ inch, plus or minus $\frac{1}{32}$ inch (see cut).

30 SERIES

The 30 series carburetor is a downdraft unit with an integrally cast fuel bowl and throttle body. It is a "sealed and balanced" carburetor in that all air for fuel bowl chamber ventilation and idling must come through the air cleaner. Two venturi are employed to aid in the complete vaporization of the fuel. The power jet and accelerating pump systems are operated by engine manifold vacuum, and are completely enclosed and protected from dirt.

FUEL SUPPLY SYSTEM

The fuel supply system includes the fuel valve and seat, float and float axle, and the bowl vent. In operation, the fuel supply system maintains a constant level of fuel in the float bowl so that uniform pressure is exerted by the fuel on the metering system under all conditions of operation. The bowl vent is provided to carry off any accumulation of gas that may be formed by the heat of operation and also to admit air to the carburetors metering system.

IDLING SYSTEM

Under idling conditions, the throttle plate is slightly opened, exposing a portion of the priming plug or idle discharge area to the effect of high manifold suction. This suction is transmitted to the idle jet by a series of channels running through the air intake and fuel bowl castings. Fuel for idling is delivered from the main jet passage through the combined metering well and idle jet assembly to the idle jet calibration at its upper end. At this point, the fuel is mixed with air entering the system from two sources. A fixed amount is drawn from the permanent air bleed from the air intake of the carburetor. An additional quantity is admitted through the idle needle valve. This mixture is then conducted through appropriate channels to the idle discharge port in the throttle body.

The permanent idle air bleed calibration, located in the fuel bowl cover, is provided to prevent the syphoning of fuel from the fuel bowl in cases where the idle needle valve might be fully closed due to abnormal idling requirements. In such cases, when the engine is shut down, no fuel is syphoned from the bowl. Without such an air bleed, considerable fuel might flow into the manifold.

MAIN JET SYSTEM

This system consists of a main jet, metering well, and secondary venturi or discharge tube. The main jet system controls the fuel delivery from about ¼ to ¾ throttle opening. The metering well combines the functions of the idle jet, well vent, and main jet air bleed. The idling and main jet systems are separated in the well construction by a tube extending from the top to a short distance from the bottom of the well. At this point, a land or barrier is formed to entirely separate the two systems.

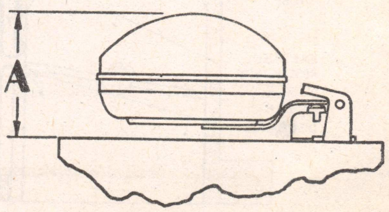
When the throttle plate is opened to a point just above the idle position, enough air passes through the secondary venturi to create a depression at the opening of the discharge jet. As the float chamber is vented to atmospheric pressure, fuel from the float bowl flows through the main jet into the metering well and is drawn through the clearance space surrounding the metering well body where it is emulsified by air passing through the air bleed holes drilled in the wall of the metering well below the fuel level. Introduction of air at this point reduces the surface tension of the fuel and compensates for variations of suction in the system. The mixture is then drawn into the secondary venturi and is discharged and mixed with the air column passing through the main venturi.

POWER & ACCELERATING SYSTEM

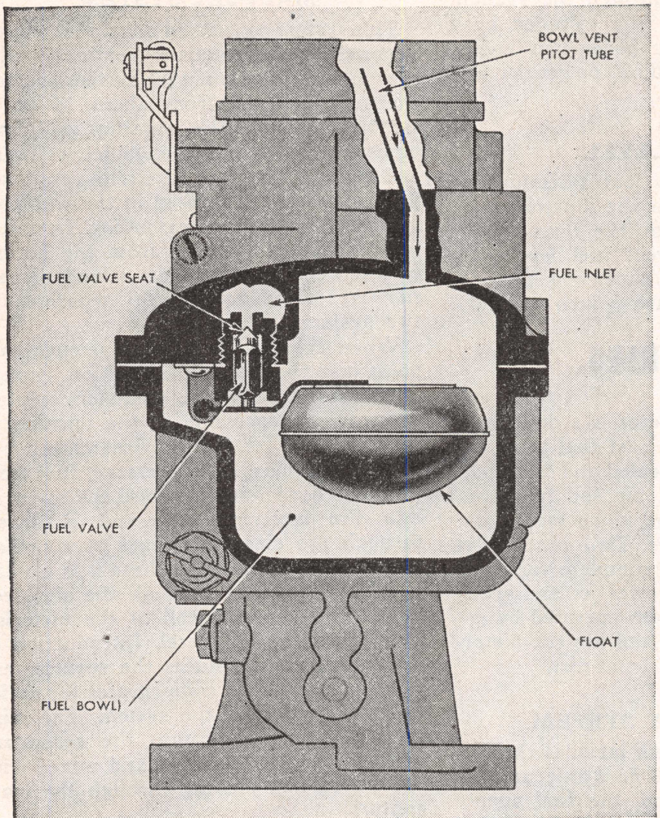
This system consists of a vacuum-operated piston assembly, an economizer or power jet valve, and three check valves controlling the operation and venting of the system.

The vacuum piston assembly consists of an upper and lower piston, connecting rod, piston spring and spring retainer. The upper piston operates in the vacuum cylinder located in the bowl cover, while the lower or pump piston moves in a cylinder located in the fuel bowl assembly.

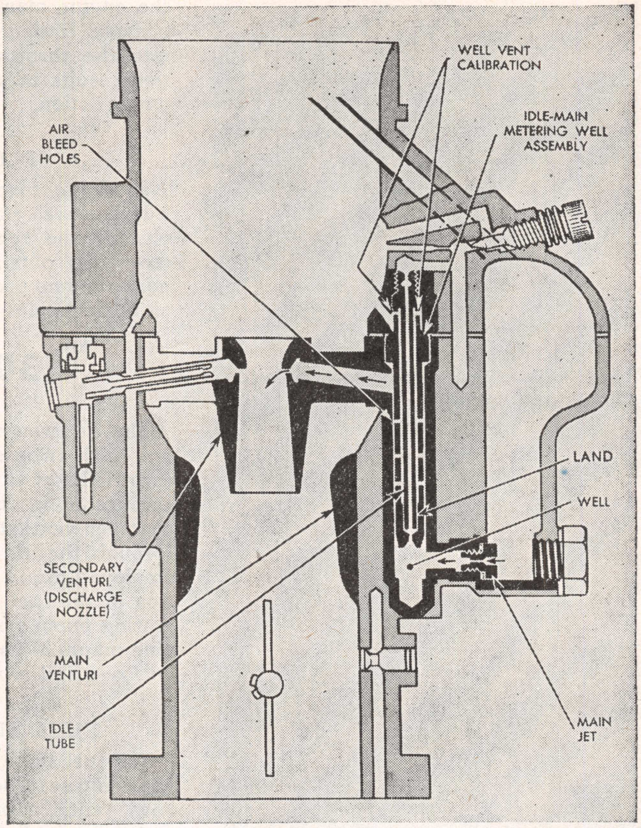
Under part-throttle operation, manifold vacuum is transferred from opening "B" (Fig. 4) through the vacuum passage to the vacuum cylinder. Under the influence of this suction, the piston is drawn upward, compressing the spring which is anchored by its retainer in the fuel bowl cover. Upward movement of the pump piston fills the lower end of the cylinder with fuel admitted through the lower check valve at the bottom of the fuel bowl. The pump assembly is then in the position as shown



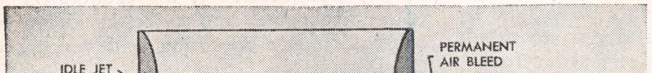
Zenith 29 and 30 Series. Checking float level


BOWL VENT PITOT TUBE
FUEL VALVE SEAT
FUEL INLET
FUEL VALVE
FLOAT
FUEL BOWL

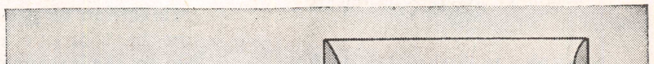
Zenith 30 Series. Fuel supply system


WELL VENT CALIBRATION
AIR BLEED HOLES
IDLE-MAIN METERING WELL ASSEMBLY
LAND
WELL
SECONDARY VENTURI (DISCHARGE NOZZLE)
MAIN VENTURI
IDLE TUBE
MAIN JET

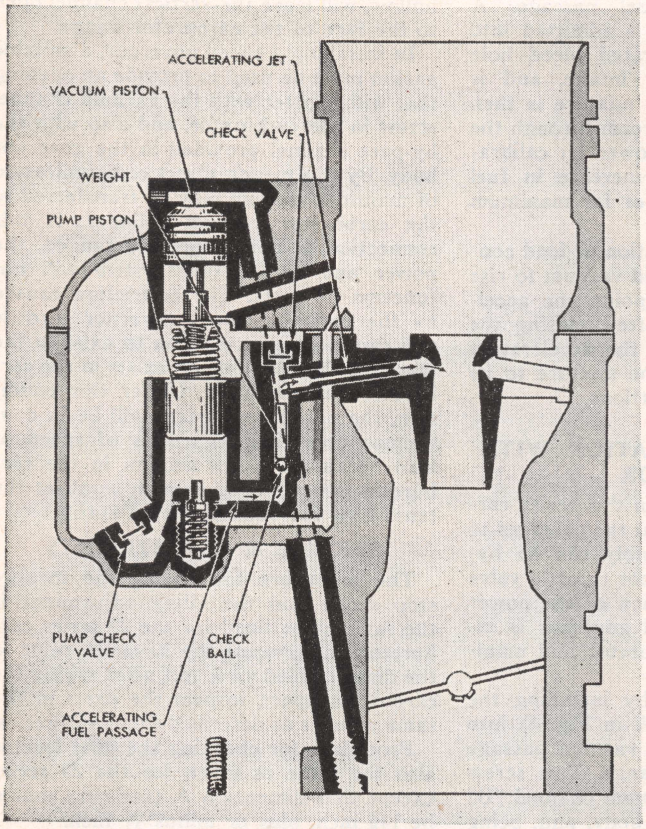
Zenith 30 Series. High speed—main jet system


IDLE JET
PERMANENT AIR BLEED
IDLE ADJUSTING NEEDLE
VACUUM PASSAGE
MAIN JET
IDLE JET TUBE
IDLE FUEL RESTRICTION
IDLE DISCHARGE

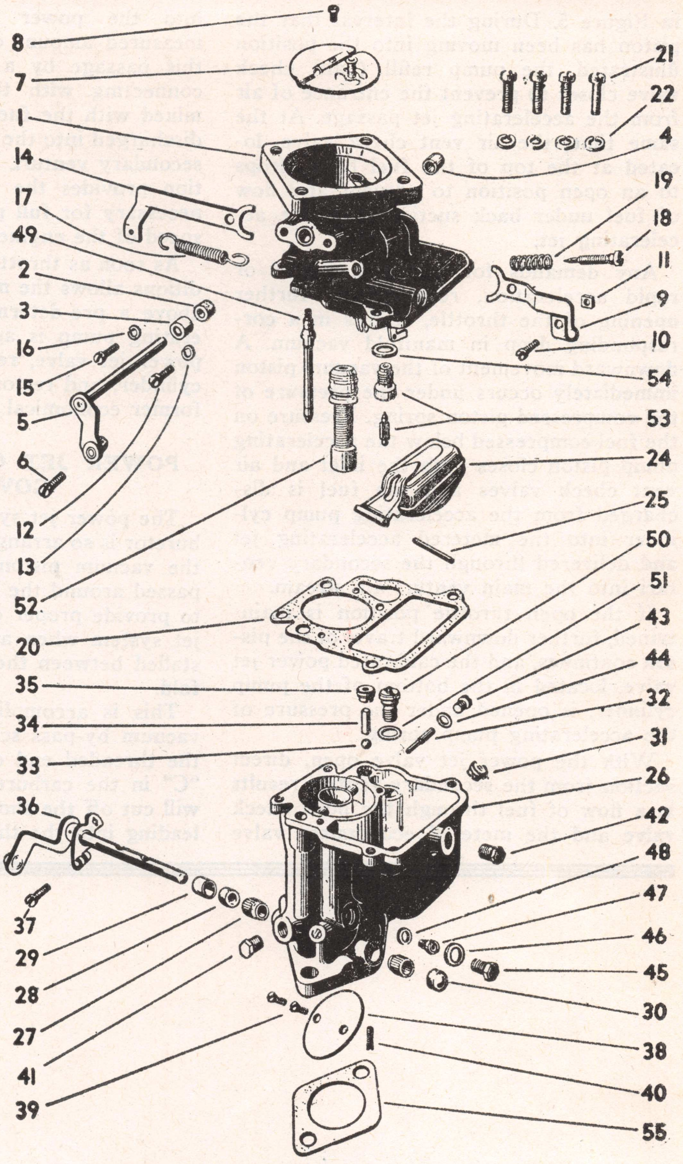
Zenith 30 Series. Idling system


VACUUM PISTON
AIR BLEED
AIR VENT PASSAGE
CHECK VALVE
CALIBRATION
POWER JET VALVE
POWER JET FUEL PASSAGE
VACUUM PASSAGE
A
B
C

Zenith 30 Series. Power and accelerating jet systems


ACCELERATING JET
VACUUM PISTON
CHECK VALVE
WEIGHT
PUMP PISTON
PUMP CHECK VALVE
CHECK BALL
ACCELERATING FUEL PASSAGE

Zenith 30 Series. Accelerating pump system


8
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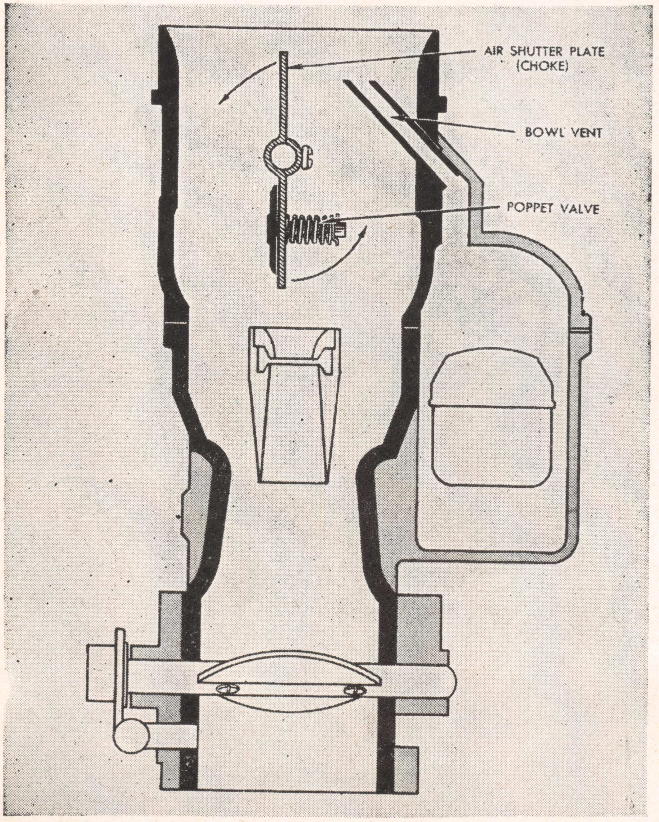
Zenith 30 Series.


AIR SHUTTER PLATE (CHOKE)
BOWL VENT
POPPET VALVE

Zenith 30 Series. Choke system

1. Air intake body
2. Shaft packing washer
3. Shaft packing retainer
4. Shaft hole plug
5. Air shutter and lever
6. Swivel screw
7. Air shutter plate
8. Air shutter screw
9. Air shutter bracket
10. Tube clamp screw
11. Tube clamp nut
12. Bracket assembly screw
13. Bracket screw lock washer
14. Return spring bracket
15. Bracket assembly screw
16. Bracket screw lock washer
17. Air shutter return spring
18. Idle adjusting screw
19. Idle adjusting screw spring
20. Bowl to intake gasket
21. Bowl to intake assembly screw
24. Float
25. Float axle
26. Bowl and throttle body
27. Throttle shaft bushing
28. Throttle shaft packing washer
29. Shaft packing retainer
30. Throttle shaft hole plug
31. Pump check valve
32. Accelerating jet
33. Pump refill check ball
34. Refill check ball weight
35. Air vent check valve
36. Throttle shaft and lever
37. Lever stop screw
38. Throttle plate
40. Vacuum channel screw
41. Vacuum spark channel plug
42. Fuel level line plug
43. Accel jet channel plug
44. Accel jet channel plug washer
45. Main jet passage plug
46. Main jet passage plug washer
47. Main jet
48. Main jet washer
49. Metering well
50. Power jet valve
51. Power jet valve washer
52. Pump
53. Fuel valve and seat
54. Fuel valve seat washer
55. Flange gasket

in Figure 5. During the interval that the piston has been moving into the position illustrated, the pump refill (ball) check valve closes to prevent the entrance of air from the accelerating jet passage. At the same time, the air vent check valve, located at the top of the fuel bowl, drops to an open position to prevent any flow of fuel under back suction from the accelerating jet.

Any demands for increased power or rapid acceleration, reflected by further opening of the throttle, results in a corresponding drop in manifold vacuum. A downward movement of the vacuum piston immediately occurs under the pressure of the compressed piston spring. Pressure on the fuel compressed below the accelerating pump piston closes both the inlet and air vent check valves and the fuel is discharged from the accelerating pump cylinder into the metered accelerating jet and delivered through the secondary venturi into the main venturi air stream.

If the open throttle position is maintained, further downward travel of the piston continues, and the calibrated power jet valve, located in the bottom of the pump cylinder, is opened under the pressure of the accelerating pump spring.

With the power jet valve open, direct suction from the secondary venturi results in a flow of fuel through the bowl check valve and the metered economizer valve into the power jet fuel passage. A measured amount of air is admitted into this passage by a calibrated bleed hole connecting with the air intake, and is mixed with the fuel. The mixture is then discharged into the air stream through the secondary venturi. The power jet calibration provides the exact increase in fuel necessary for full power or for maximum speed of the engine.

As soon as throttle position or load conditions allows the manifold vacuum to rise above a pre-determined point, the accelerating pump is again lifted, closing the power jet valve, refilling the accelerating cylinder, and restoring the mixture to its former economical proportions.

POWER JET OPERATION WITH GOVERNOR

The power jet system in this series carburetor is so arranged that the passages to the vacuum piston assembly can be bypassed around the governor throttle valve to provide proper operation of the power jet system when a speed governor is installed between the carburetor and manifold.

This is accomplished by installing the vacuum by-pass screw (A in Fig. 4) into the threaded end of the vacuum passage "C" in the carburetor flange. This screw will cut off the short vacuum channel "B" leading into the throttle body, and, being hollow, will leave the vertical channel open to the face of the carburetor flange.

In installing a speed governor, a suitable gasket **must** be used to provide an opening that will register with the vacuum channel screw in the carburetor, and also with the by-pass channel provided in the governor body. By this means, direct communication of manifold vacuum may be transferred to the carburetor vacuum cylinder. If this connection is not properly arranged, the power and accelerating system will not function properly. The restriction caused by the partially closed governor throttle will cause a higher suction to exist in the manifold than that which exists in the carburetor throttle body. Under this condition, the power jet system will be in continuous operation regardless of speed or load because the low suction in the carburetor is not strong enough to offset the tension of the vacuum piston spring.

SERVICE & ADJUSTMENTS

The procedure for setting the throttle stop screw and the idling adjustment is the same as outlined for the 29 series carburetor. In servicing the 30 series, refer to the disassembled view and, after taking the carburetor apart, inspect the parts in the same manner as described for the 29 series.

Procedure for checking the float level is also the same as given for the 29 series except that dimension A (see cut) should be 1⅜ inch, plus or minus $\frac{1}{32}$ inch.

AUTO-LITE DISTRIBUTOR SPECIFICATIONS

Unit Number	Rotation	Breaker Gap, Inch	Cam Angle, Degrees	Maximum Advance Distributor Degrees			Automatic Advance Curve Number①	Vacuum Advance Curve Number②
				Manual	Automatic	Vacuum		
IGC-4030D	C	.020	41	10	12.5	None	297	None
IGC-4264	C	.025	47	10	12.5	None	408	None
IGC-4710	CC	.020	38	None	11	None	816	None
IGC-4710-1	CC	.020	38	None	11	None	816	None
IGC-4710A	CC	.020	38	None	10	None	817	None
IGC-4713	CC	.020	38	None	17.5	None	820	None
IGC-4722	CC	.020	38	None	11	None	816	None
IGC-4803	CC	.020	38	3	8.5	None	591	None
IGC-4901	CC	.020	38	None	17.5	None	820	None
IGC-4905	CC	.020	38	None	13	None	847	None
IGC-4907	CC	.020	38	3	8	None	851	None
IGC-4908	CC	.020	38	None	17	None	859	None
IGC-4909A1	CC	.020	38	3	6	None	876	None
IGE-4003H	CC	.020	35	10	12.5	None	676	None
IGS-4203A1	C	.020	38	None	9	9	769	768
IGS-4203B1	C	.020	38	None	10	8.5	770	767
IGW-4044	C	.020	41	None	8	None	554	None
IGW-4108A	CC	.020	35	None	11	None	731	None
IGW-4108B	CC	.020	35	None	11	None	823	None
IGW-4139C	CC	.020	41	None	10	None	191	None
IGW-4156	CC	.020	41	None	6	None	728	None
IGW-4159-1	CC	.020	41	12	10	None	733	None
IGZ-4003-1	C	.020	40	None	13	None	541	None
IGZ-4006A	CC	.020	40	None	20	None	355	None
IGZ-4010	CC	.020	40	None	10.5	None	765	None
IGZ-4010A	CC	.020	40	None	11	None	816	None

NOTE—Breaker arm spring tension on all units listed should be from 17 to 20 ounces as measured with a spring scale hooked at the contact point and in line with the center of the contacts. Take reading just as points open.

① See the Auto-Lite "Distributor Automatic Advance Curve" Table.

② See the Auto-Lite "Vacuum Advance Curve" table.

C—Clockwise.

CC—Counterclockwise.

AUTO-LITE AUTOMATIC ADVANCE CURVES

Advance Curve Number ①	Start Advance		Intermediate Advance		Maximum Advance	
	Distributor R. P. M.	Distributor Degrees	Distributor R. P. M.	Distributor Degrees	Distributor R. P. M.	Distributor Degrees
297	410	3	630	6	1100	12.5
408	540	3	780	6	1300	12.5
816	360	3	500	7	900	11
817	380	2	500	5	1200	10
820	385	4	500	7.5	1350	17.5
847	500	5	590	6	1200	13
851	540	2	825	4	1400	8
859	450	6	725	10	1200	17
876	490	1	850	3	1400	6

① See the Auto-Lite "Distributor Specifications for Automatic Advance Curve Number" desired.

DELCO-REMY DISTRIBUTOR INDEX

Model No.	Direction of Rotation	Advance Curve No.	Cam Angle Deg.	Model No.	Direction of Rotation	Advance Curve No.	Cam Angle Deg.	Model No.	Direction of Rotation	Advance Curve No.	Cam Angle Deg.
4145	CC	1055	37	1110058	CC	839	35	1110153	CC	1157	35
4197	CC	123	37	1110074	CC	1003	35	1110157	C	1095	35
4221	CC	1055	37	1110082	CC	1109	35	1110170	C	1163	35
4222	C	1139	37	1110101	CC	874	35	1110176	C	974	35
4224	CC	1134	37	1110122	C	1134	35	1110181	CC	1003	35
4230	C	1095	37	1110126	CC	874	35	1110189	C	974	35
4231	C	1151	37	1110141	C	1151	35	1110192	C	1169	35
4234	C	1152	37	1110142	C	1151	35	1110403	CC	812	32①
4248	CC	1164	37	1110143	C	1152	35	1110605	C	1108②	31
1110003	CC	....	35	1110147	C	1154	35				

C—Clockwise. CC—Counterclockwise.

① Cam angle should be 49 degrees on early production cams.

② Point opening .0125″–.0175″.

NOTE—Breaker gap on all units, unless otherwise indicated is .018″–.024″. The cam angle listed is subject to a variation of plus or minus 2 degrees and is based on a worn-in rubbing block. When a new breaker arm and rubbing is being installed, cam angle must be set 3 degrees less than shown in the table.

DELCO-REMY DISTRIBUTOR ADVANCE CURVES

Advance Curve Number	Start Advance		Intermediate Advance		Maximum Advance	
	Engine R.P.M.	Engine Degrees	Engine R.P.M.	Engine Degrees	Engine R.P.M.	Engine Degrees
839	800	3.0	1800	12.0	3200	22.0
974	400	2.0	....	......	2800	18.0
1055	400	2.0	....	......	1800	34.0
1108	500	2.0	1200	16.0	3000	26.0
1139	430	2.0	....	......	1400	27.0
1151	400	2.0	....	......	1650	22.0
1152	400	1.0	....	......	1400	22.0
1154	600	4.0	1000 ④	10.0 ④	2800	20.0
1157	400	2.0			2000	14.0
1163	600	2.0	900	14.0	3000	34.0
1164	500	2.0	1200	18.0	2600	28.0
1169	500	2.0	800	14.0	2400	30.0

④ Low Intermediate 800 R. P. M., 4.0 degrees; high Intermediate 1200 R. P. M., 9.0 degrees.

NOTE—Refer to the Delco-Remy numerical index for the advance curve number desired.

AUTO-LITE STARTING MOTOR TEST SPECIFICATIONS

Unit Number	Brush Spring Tension, Ounces	No Load Test			Lock Test		
		Amperes	Volts	R.P.M.	Amperes	Volts	Torque Pounds, Feet
MAB-4007	42–53	60	5.5	3700	750	4.0	21.5
MAB-4044A	42–53	60	5.5	3700	750	4.0	21.5
MAB-4072A	42–53	60	5.5	3700	750	4.0	21.5
MAB-4114	42–53	60	5.5	3700	750	4.0	21.5
MAK-4023	38–61	70	5.5	5000	520	4.0	7.0
MAS-4008	12–16	35	11.0	4100	440	6.0	20.0
MAS-4009	12–16	35	11.0	4100	440	6.0	20.0
ML-4193	12–16	50	5.5	2980	750	4.0	26.0
ML-4203	12–16	50	5.5	2980	750	4.0	26.0
ML-4208	12–16	50	5.5	2980	750	4.0	26.0
ML-4210	12–16	50	5.5	2980	750	4.0	26.0
MR-4113	12–16	35	5.5	3100	700	4.0	43.0
MZ-4075	42–53	60	5.5	5000	560	4.0	11.8
MZ-4115	42–53	60	5.5	5000	560	4.0	11.8

DELCO-REMY STARTING MOTOR INDEX

Starting Motor No.	Direction of Rotation	Specification Number	Starting Motor No.	Direction of Rotation	Specification Number	Starting Motor No.	Direction of Rotation	Specification Number	Starting Motor No.	Direction of Rotation	Specification Number
793	C	383	1108703	C	429	1109101	CC	383	1109306	C	438
1107831	C	364	1108718	CC	429	1109112	C	383	1109307	CC	438
1107836	C	364	1108723	C	429	1109120	C	383	1109334	C	401
1108106	C	410	1108901	CC	425	1109302	CC	401	1109336	C	401
1108402	C	377	1108902	C	425	1109304	C	438			
1108409	C	377	1108911	C	425	1109305	CC	438			

C—Clockwise.
CC—Counterclockwise.

DELCO-REMY STARTING MOTOR TEST SPECIFICATIONS

Spec. No.	Brush Spring Tension, Ounces	No Load Test			Lock Test		
		Amperes	Volts	R.P.M.	Amperes	Volts	Torque Lbs. Ft.
438	36–40	115	30.7	7250	500	4.3	25

NOTE—Refer to the Delco-Remy numerical index for specification number desired.

AUTO-LITE GENERATOR SPECIFICATIONS

THIRD BRUSH CONTROL TYPE

Unit Number	Direction of Rotation	Brush Spring Tension		Low Output Test			Maximum Output①	
		Main, Ounces	Third, Ounces	Amperes	Maximum R. P. M. at Volts	Maximum R. P. M. at Volts	Amperes at Volts	Amperes at Volts
GAE-4027	C	20–26	20–26	4	835@13.	860@15.	8.3–10.3@12.2	10.5–12.5@15.
GAE-4033	CC	20–26	20–26	4	835@13.	860@15.	8.3–10.3@12.2	10.5–12.5@15.
GAE-4042	C	20–26	20–26	4	835@13.	860@15.	8.3–10.3@12.3	10.5–12.5@15.
GAE-4043	CC	20–26	20–26	4	835@13.	860@15.	8.3–10.3@12.2	10.5–12.5@15.
GAE-4046	CC	20–26	20–26	4	835@13.	860@15.	8.3–10.3@12.2	10.5–12.5@15.
GAR-4539	CC	18–22	18–22	8	1135@ 6.0	1165@ 8.	11.0–13.0@ 6.	15.0–17.0@ 8.
GAS-4124-1	CC	15–20	15–20	4	1280@ 7.	1295@ 7.6	6.5– 7.5@ 7.8	6.6– 7.6@ 8.
GAS-4138	C	15–20	15–20	4	1280@ 7.	1295@ 7.6	6.5– 7.5@ 7.8	6.6– 7.6@ 8.
GAS-4147	C	15–20	15–20	4	1280@ 7.	1295@ 7.6	6.5– 7.5@ 7.8	6.6– 7.6@ 8.
GAS-4153	C	15–20	15–20	4	1280@ 7.	1295@ 7.6	6.5– 7.5@ 7.8	6.6– 7.6@ 8.
GAS-4173A	C	15–20	15–20	4	1280@ 7.	1295@ 7.6	6.5– 7.5@ 7.8	6.6– 7.6@ 8.
GAS-4177	C	15–20	15–20	4	1280@ 7.	1295@ 7.6	6.5– 7.5@ 7.8	6.6– 7.6@ 8.
GAS-4182	C	15–20	15–20	4	1280@ 7.	1295@ 7.6	6.5– 7.5@ 7.8	6.6– 7.6@ 8.
GAS-4185	CC	15–20	15–20	4	1280@ 7.	1295@ 7.6	6.5– 7.5@ 7.8	6.6– 7.6@ 8.
GBE-4301	C	17–22	17–22	4	1200@13.	1275@15.	10.7–12.7@12.2	14.0–16.0@15.
GBM-4621-5	C	37–44	50–60	8	1250@ 7.6	....	13.1–15.2@ 7.6	14.0–16.0@ 8.
GBM-4815A	C	37–44	50–60	8	1250@ 7.6	....	13.1–15.2@ 7.6	14.0–16.0@ 8.
GBM-4818A	C	37–44	37–44	8	1240@ 7.6	....	15.8–17.8@ 7.6	17.0–19.0@ 8.
GCT-4812A	C	53	53	4	1165@14.2	....	7.7– 8.7@14.6	8.0– 9.0@15.0
GDY-4104A	CC	15–20	15–20	2	1215@13.4	1235@14.2	5.8– 6.7@14.6	6.0– 7.0@15.0
GFA-4801-2	C	35–53	35–53	8	1030@ 7.2	1030@ 7.6	14.4–16.4@ 7.6	15.0–17.0@ 8.0
GFA-4806-2	C	35–53	35–53	8	1030@ 7.2	1030@ 7.6	14.4–16.4@ 7.6	15.0–17.0@ 8.0
GFA-4808-2	C	35–53	35–53	8	1030@ 7.2	1030@ 7.6	14.4–16.4@ 7.6	15.0–17.0@ 8.0
GFA-4810-2	C	35–53	35–53	8	1030@ 7.2	1030@ 7.6	14.4–16.4@ 7.6	15.0–17.0@ 8.0
GFA-4812-2	C	35–53	35–53	8	1030@ 7.2	1030@ 7.6	14.4–16.4@ 7.6	15.0–17.0@ 8.0
GFW-4805	C	35–53	35–53	4	850@14.6	....	9.7@14.6	10.0@15.0
GFW-4806	C	35–53	35–53	4	850@14.6	....	9.7@14.6	10.0@15.0
GFW-4807	CC	35–53	35–53	4	850@14.6	....	9.7@14.6	10.0@15.0

① Maximum output readings taken at 70 degrees F. For each 15-degree change of temperature, add 1 ampere if below 70 degrees and subtract 1 ampere if above 70 degrees. C—Clockwise. CC—Counterclockwise.

AUTO-LITE GENERATOR SPECIFICATIONS

CURRENT-VOLTAGE REGULATOR CONTROL TYPE

Unit Number	Direction of Rotation	Brush Spring Tension, Ounces	Ground Polarity	Low Output Test		Maximum Output Test①			
				Amperes	Maximum R. P. M. at Volts	Maximum R. P. M. at Volts	Amperes	Maximum R. P. M. at Volts	Maximum R. P. M. at Volts
GBG-4611A	C	23–26	P	8	835@14.2	850@14.6	40	1060@14.6	1065@15.0
GCE-4815A	C	64–68	P	8	910@ 6.0	1000@ 8.	30	1500@ 6.	1500@ 8.0
GDM-4808-1	CC	30–37	P	4	....	970@14.6	30	1415@14.6	1420@15.0
GDZ-4801H	C	53	P	8	....	1125@ 6.8	36.7	....	1125@ 8.0
GEB-4809	C	64–68	P	8	725@ 7.0	740@ 7.6	32	1160@ 7.6	1165@ 8.0
GEG-4802	C	64–68	P	8	930@ 7.0	955@ 7.6	40	1460@ 7.6	1465@ 8.0
GEG-4811A	C	64–68	P	8	930@ 7.0	955@ 7.6	40	1460@ 7.6	1465@ 8.0
GEG-4822	C	64–68	P	8	930@ 7.0	955@ 7.6	40	1460@ 7.6	1465@ 8.0
GGA-4802	C	30–37	P	4	....	890@14.6	40	1500@14.6	1500@15.
GGA-4805A	C	30–37	P	4	....	890@14.6	40	1500@14.6	1500@15.
GGA-4806-1	C	30–37	P	4	....	890@14.6	18	14.6①	15.0①

① Do not run generator in excess of the maximum test figures given above for any length of time as to do so may result in burnt armature and field coils. Maximum output readings taken at 70 degrees F. For each 15 degree change of temperature, add 1 ampere if below 70 degrees and subtract 1 ampere if above 70 degrees.

C—Clockwise. CC—Counterclockwise.

P—Positive. N—Negative.

DELCO-REMY REGULATOR INDEX

Model Number	Table Number ①	Specification Number	Model Number	Table Number ①	Specification Number	Model Number	Table Number ①	Specification Number
5574	3 (N)	1448	5635	3 (N)	1447	1118468	3 (N)	2019
5608	3 (P)	1413	5642	3 (P)	1451	1118469	3 (P)	1413
5619	3 (P)	1471	5645	3 (P)	1414	1118494	3 (P)	2026
5620	3 (P)	2001						

① For table No. 3, see "Heavy Duty Regulator" table.

P—Used with positive grounded battery.

N—Used with negative grounded battery.

DELCO-REMY REGULATOR SPECIFICATIONS

Specification Number	Current Regulator		Voltage Regulator		Cutout Relay			
	Current Setting Amperes	Point Opening Inch	Voltage Setting ①	Point Opening Inch	Voltage to Close Points	Air Gap Inch	Point Opening Inch	Point Open Amperes Reverse Current
2026 ②	55	.015	14.6	.015	13.5	.057	.020	0–3.0

NOTE—See the Delco-Remy Numerical Index for specification number desired.

① Setting made on open circuit at from 135 to 145 degrees F. Do not operate generator at more than 1500 R. P. M.

② On these units, set voltage regulator air gap .018"–.020": cutout relay air gap .050": field relay air gap .010": field relay open circuit voltage 8 volts on 12 volt system. Set relay before voltage regulator.

AUTO-LITE VOLTAGE AND CURRENT

Unit Number	Cutout Relay					Voltage Regulator		
	Resistance of Winding, Ohms	Armature Air Gap, Inch	Point Gap, Inch	Points Close, Volts	Points Open, Reverse Current, Amperes	Resistance of Winding, Ohms	Armature Air Gap, Inch	Point Gap, Inch
VRC-4102B	15.77–17.43	.0595–.0625	.015⑧	6.5–7.0	.5–4.0	4.27–4.72	.040–.042	.010–.012
VRF-4004A	111–123	.034–.038	.015⑧	13.0–13.75	.5–3.0	45.8–49.6	.0595–.0625	.010–0.20
VRH-4102A	43.7–48.3	.0595–.0625	.015⑧	13.0–13.5	.5–6.0	15.68–17.32	.040–.042	.010⑧
VRP-4001A	29.8–33.	.031–.034	.015⑧	6.4–6.6	4.2–4.8⑦	10.8–12.0	.048–.052	.012⑧
VRP-4006G	29.8–33.	.031–.034	.015⑧	6.4–6.6	4.2–4.8⑦	10.8–12.0	.048–.052	.012⑧
VRP-4006H	29.8–33.	.031–.034	.015⑧	6.4–7.0	4.1–4.8⑰	10.8–12.0	.048–.052	.012⑧
VRS-4004A	111–125	.031–.034	.015⑧	13.0–13.75	8.2–9.3	43.7–49.3	.048–.052	.012⑧
VRS-4004D	111–125	.031–.034	.015⑧	13.0–13.75	8.2–9.3	43.7–49.3	.048–.052	.012⑧
VRT-4003A1	111–125	.031–.034	.015⑧	13.0–13.75	8.2–9.3	43.7–49.3	.048–.052	.012⑧
VRX-4001B	111–125	.031–.034	.015⑧	12.8–13.5	8.2–9.3	43.7–49.3	.048–.052	.012⑧
VRV-4003A	267–297 ⑯	.048–.052	.015⑧	26.0–27.0	1.9–3.	179–201	.048–.052	.012 ⑧

③ Plus or minus .15 volt.

④ For R2 resistor, 5 to 6 ohms. For R3 resistor, .18 to 22 ohms.

⑤ For R2 resistor, 13 5 to 16.5 ohms. For R3 resistor, 28 to 32 ohms. For R4 resistor, .9 to 1.1 ohms.

⑦ Points open 4.2 to 4.8 volts from sealed position.

⑧ Minimum.

⑨ Stamped ST281-7. If stamped ST281-6, set air gap at .034–.038.

AUTO-LITE T C VOLTAGE REGULATOR

Unit Number	Volts	Cutout Relay				Voltage Regulator		
		Armature Air Gap, Inch⑨	Breaker Point Gap, Inch⑩	Points Close at Volts	Points Open at Amperes Discharge	Armature Air Gap, Inch①	Regulator Point Gap, Inch②	Winding Resistance, Ohms③
TC-4303D2	12	.020	.030	13.0–13.5	.5–2.0	.045	.005	102–112
TC-4303E	12	.020	.030	13.5–14.5	.5–2.0	.045	.005	102–112
TC-4326A	6	.020	.030	6.4– 7.	1.–3.5	.045	.005	29– 33

① With points closed and spring tension on armature. Dimension given can be plus or minus .001″.

② Minimum.

③ The resistance given is for the shunt winding taken at 77° F. for 6-volt regulator and from 70 to 80 degrees F. for 12-volt units. The antiflutter winding should show a resistance of from 36 to 44 ohms.

REGULATOR SPECIFICATIONS

Voltage Regulator			Current Regulator						
Operating Voltage at 50° F. ③	Operating Voltage at 70° F. ③	Operating Voltage at 100° F. ③	Armature Air Gap, Inch	Point Gap, Inch	Operating Amperage	Carbon Resistance R1, Ohms	Carbon Resistance R2, Ohms	Ground Polarity	Unit Number
7.51	7.45	7.36	.047–.049	.030–.033	39–41	76–84	④	P	VRC-4102B
14.59	14.50	14.37	None	None	None	28–32	⑮	P	VRF-4004A
14.51	14.45	14.36	.047–.049	.010⑧	54–56	76–84	⑥	N	VRH-4102A
7.41	7.35	7.27	.048–.052⑨	.012⑧	34–36	36–40	6.5–7.5	P	VRP-4001A
7.41	7.35	7.27	.048–.052⑨	.012⑧	24–26	28–32	6.5–7.5	P	VRP-4006G
7.41	7.35	7.27	.048–.052⑨	.012⑧	34–36	36–40	6.5–7.5	P	VRP-4006H
14.59	14.50	14.37	.048–.052⑨	.012⑧	14–16	57–63	28–32	P	VRS-4004A
14.59	14.50	14.37	.048–.052⑨	.012⑧	17–19	76–84	28–32	P	VRS-4004D
14.59	14.50	14.37	.048–.052⑨	.012⑧	.....	28–32	.....	P	VRT-4003A1
14.09	14.00	13.87	.048–.052	.012⑧	29–31	76–84	19–21	P	VRX-4001B
28.84	28.50	27.98	.048–.052⑨	.012⑧	9.8–10.2	158–162	195–205	P	VRV-4003A

⑮ On regulators made before Serial Number 9R000001, carbon resistor, which was marked 60 with resistance of 57 to 63 ohms, was used. When replacing resistors use only 30 ohm.

⑯ Remove the 200 ohm resistor before checking the circuit breaker shunt coil resistance.

⑰ From sealed position.

SPECIFICATIONS

Voltage Regulator								
Points to Open at Voltage and Temperature				Points to Close at Voltage and Temperature				Unit Number
50°	70°	90°	110°	50°	70°	90°	110°	
15.75–16.15	15.45–15.85	15.15–15.55	14.85–15.25	⑥	⑥	⑥	⑥	TC-4303D2
16.90–17.70	16.60–17.40	16.30–17.10	16.02–16.82	⑤	⑤	⑤	⑤	TC-4303E
7.58–7.98	7.45–7.85	7.32–7.72	7.20–7.60	5.93–6.22	5.80–6.10	5.66–5.96	5.54–5.84	TC-4326A

⑤ Closing voltage must be below opening voltage by from 2.4 to 2.8 volts.

⑥ Closing voltage must be below opening voltage by from 2.0 to 2.4.

⑨ Plus or minus .010″.

⑩ Plus or minus .005″.

DELCO-REMY GENERATOR INDEX

Generator Number	Specification Number	Direction of Rotation	Brush Spring Tension, Oz.	Generator Number	Specification Number	Direction of Rotation	Brush Spring Tension, Oz.	Generator Number	Specification Number	Direction of Rotation	Brush Spring Tension, Oz.
507	1257	CC	25	1106456	1662	C	25	1117510	1685	CC	25
618	1635	CC	25	1106510	1722	CC	25	1117511	1612	CC	25
943X	1203	C	25	1106511	1723	CC	25	1117526	1682	C	25
956	1635	CC	25	1106512	1723	C	25	1117527	1679	CC	50
978	1635	C	25	1106645	1650	C	25	1117528	1679	CC	50
982	1635	C	25	1106655	1690	C	25	1117532	1272	CC	25
989	1635	CC	25	1106662	1695	CC	25	1117535	1612	CC	25
994	1635	CC	25	1117016	1648	C	25	1117537	1679	C	50
1102962	1676	C	25	1117033	1648	CC	25	1117541	1272	C	25
1102967	1676	C	25	1117036	1238	C	25	1117542	1272	CC	25
1105745	1604	CC	25	1117046	335	C	25	1117543	1682	CC	25
1105776	1604	C	25	1117204	333	C	25	1117544	1682	CC	25
1105781	1604	C	25	1117211	1263	C	25	1117545	1682	CC	25
1105864	1681	C	25	1117306	1635	C	25	1117546	1612	CC	25
1105866	1688	C	25	1117313	1732	CC	25	1117549	1682	C	25
110 5871	1681	C	25	1117315	1635	CC	25	1117553	1682	C	25
110 5872	1688	C	25								

C—Clockwise. CC—Counterclockwise.

NOTE—Third brush spring tension 17 ounces unless otherwise indicated.

DELCO-REMY GENERATOR TEST SPECIFICATIONS

Spec. No.	Field Current at 6 Volts (Amperes)	Maximum Cold Output			Maximum Hot Output		
		Amperes	Volts	Approximate R. P. M.	Amperes	Volts	Approximate R. P. M.
1203	0.95–1.2	8.5–10.5	8.3–8.5	2400	6–8	7.0–7.2	2500
1257	1.78–1.92①	50	12.0	600	②	②	②
1679	1.78–1.92①	75	13.0	540	②	②	②
1682	1.78–1.92①	120	13.0	850	②	②	②
1685	0.64–0.73	40	35.0	1020	⑦	⑦	⑦
1722	.80–.89⑤	10	26.0	1125	②	②	②
1723	.80–.87⑦	10	35.0	1300	②	②	②
1732	1.46–1.62①	55	13.0	1650	②	②	②

NOTE—Refer to the Delco-Remy numerical index for specification number desired. Generators equipped with thermostats should not be adjusted to the specified maximum hot output unless the thermostat points are open.

① Field current at 12 volts.
② Maximum output controlled by current regulator.
⑤ Field current at 24 volts.
⑦ Field current at 32 volts.

FULLER TRANSMISSION

MODEL 5-A-920

Five speeds forward and one reverse with direct drive on fourth and overdrive on fifth.

NOTES—Do not force the control cover off the transmission. Forcing may spring the yokes out of alignment and cause partial engagement and gear interference. Follow the directions relative to shifting and the cover can be taken off. If binding occurs, move the cover from side to side to provide clearance for the yokes.

When dismantling the control cover, all parts should be laid on a clean bench in the same sequence as removed. This procedure will not only simplify reassembly of yokes and bars in their proper places, but will also reduce the possibility of losing the small yoke bar interlock parts, which prevent engagement of two speeds at the same time.

Unless absolutely necessary, the clutch housing should not be detached from the case. If it is removed, however, extreme care should be taken when reassembling it to maintain alignment between its machined face and the mainshaft bores of the case as well as concentricity of the mainshaft bores and the pilot diameter adjacent to the machined face.

DISASSEMBLE

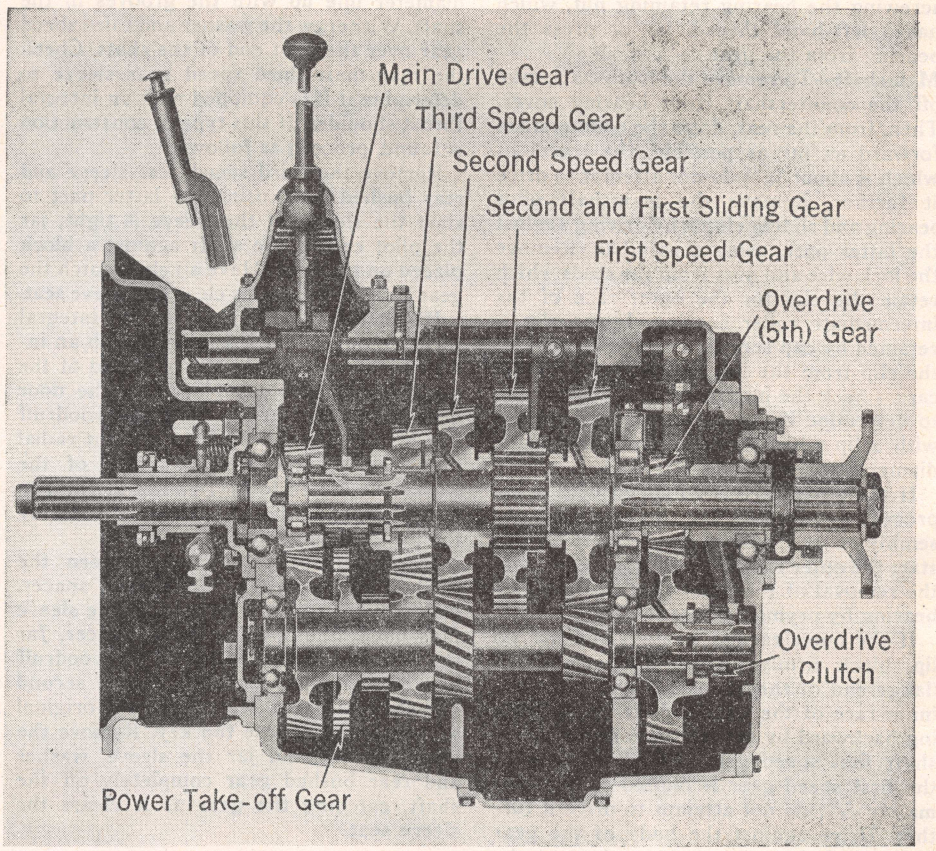
Shift Lever Housing—To remove the gear shift lever housing, shift the transmission into second speed, remove the nuts and lockwashers from the studs which attach the cover to the case, and lift off the cover.

To disassemble the gear shift lever housing, remove the lever grip and dust cover, and place the assembly in a vise with the bottom opening upward. Remove the shift lever tension spring by twisting a heavy screw driver between the spring and housing, which will force the spring from under the cast retaining lugs in the housing. Take out the shaft lever tension spring washer and withdraw the lever.

Shift Bar Housing—To remove the shifting bar housing assembly, first make sure that the gears are in second speed then remove the attaching cap screws and lift off the housing.

To dismantle the shift bar housing, shift the assembly back into neutral, remove the tension spring cover and withdraw the springs. Turn the assembly with yokes upward and jar it on the floor to remove the ½" steel balls assembled under the poppet springs. Then mount the assembly in a vise with the reverse yoke upward, cut the lock wires and remove the lock screws from the shifting yokes and blocks. Drive the three upper bars from the housing, starting with the reverse shifting bar—which is uppermost. The welch plugs assembled in the yoke bar holes will be driven from the housing as the bars emerge.

NOTE—With spring tension removed from the yoke bars, it may be necessary to move them by hand to the neutral position before the upper bar will move. This procedure may be necessary as each bar is removed from the housing.



FULLER MODEL 5-A-920

At the right-hand rear corner of the housing, remove the stud which engages the overdrive shifting block and which prevents radial movement of the overdrive shifting bar. Move the overdrive shifting bar forward until its rear end clears the housing. Pry the bar forward with a heavy screw driver to remove the welch plug, and withdraw the bar.

Mainshaft Rear Bearing—To remove the mainshaft rear bearing, remove the bearing cover and locate and mark the three tapped holes in the rear bearing support plate which have no cap screws assembled into them. Turn into each of these holes a ⅜" cap screw at least 1½" long which is threaded its full length and which has been hardened. Then remove the cap screws by which the bearing cover and support plate is attached. Pull the bearing cover and support plate to the rear and from the shaft by tightening evenly the three puller screws, then remove the bearing from the support plate.

NOTE—If desired, the rear bearing support plate, the bearing cover and bearing may be pulled as a single unit. It is also possible that the rear bearing spacer may be removed with the bearing. If this occurs, make sure that the pin which prevents radial movement is not lost as the spacer clears the end of the shaft.

Overdrive Gearing—To remove the overdrive gearing from the rear of the case, cut the lock wire and remove the lock screw from the overdrive shifting yoke. Drive the overdrive yoke bar to the rear and out of the case. This operation will also remove the thimble installed in the yoke bar hole. After taking out the overdrive shifting yoke, withdraw the mainshaft rear bearing spacer if it is still assembled in the mainshaft, but be careful not to lose the pin. Withdraw the mainshaft overdrive gear and front thrust washer. After sliding off the countershaft sliding clutch, pry the key out of the countershaft and turn the countershaft gear retaining washer in its groove until the lugs on its inside diameter line up with the grooves in the shaft. The countershaft bushed gear may then be slid from the shaft, as well as the washer.

Clutch Shaft & Gear—To remove the clutch shaft and drive gear, take off the clutch release mechanism. Then remove the retaining cap screws and slide off the drive gear bearing cover. Withdraw the drive gear and bearing as a unit.

To dismantle the clutch shaft and drive gear, mount the gear in a vise, using copper jaws, and remove the set screw from the drive gear bearing retaining nut. After un-

screwing the bearing retaining nut, which has a **left-hand thread,** jar or press the bearing from the gear.

Mainshaft—To remove the mainshaft, take off the countershaft front bearing cover. Then, from the rear, drive the countershaft forward as far as possible, the travel of which is about ⅛"; do not attempt to drive it further. Remove the mainshaft pilot bearing and sliding clutch by driving against the latter part, using a soft bar. Remove the lock wire and nuts from the studs which retain the clip for the outer race of the intermediate roller bearing. If the clip is retained by cap screws, unscrew them. Lift the clip from the intermediate web of the case. Check the intermediate roller bearing to determine if the outer race is equipped with a lip which projects from the inside diameter at the rear face.

If the outer race is equipped with a lip, proceed as follows: Pull the mainshaft assembly to the rear approximately 5/32" to start the outer race from its bore. Complete the removal of the outer race of the roller bearing by prying against the lip.

If the outer race is straight and has no lip, block firmly against the companion flange end of the mainshaft and force the inner race of the intermediate roller bearing backward by driving against the mainshaft first speed gear. **NOTE**—Travel of the first speed gear is limited to approximately 3/16"; do not attempt to drive it further. Drive against the body of the gear with a soft bar so as not to damage the gear teeth. Drive the outer race forward and completely out of its bore. Move the mainshaft first speed gear to its original position to allow clearance for the outer race to emerge from its bore. If possible, remove the straight races from the rear as this will simplify the removal of the mainshaft assembly.

To remove the mainshaft and gears from the case, attach a small "C" clamp to the sliding gear. Then with a chain hoist hooked to the "C" clamp, lift the mainshaft assembly from the case, guiding the teeth of the second speed gear into and up through those of the countershaft third speed gear. If a hoist is not available, removal of this assembly is a two-man job.

To dismantle the mainshaft, hold the assembly upright and jar the companion flange end of the mainshaft on a block of wood placed on the floor. The weight of the mainshaft first speed gear will force the inner race of the roller bearing off the shaft. The bushed gear and inner race of the bearing should be caught by a helper as they clear the bearing seat. Remove the large sliding gear over the companion flange end of the shaft. **NOTE**—Bushed gears are assembled to the mainshaft from both the front and rear ends and must be removed in the same manner. Do not attempt to remove all the bushed gears over the pilot end of the shaft.

Mount the assembly in a vise, using copper jaws, and pry the third speed washer key from its keyway between the splines. Turn the third speed gear retaining washer in its groove until the lugs on its inside diameter line up with the grooves in the shaft. Withdraw the washer and third speed gear over the pilot end of the shaft. Check the mainshaft third speed gear sleeve to determine if it is equipped with an integral thrust shoulder. If this type of construction is found, proceed as follows:

Remove the third speed gear sleeve and rear bushed gear, using the latter part to start the sleeve. If the sleeve is tight, jar the pilot end of the shaft against a block placed on the floor. Have a helper catch the gear and sleeve as they clear the sleeve seat.

If the third speed gear has no integral thrust shoulder but is equipped with an independent washer, jar the pilot end of the shaft against a block placed on the floor until the washer strikes the small woodruff key installed in the shaft to prevent radial movement of the sleeve. Travel of the washer is limited to ¼"; do not attempt to jar it further as there is danger of shearing the key and damaging the washer.

Insert on the shaft and between the washer and sleeve a "C" shaped spacer, making sure that the keyway in the sleeve falls under the opening in the spacer. Jar the pilot end of the shaft until the woodruff key is completely exposed. Use a second "C" shaped spacer, wider than the original to completely expose the key. Remove the woodruff key and jar the sleeve, washer and rear bushed gear completely off the shaft, catching the gear as it clears the sleeve seat.

Reverse Gearing—To remove the reverse gearing, take out the reverse idle shaft lock and apply a puller to remove the shaft.

NOTE—The puller for this operation consists of a short piece of pipe, a long ½" bolt having 13 threads to the inch, which is the same size as those tapped in the idler shaft, a nut for the bolt and a flat piece of steel with a hole in its center sufficiently large to permit passage of the bolt. After assembling this equipment inside the opening in the rear of the case, the nut is turned up on the bolt close to the head. The bolt is then passed through the plate and pipe in the order named and screwed into the idler shaft. The nut is then tightened against the plate with the result that a pulling action is exerted against the shaft with the case acting as a base through the pipe and plate. After pulling the shaft, lift both sections of the reverse gearing from the case, and take out the two roller bearings from the bore of the reverse idler gear sleeve.

To dismantle the reverse gearing, withdraw the bushed gear from the idler assembly. Release the snap ring by which the reverse idler gear driver is retained on the sleeve, and press the driver from the shaft.

Countershaft—To remove the countershaft assembly, cut the lock wire and remove the cap screws from the front bearing retainer plate. Force the countershaft assembly backward and out of the front bearing. Pull the countershaft rear bearing, sleeve and washer to the rear approximately ⅝" or until the washer strikes the woodruff key, which is assembled into the shaft to prevent radial movement of the sleeve. Force the bearing forward until it is reseated on the shaft, leaving the sleeve and washer in the position to which they were pulled. Insert a "C" shaped spacer on the shaft between the washer and sleeve, making sure the keyway in the sleeve falls between the open ends of the spacer. Pull the countershaft rear bearing backward until the woodruff key is completely exposed between the open ends of the spacer. Remove the key and pull the rear bearing, sleeve and washer completely off the shaft.

NOTE—In later units, the location of the keyway is moved to the rear so that the rear bearing can be pulled completely from its seat before the washer strikes the key. With the benefit of this change, it is not necessary to reseat the bearing to insert the "C" shaped spacer.

Tilt the countershaft assembly and remove through the top of the case.

To dismantle the countershaft assembly, release the snap ring from the front end of the shaft and press the gears from the shaft **one at a time.**

TRANSMISSION ASSEMBLY NOTES

With the exception of two specific points, the general instructions for reassembly are merely a reversal of those for disassembly. These specific instructions are as follows:

When assembling the mainshaft bushed gears, make sure they move freely. All parts should be carefully cleaned and liberally lubricated. The end play of all helical gears should be held to a minimum of .006" and a maximum of .014". Check carefully with either an indicator or a feeler.

CAUTION—Of the two limits shown above in connection with end play, the minimum of .006" is by far the more important. To go below the minimum is to invite trouble. The bushed gears may freeze to the shaft or sleeve as a result of insufficient endwise clearance.

The mainshaft rear bearing and support plate should be reinstalled as a single unit. This procedure permits the mainshaft to locate both the bearing and the plate. If the bearing is installed after the support plate it attached to the case, the rear end of the mainshaft will be located by the bearing, thus making it possible to pre-load both the intermediate roller and mainshaft pilot bearings. Such pre-loading should be avoided.

When installing the outer race of the intermediate roller bearing of the type having no lip, it should be reassembled from the rear, even though it may be disassembled by driving it forward through the bore.

GENERAL PRECAUTIONS

Clearances—Replace worn washers to assist in maintaining original fit. Hold end play of gears to a minimum of .006". Replace bushings in gears having excessive radial clearance.

Assembling Bushed Gears—When assembling either new or rebushed gears to shaft, be sure that they move freely after having been assembled in their proper places. Clean all mounting parts and coat with clean oil before replacing gears.

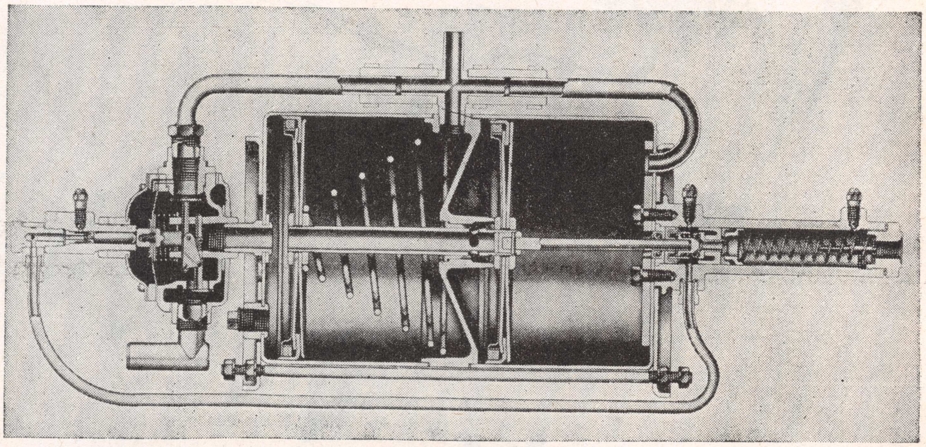
Assembling Service Bushings—After removing the old bushing, clean the bore of the gear carefully and remove all burrs. Coat the outside of the bushing and inside of the gear with a saturated solution of salt and water so the bushing will corrode into the gear bore. The solution should be such that the water cannot dissolve all the salt. Line up oil holes if bushings are so equipped. Carefully press bushing fully into the gear. Face off any projecting end of bushing. Drill oil holes in bushing through holes in gear. Remove all burrs resulting from drilling and break off sharp edges on ends of bushing.

Universal Joint Flange—The mainshaft is held in its proper place by the universal joint companion flange. The omission of parts between the flange and bearing, or failure to pull the flange tightly into place will allow the mainshaft to move endwise with resultant damage to the pilot bearing, mainshaft and drive gear.

Power Take-Off—If a power take-off is attached, be sure sufficient filler blocks and gaskets are used to prevent the gears from meshing too deeply. If the gears bottom they will damage not only themselves bu the transmission case as well.

BENDIX HYDROVAC

The Hydrovac combines in one compact assembly a hydraulically-actuated control valve, a tandem piston power cylinder and a hydraulic slave cylinder. The assembly is a complete self-contained vacuum power brake system which eliminates the need for external levers or linkage. Connections to the vehicle braking system are entirely hydraulic, consisting of a line from the vehicle brake master cylinder to the Hydrovac, and a hydraulic line from the Hydrovac connecting to the wheel cylinders of the vehicle brake system. Contrasted with conventional power brake systems, the Hydrovac is connected hydraulically instead of mechanically, both to the vehicle master cylinder and wheel cylinders.



Showing the inside working parts of the Hydrovac (First Series). The three basic units are the power cylinder (center), the control valve (left), and the hydraulic slave cylinder (right).

FIRST SERIES

Operation—The power cylinder is divided into two equal compartments, each of which is provided with a piston. (Certain installations which require less power use a design with only one cylinder and piston; otherwise these units work as described.) The two pistons work on one piston rod, giving the effect of two cylinders placed end-to-end with pistons connected in tandem. This arrangement gives double the effective piston area and consequently twice the power of a single cylinder of the same diameter. Each cylinder compartment is provided with the necessary seals and passages to operate on the vacuum suspended principle.

A conical spring serves to return the pistons to released position when the air pressures on both sides of each piston are balanced.

Hydraulic pressure from the brake master cylinder acts upon the hydraulic piston in the control valve assembly and forces its diaphragm towards the valves. This movement of the diaphragm moves the valves into the applied, holding or released positions.

A hydraulic or "slave" cylinder of the Hydrovac unit is provided with a piston and rubber cup similar to the master cylinder. The piston rod from the power cylinder forces this piston and cup into the hydraulic slave cylinder. In that way, fluid is forced to the wheel cylinders of the vehicle to apply the brakes.

The end of the piston push rod fits into a tapered valve which seats against the hydraulic piston. A passage through the hydraulic piston allows fluid to pass through when the valve is off its seat, that is, when the power cylinder pistons are in released position.

In the released position, the vacuum valve is open, the atmospheric valve is closed, and the vacuum is present on both sides of the power cylinder pistons.

In the applied position, hydraulic pressure from the master cylinder is applied to the control valve piston, moving the vacuum valve to the closed position and opening the atmospheric valve. This admits atmosphere to the forward side of each piston, while vacuum is maintained at the rearward sides.

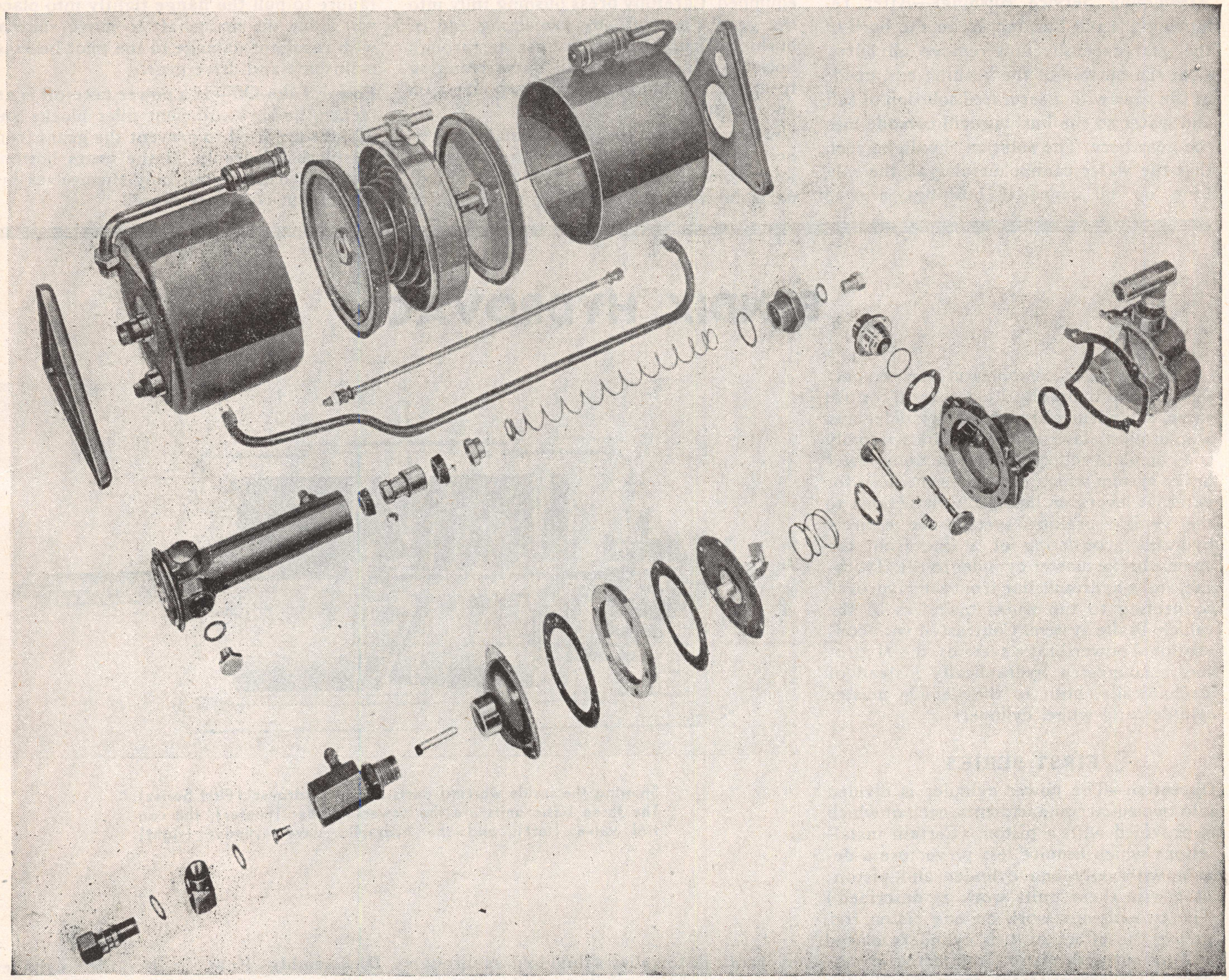
In the holding position, when the brake pedal is held partially applied and physical pressure is constant, the master cylinder line pressure at the control valve remains constant.

Should the vacuum become inoperative due to damaged lines or other accidental cause, the power cylinder pistons return to released position and the vehicle hydraulic system automatically returns to physical operation. Under this condition, the power cylinder pistons remain at rest; the hydraulic fluid flows through the hydraulic piston, through the slave cylinder and to the wheel cylinders.

Disassembly—First mark the cylinder shells, center plate and hydraulic cylinder with a center punch or scriber so that they can be assembled in the same relative position. Then remove the through bolts which hold cylinder shells and center plate together. Take off the hydraulic jumper line which runs from the control valve to the hydraulic cylinder. Loosen the hose and separate the cylinder shells from the center plate. If the parts stick together, tap them with a rawhide mallet. Hold the unit over a pan to catch the oil as the parts are separated.

Remove the four cap screws and take off the hydraulic cylinder. After taking out the end plug, the hydraulic piston and related parts can be removed. Compress the power cylinder piston release spring and hold in the compressed position by inserting a pin through the port holes in the piston rod The spring is to be held compressed in this manner while disassembling the rear piston (Regardless of its position on the vehicle, the piston rod end of the Hydrovac is referred to as the rear.)

With the pin inserted through the port holes, use an offset open end wrench to hold the nut at the front end of the piston while the rear nut is being removed. After



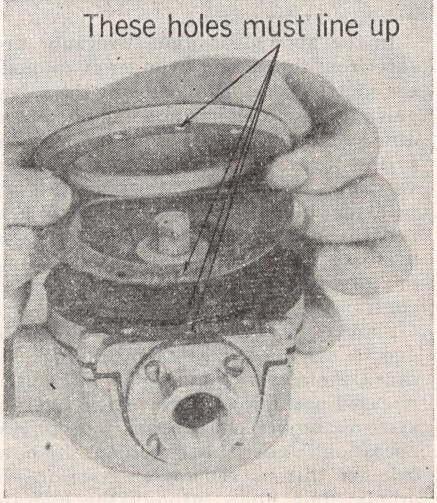
Exploded view of Hydrovac (First Series)

removing the rear piston, take out the retainer pin from the piston rod and slide out the push rod. Remove the pin from the piston rod port holes (one installed temporarily) and slip the center plate and release spring off the piston rod.

Hold the lower nut on the front piston in a vise, remove this nut and take off the front piston. Remove the piston rod leather seal from the center plate. This seal is held in place by a snap ring and washer.

Control Valve, Disassemble—Take the control valve from the front cylinder, loosen the lock nut and remove the small hydraulic cylinder from the control valve. Disassemble the hydraulic cylinder for inspection. Take off the diaphragm cover and spacer ring, and remove the vacuum valve seat, vacuum valve and diaphragm assembly.

To take out the diaphragm and triangular linkage, compress the spring with the fingers. Take off the lower part of the valve body and remove the atmospheric valve spring and washer.



Removing control valve cover, spacer ring and diaphragm

Assemble—Clean all parts thoroughly, using Bendix cleaner for metal parts and alcohol for cleaning hydraulic parts. Do not use gasoline, kerosene or Bendix cleaner on rubber parts or other parts from the hydraulic system.

Inspect all parts for wear and damage. If the valve seats are slightly pitted or corroded, they may be cleaned with fine steel wool. Install a new diaphragm and new gaskets in the control valve. Clean all flange surfaces to insure an air tight fit. Compress the diaphragm spring and washer to assemble the link pins in the valve stems. Lubricate the internal linkage of the control valve with cable lubricant. When assembling the control valve, be sure the bypass holes in the spacer plate, valve body, diaphragm and gasket all line up so that the passage is clear. While tightening the diaphragm screws, hold the diaphragm down just enough to close the vacuum valve. This prevents buckling of the diaphragm between the screw holes.

If the hydraulic cylinder of the control valve is scored or pitted, the part should be replaced. It is not practicable to refinish this bore because of its small diameter and the unavoidable enlargement of the bore.

When assembling the control valve hydraulic cylinder and plunger, be particularly sure that all parts are clean and free from grit. Blow out all passages with compressed air and wipe the bore of the cylinder clean and dry with a cloth. Do not lay parts on the bare work bench where they may pick up dirt; place them on clean paper.

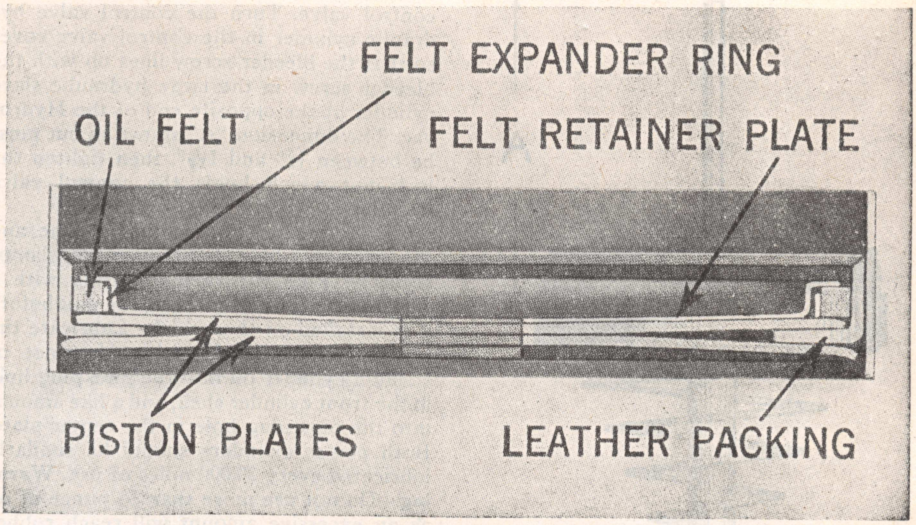
Assemble the piston stop and hydraulic connection but do not tighten at this time. Place a few drops of clean hydraulic brake fluid inside the control valve cylinder. Also dip the piston and rubber cup in brake fluid, and assemble these parts. With the lock nut turned up to the end of the threads on the control valve hydraulic cylinder, screw the cylinder all the way into the control valve cover but do not tighten the lock nut at this time.

Vacuum Cylinder, Assemble—Install a new piston rod leather seal in the center plate after soaking the seal in vacuum cylinder oil. Piston rod leather seal should be seated after assembly in the center plate to prevent vacuum leaks between seat and seal. To seat the seal properly, use a short length of round stock, flat on end, 1⅝" diameter for units having 1¼" piston rods, or $1\frac{3}{16}$" diameter for units having ¾" diameter piston rods. Tapping the round stock with a hammer will seat the seal properly and prevent vacuum leaks.

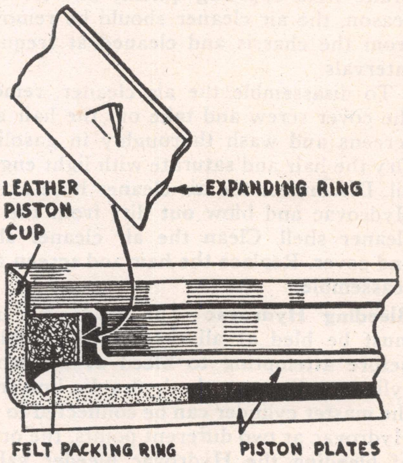
Assemble the front piston into a special Bendix assembly ring (see cut). Place the large diameter piston plate in the ring. Brush a generous ring of shellac or sealing compound around the hole in the piston plate. Place the leather packing on top of the plate with the lip upward. Place the smaller diameter piston plate with the lip toward the leather packing. Install the oil felt. Install the felt expander ring with the grippers pointing upward and outward, and hook the expander ring securely in the notch provided near the loop. Place the felt retainer plate over the felt and felt expander ring. Register the opening squarely over the loop in the expander ring. Run the piston rod nut down to the end of the threads on the front end of the piston rod (the port holes are in the rear end of the rod). Coat the threads of the piston rod with shellac or sealing compound.

With the piston still in the assembly ring, place the piston on the piston rod. The lip of the leather cup must extend away from the length of the piston rod. Remove the assembly ring.

Turn the end nut down until just flush with the end of the piston rod. Following this, tighten the other nut firmly against the piston plate. After final tightening, the nut on the end of the piston rod should be exactly flush with the end of the piston rod. Stake the outside and inside nuts at several places, using a center punch.



Use of special assembly ring in assembling piston



Showing expander ring installed firmly against felt packing ring, with the grippers pointing upward and outward and expander ring hooked securely in notch provided near loop.

Place the front piston rod nut in a vise with the piston rod upward. Care must be taken so that the lip of the leather piston cup is not bent out of shape. Place the piston return spring and center plate in position. Be sure the center plate is right side up, that is, with the piston guide boss at the center, extending upward.

Again place a pin in the port holes to hold the center plate temporarily out of the way so the rear piston can be assembled. Turn the inside piston rod nut down to the end of the threads on the piston rod. Coat piston rod threads with shellac or sealing compound. Assemble the rear piston in a piston ring and, with the assembly ring still in place, put the piston on the piston rod. Place the push rod in position and secure it with the retaining pin.

Turn down the outside piston nut until it is flush with the end of the piston rod, then tighten the inner nut against the piston plate. Remove the temporary pin from the port holes. Distance "A" (see cut) between the gasket surface on the center plate and the end of the push rod should be within the tolerances shown. If necessary, adjust the nuts to obtain the desired result.

Again place the pin in the port holes. Bring the inside piston nut up against the piston plate and tighten securely. Do not stake the outer nut at this time. Remove the pin from the port holes, which allows the center plate to come up against the rear piston.

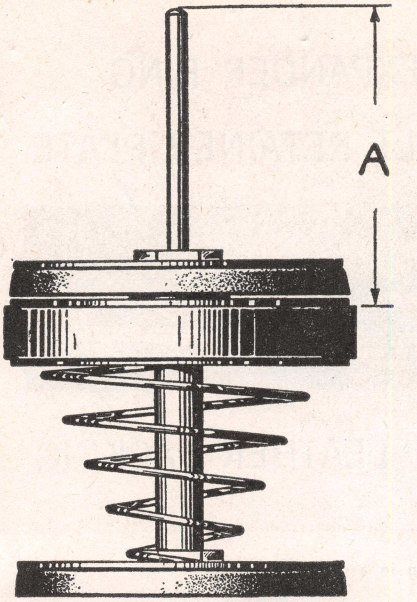
To check the length of the push rod, fit the rear cylinder shell in position over the piston and against the center plate; do not use a gasket at this time. Using the special gauge (see cut), check the length of the push rod by measuring the distance from the end of the cylinder shell (no gasket) to the end of the push rod. If the push rod is too long or if it lacks more than .030" of touching the gauge, reset the piston on the piston rod so that the push rod comes to the required length. Lock and stake both piston nuts.

Place the retainer washer, rubber seal and leather seal in the mounting flange end of the hydraulic cylinder. Dip the rubber seal in hydraulic fluid before assembly but do not oil the leather seal, since it is oiled sufficiently when manufactured and excess oil will damage the leather seal.

Attach the hydraulic cylinder to the rear cylinder shell. Dip the hydraulic parts in brake fluid and place the piston cup and spring in the cylinder; install the stop and end plug.

Place new gaskets on both sides of the center plate. Dip the power cylinder piston leathers in vacuum cylinder oil, and apply a liberal coating of this oil to the cylinder walls. Place the cylinder shells in position over the pistons and against the center plate. Line up shells and center plate with scribe marks made before disassembly then tighten the through bolts evenly.

Place shellac on the threads of the fitting



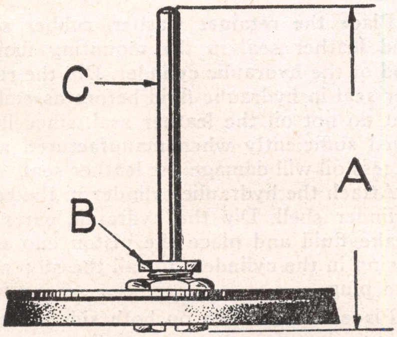
Setting the length of the push rod

FIRST SERIES

Hydrovac Part No.	—Dimension "A" in Inches— Units with Plain Center Plate	Units with Grooved Center Plate
371730	6.360-6.390	6.322-6.342
371830	7.251-7.281	7.197-7.217
372290	6.360-6.390	6.322-6.342
372428	7.251-7.281	7.197-7.217
373380	6.360-6.390	6.322-6.342
373500	6.360-6.390	6.322-6.342

SECOND SERIES

Hydrovac Part No.	Dimension "A" in Inches
372960	7.142-7.172
373000	6.475-6.505
373050	6.810-6.840
373100	6.270-6.300
373163	7.142-7.172
373330	6.475-6.505
373370	7.142-7.172
373390	7.142-7.172
373636	6.810-6.840
373639	6.270-6.300
373700	7.142-7.172



Setting length of single cylinder Hydrovac push rods. Lock nut "B" and push rod "C" must be adjusted so distance "A" is within tolerances given below.

Hydrovac Part No.	Dimension "A" in Inches
372774	6.355-6.375
373200	6.605-6.625

of the front cylinder shell and install the control valve. Turn the control valve hydraulic cylinder in the control valve cover so that the bleeder screw lines up with the bleeder screw in the large hydraulic slave cylinder at the opposite end of the Hydrovac. The dimension "A" shown in cut must be between $\frac{15}{16}$" and $1\frac{1}{16}$", then tighten the lock nut which holds the control valve cylinder in place.

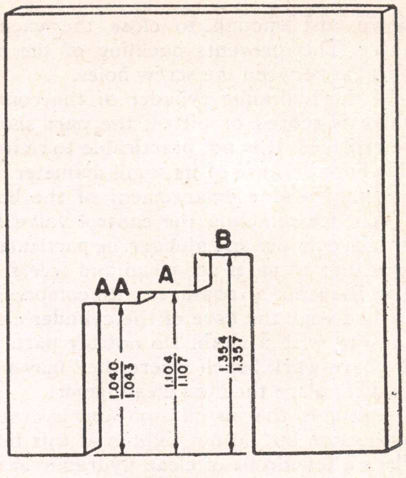
Connect the hydraulic jumper line and the vacuum hoses, tightening the clamps securely. Plug the vacuum fitting with a cork to prevent dirt entering the unit before it is installed on the vehicle. Lubricate the power cylinder by injecting ½ ounce of vacuum cylinder oil into the pipe plug hole in the front cylinder shell, and a like amount into the pipe plug hole in the center plate. Both power cylinders should be similarly lubricated every 20,000 miles of use. **Warning**—Do not use more than ½ ounce of oil as an excessive amount will reach rubber parts and cause deterioration and leaks.

Hydrovac Air Cleaner—A clogged air cleaner will prevent the vacuum power brake from applying quickly and for that reason, the air cleaner should be removed from the chassis and cleaned at frequent intervals.

To disassemble the air cleaner, remove the cover screw and take out the hair and screens and wash thoroughly in gasoline. Dry the hair and saturate with light engine oil. Disconnect the air cleaner hose at the Hydrovac and blow out dirt from the air cleaner shell. Clean the air cleaner shell and cover. Replace the hair and screen and reassemble.

Bleeding Hydrovac—The Hydrovac unit must be bled at all three bleeder valves before attempting to bleed at the wheel cylinders. Because the hydraulic line from the master cylinder can be connected to the Hydrovac at two different points, the order of bleeding the Hydrovac bleeder valves will vary.

If the hydraulic line from the master cylinder connects to the Hydrovac unit at the control valve, bleed the unit in 1-2-3 order as shown in the illustration. If the hydraulic line from the master cylinder connects to the slave cylinder, bleed the unit in 2-1-3 order.



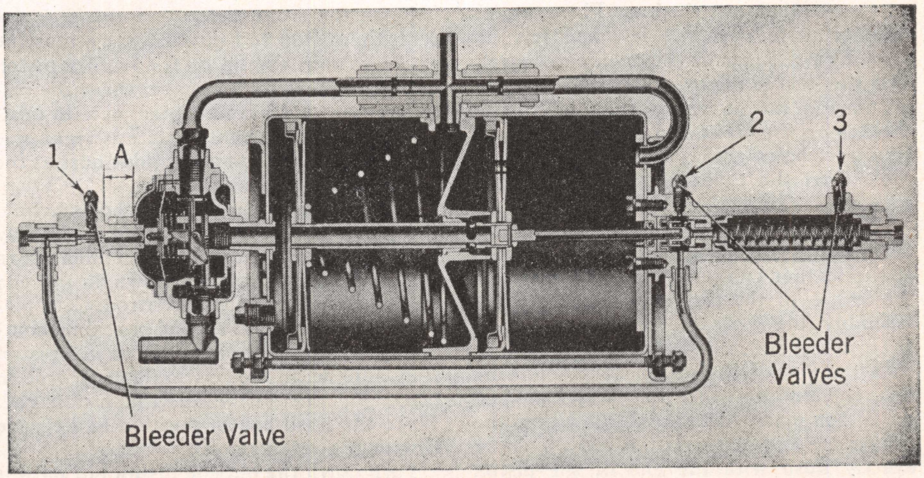
Hydrovac Push Rod Gauge. Use step "AA" in gauge to check push rod for Hydrovacs with $\frac{1}{16}$" groove in center plate. Step "A" to check push rod for First Series Hydrovacs without groove in center plate. Use step "B" for Second Series Hydrovacs.

NOTE—Bleed the Hydrovac and wheel cylinders with the engine not running.

SECOND SERIES HYDROVAC

The second series Hydrovac is similar to the first series in that it consists of a double (or single) piston vacuum suspended power cylinder, a hydraulic slave cylinder and a hydraulic control valve. The hydraulic connections to the power unit are from the vehicle master cylinder outlet to the hydraulic inlet in the slave cylinder housing. The hydraulic line from the end of the slave cylinder always leads to the wheel cylinders. The chief difference between the first and second series is that the second series control valve is integral with the slave cylinder.

Vacuum from the power cylinder is provided by connecting a vacuum hose or line

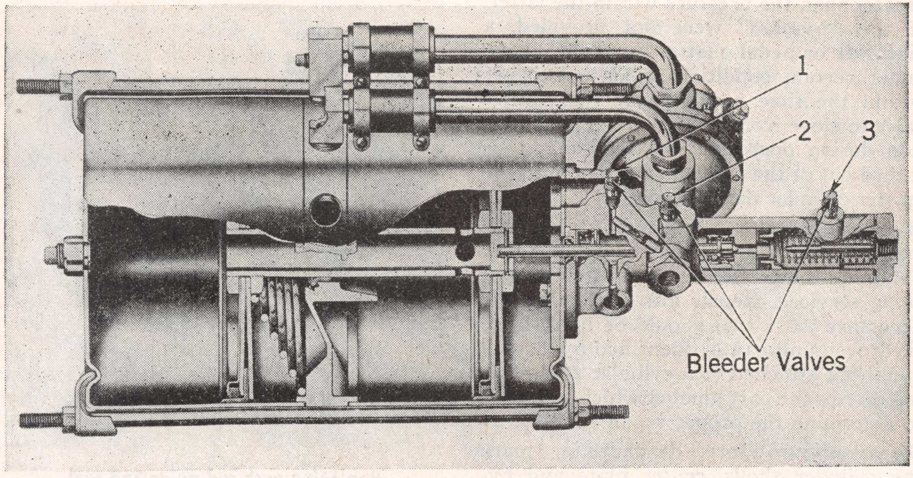


Control Valve Mechanism. Dimension "A" should be between $\frac{15}{16}$" and $1\frac{1}{16}$" (First Series).

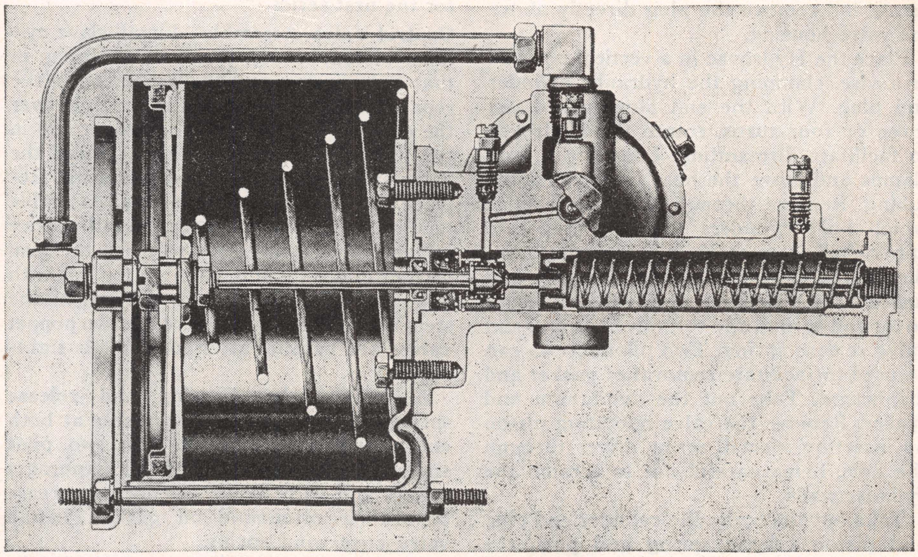
to the threaded port hole in the center section between the two cylinder shells, then leading this line to a reserve tank (if used) then to a check valve and from there to a vacuum source, either manifold or vacuum pump. The air inlet in the hydraulic operating valve is then piped to the air cleaner.

The operation of the second series is identical with the operation of the first series except where a double hydraulic line system is used. In the double hydraulic line system, where a low initial pedal pressure is required, one line is connected between the master cylinder check valve outlet ("A" in cut) and the slave cylinder port of the Hydrovac. This line supplies fluid through the slave cylinder to the wheel cylinders. Another line is connected between an outlet in the master cylinder located behind its check valve at "B," and a port in the control valve directly behind the valve piston. The sole purpose of the second line is to operate the control valve, and in doing so, the residual line pressure in the hydraulic brake system is eliminated from the control valve, thus requiring much less initial pedal pressure to operate the control valve, yet the original residual line pressure in the system through the other line is maintained.

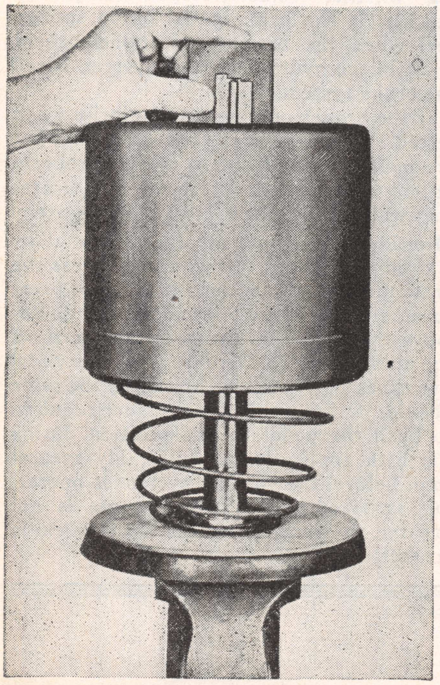
In the released position, this second line at "B" is open to atmosphere through the master cylinder vent. In the first line referred to, there is a ball check valve located in the passage between the slave cylinder piston and the control valve. The purpose of this check valve is to permit hydraulic fluid to pass from the control valve into the chamber behind the slave cylinder piston whenever the pressure within the former is



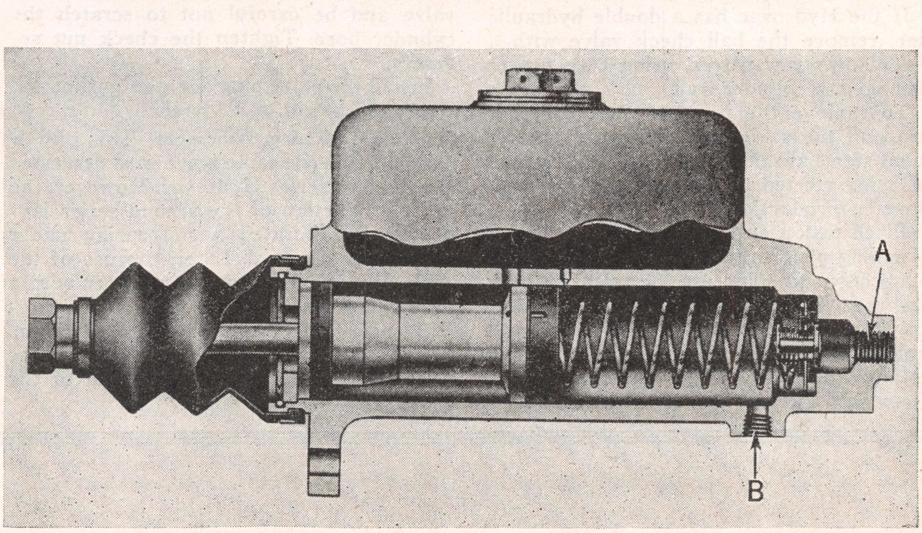
Section through Second Series Hydrovac with control valve integral with hydraulic slave cylinder, and double piston vacuum suspended power cylinder.



Section through Second Series Hydrovac with control valve integral with the hydraulic slave cylinder and single piston vacuum suspended power cylinder.



Showing Hydrovac push rod gauge in use.



Section of typical Brake Master Cylinder having double hydraulic line.

greater than the pressure within the latter. If this "by-pass" were not provided, a vibration or pedal chatter might be set up under certain conditions. This is because within the time required for the control valve to move from applied to released position during operation, the fluid might be forced out of the control valve and into the master cylinder through port "B".

Hydrovac Service—No attempt should be made to overhaul a Hydrovac without first obtaining the proper repair kit for the unit being serviced. Repair kits contain all the necessary parts that should be used. Each Hydrovac unit can be identified by a small metal tag attached to a cylinder stud. This tag carries the part number which is needed to determine the proper repair kit.

Disassembly—Before dismantling, mark the cylinder shells, center plate and hydraulic cylinder with a center punch or scriber so that these parts can be assembled in their original positions. Then loosen the hydraulic cylinder end plug three or four turns, and remove the plug directly above the valve housing.

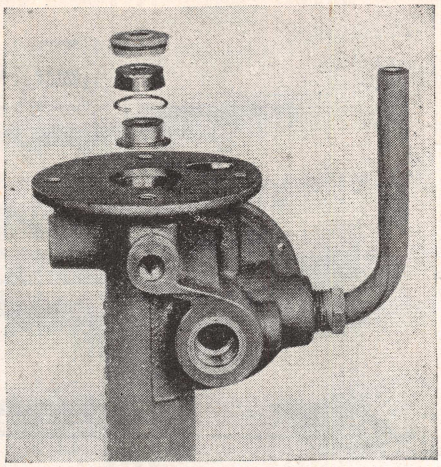
Place the Hydrovac in a vertical position in a vise, clamping the hydraulic cylinder end plug. With the end plug turned out three or four turns, rotate the Hydrovac to facilitate dismantling. Loosen the hose clamps and move the hose back along the tubing. Remove through bolts and clamps which hold cylinders together. Separate upper shell from center plate, then remove the center plate and piston assembly and lower shell. Remove the valve housing cover and spring, and the valve housing and valve release spring. Two pilot screws can be used to facilitate removal of gasket and diaphragm. Take out the diaphragm and spacer. Remove the valve operating piston by inserting a small screw driver through the hole, being careful not to scratch the cylinder walls.

Take out the hydraulic cylinder end plug and piston release spring and push the hydraulic piston out through the plug end of the cylinder by inserting a rod or screw driver in the opposite end.

If the Hydrovac has a double hydraulic line, remove the ball check valve with a 3/16" blade screw driver, using care not to damage the cylinder wall.

To remove the poppet valve, drill the head off the valve stem. (Service replacement stems are threaded at one end instead of being riveted to the poppet valve as is done in production.)

Place piston and center plate in a vise, clamping piston rod nuts. Push the center plate down to compress the release spring and use a "C" clamp to hold in this position. Insert a rod through the piston rod port holes and remove the upper piston rod nut, retainer pin and slave cylinder push rod. Remove the lower piston nut with a wrench.



Replacing push rod guide and seal, and rubber cup (later design).

Clean and examine all parts as instructed for the first series.

Control Valve, Assemble—Install slave cylinder piston, spring, stop and end plug, in that order, using new parts included in the repair kit. Spread a film of brake fluid over the cylinder wall and dip the rubber cup in the fluid just before assembly. Install the valve stop lock washer and lock ring. Replace the valve operating piston. Assemble new diaphragm and spacer. Install service poppet valve, being sure to place the lead washer under the nut. Tighten the nut with a 4" wrench while holding the end of the stem in a drill chuck. Be sure the two poppet valves are parallel after lock nut is tightened.

Assemble valve housing and release spring. Be sure spring is in recess at both ends, then install gasket. Use two pilot screws to align the holes of the diaphragm gasket and valve body. Do not use grease or sealing compound on gasket. Install valve cover and spring.

On Hydrovacs having double hydraulic line, install new by-pass ball check valve. Use a new lead gasket when installing this valve and be careful not to scratch the cylinder bore. Tighten the check nut securely.

Install the valve plug and new gasket and tighten plug with a 10" wrench.

Vacuum Cylinder, Assemble—This unit is assembled in the same manner as described for the first series Hydrovac. However, the early production of the second series Hydrovac incorporated a coil spring under the rubber cup seal. Later, the use of the spring was eliminated and a spacer with a high collar substituted in place of the original spacer, as shown in the illustration. This change does not effect a change in the part number of the Hydrovac unit or the repair kit.

When repairing Hydrovacs, the preferred combination of parts is the later design but the original parts will perform satisfactorily. If the Hydrovac being serviced is a "Second Series" of latest design, and repair kit used is of the first design, do not use the spring and collar washer supplied in kit; assemble parts as shown for the latest design.

When the Hydrovac is of the early design, use parts from latest repair kit and make the above preferred assembly.

When assembling the Hydrovac, lubricate both pistons by saturating the felt wicks with vacuum cylinder oil. Also apply vacuum cylinder oil to the inner walls of both cylinder shells and leather piston packings. Do not allow any of this oil to come in contact with slave cylinder parts. Install the center plate and piston assembly, using new gaskets at center plate. Assemble the upper cylinder shell. Line up cylinder shells and center plate with scriber marks made before disassembly. Install through bolts and clamps and tighten evenly. Slide vacuum hose on their fittings and tighten hose clamps.

NOTE—Clean air cleaner as described for the first series Hydrovac, and follow the 2-1-3 order of bleeding the unit as shown in the illustration for the second series.

PERFORMANCE TESTS

Engine Running—Apply the brake firmly and hold foot pressure. If brake pedal pad comes within 2" of the floor board, a brake adjustment is required.

If brake pedal gradually "falls away" under foot pressure, the hydraulic brake system is leaking, and immediate correction must be made.

Road test the vehicle by making a brake application at about 20 miles per hour, noting whether vehicle stops evenly and quickly. If the brake pedal has a spongy feel when the brakes are applied, there is air in the hydraulic brake system. Bleed the brake system.

If the brakes operate satisfactorily when tested at temperatures above freezing, but are ineffective and do not release properly at temperatures below freezing, it indicates that water is present in the vacuum system.

Monthly Test—Start the engine and allow it to idle for about 10 seconds. Depress the brake pedal with about as much foot pressure as required for normal stopping. Remove the foot from the pedal and turn off the ignition switch. Depress the brake pedal five times slowly to approximately the same position as before. If the pressure required to push the pedal to this position during the fifth application is noticeably greater than before, the vacuum system is operating satisfactorily. If the pressure is not greater, the vacuum system is not working correctly.

MoToR's Truck Repair Manual May Be Used for Servicing Many Buses, Tractors, Road Machinery, Etc.

Although MoToR's Truck Repair Manual is primarily designed for servicing trucks, *many* of the units described in it are used in a wide variety of machines including buses, farm and industrial tractors, contractor and road building equipment and stationary power machinery.

In order to determine whether a unit in a given gasoline or oil powered machine is covered by this book, first look at the unit to obtain its make and model number and then look the make and model number up in the book. If the make and model is found in the book, the service information will be applicable regardless of what kind of machine the unit is used in.

This remark applies to the whole list of units including engines, clutches, transmissions, rear axles, and steering gears as well as to electric equipment and carburetors—with minor exceptions.

Manufacturers who use truck engines, in one or more of their models are as follows—it is not feasible to provide similar lists for other units:

Make of Equipment	***Make of Engine***
"Adnun Blacktop"—See Foote Co., Inc.	
"Aerocoach"—See General American Aerocoach Co.	
Ahrens-Fox Fire Engine Co. "Ahrens-Fox"—Motor Fire Apparatus	Hercules
Arthurdale Farm Equipment Corp. "Co-op"—Tractors	Chrysler‡
"Avenue"—See Superior Coach Co.	
Avery Farm Machinery Co. "Harvest-All"—Combines "Ro-Trak"—Tractors	Hercules Hercules
Bay City Shovels, Inc. "Bay City"—Power Shovels and Truck Cranes	Cummins (D), Hercules, Hercules (D), International and Waukesha
John Bean Manufacturing Co., Division of Food Machinery Corp. "Bean" — Orchard Sprayers, Pumps and Farm Machinery, etc.	Continental Hercules
Beaver Metropolitan Coaches, Inc. "Beaver"—Motor Buses	Chevrolet, Dodge, Ford-Mercury, Hercules and International
C. D. Beck & Co. "Beck"—Safety Coaches	Chevrolet International
Brookville Locomotive Co. "Brookville" — Industrial Locomotives and Rail Cars	Buda (D) Ford Hercules (D)
Buckeye Traction Ditcher Co. "Buckeye"—Shovels & Cranes, Finegraders, Trenchers & Excavators	Buda Buda (D) Hercules Hercules (D)
Buffalo Fire Appliance Corp. "Buffalo"—Motor Fire Apparatus	Hercules
Buffalo-Springfield Roller Co. "Buffalo - Springfield" — Road Rollers (Tandem, Trench, and 3-Wheel Types)	Buda (D) Hercules Hercules (D)
"Buggy-Mobile"—See Mixermobile Mfg.	Waukesha
"Burro"—See Cullen-Friestedt Co.	
"Cletrac"—See Cleveland Tractor	
Byers Machine Co. "Byers"—Excavating Machinery and Cranes	Buda
C. H. & E. Manufacturing Co., Inc. "C. H. & E."—Industrial Machinery—Saw Rigs, Pumping Units, Hoists and Road Rollers	Waukesha
Campbell & Budlong, Inc. "Robin Sprayers" — Farm and Orchard Sprayers	Waukesha
Ralph B. Carter Co. "Humdinger"—Contractor's Machinery—Pumps (Portable and Stationary) Self-Priming Centrifugal, Vertical Self-Priming Caisson, High Pressure Jetting, Diaphragm, Plunger, etc., types "Carter"—Sludge Pumps	Chrysler‡ Continental Ford Hercules

Make of Equipment	***Make of Engine***
J. I. Case Co. "Case" — Farm and Industrial Tractors, Farm Machinery and Power Units	Continental Waukesha
Chain Belt Co. "Rex" — Mixers, Pavers, Moto-Mixers, Speed Prime Pumps, Concrete Pumps and Concrete Pump Remixers	Hercules Waukesha
Chicago Pneumatic Tool Co. "CPT"—Portable Air Compressors	Hercules Hercules (D)
Clark Tructractor, Division of Clark Equip. Co. "Clark"—Industrial Tractors	Chrysler‡ Continental
"Cletrac"—See Cleveland Tractor Co.	
Cleveland Tractor Co. "Cletrac" — Track and Wheel Type Tractors	Hercules Hercules (D)
Cleveland Trencher Co. "Cleveland" — Trench Diggers, Back-Fillers	Buda Hercules
"CMC"—See Construction Machinery Co.	
Construction Machinery Co. "CMC" — Pumps, Hoists, Saw Rigs, Mixers—Drum Type "Wonder"—Mixers, Tilting Type	Continental Hercules Waukesha
"Co-op"—See Arthurdale Farm Equipment Corp.	
"CPT"—See Chicago Pneumatic Tool Co.	
Crown Body and Coach Corp. "Crown Super Coach"—Coaches and School Buses	Ford Hercules Waukesha
Cullen-Friestedt Co. "Burro"—Railroad Cranes	Hercules Waukesha
Dain Manufacturing Co. "John Deere"—Hay Presses	Hercules
Davenport-Besler Corp. "Davenport" — Industrial Locomotives	Buda (D) GMC (D) Hercules Hercules (D) Waukesha
Davey Compressor Co. "Davey" — Portable Air Compressors	Buda Hercules
"John Deere"—See Dain Manufacturing Co.	
John Deere Harvester Works "John Deere"—Combines	Hercules
Dodge Truck Div., Chrysler Corp. "Dodge"—Buses	Dodge
Domestic Engine & Pump Co. "Domestic"—Pump and Hoist Units	Continental Waukesha
Elgin Sweeper Co. "Elgin"—Street Sweepers	Hercules
Euclid Road Machinery Co. "Euclid"—Dirt Haulage Trucks and Tractors	Cummins (D) GMC (D) Waukesha

‡See MoToR's Auto Repair Manual.

Make of Equipment	Make of Engine
Evans Products Co. "Evans Auto-Railer" — Auto Railer, Locomotives (4 and 6 Wheel), Passenger Coaches, Maintenance-of-Way, Equipment	Buda, Chevrolet, Continental, Dodge, Ford, Hercules, Reo and Waukesha
"Fabco"—See F. A. B. Manufacturing Co.	
F. A. B. Manufacturing Co. "Fabco"—Dual Drive Units and Fire Apparatus "Gillig"—School Buses	Chevrolet Ford Hercules
Fairmont Railway Motors, Inc. "Fairmont"—Motor Cars (Rail Cars) and Maintenance-of-Way Equipment	Ford Waukesha
Fate-Root-Heath Co. "Silver King"—Tractors (3 and 4 Wheel Types) and Highway Mowers	Continental Hercules
Federal Motor Truck Co. "Federal"—Buses	Continental Hercules Waukesha
Fitzjohn Coach Co. "Fitzjohn"—Passenger Buses	Chevrolet Ford-Mercury Hercules
"Flxible-Clipper"—See Flxible Co.	
Flxible Co. "Flxible-Clipper"—Buses	Buick‡ Cadillac‡ Chevrolet
Foote Co., Inc. "Multi-Foote" — Concrete Paver "Adnun Black-Top" — Asphalt Pavers	Buda Hercules Waukesha
Ford Motor Co. "Ford"—Buses	Ford
Fox River Tractor Co. "Fox"—Farm Machinery—Ensilage Cutters	Continental
Galion Iron Works & Mfg. Co. "Galion"—Road	Hercules Hercules (D)
General American Aerocoach Co. "Aerocoach" and "Mastercraft"—Buses and Coaches	Chevrolet Ford-Mercury International
General Motors Truck & Coach Div., Yellow Truck & Coach Mfg. Co. "Yellow Coach"	GMC
"Gillig"—See F. A. B. Manufacturing Co.	
Hahn Motors, Inc. "Hahn"—Motor Trucks and Fire Apparatus	Hercules Waukesha
Hardie Mfg. Co. "Hardie"—Farm Equipment—Sprayers and Pumps	Waukesha
"Harvest-All"—See Avery Farm Equipment Co.	
Hercules Co., Division of Osgood Co. "Hercules"—Road Rollers	Buda, Buda (D), Cummins, Hercules, Hercules (D), Waukesha, Hesselman
Huber Mfg. Co. "Huber"—Tractors and Road Rollers "Superior"—Road Graders "Huber"—Combines	Buda Continental Hercules Waukesha
Hug Co. "Hug"—Motor Trucks and Heavy Dirt Moving Vehicles	Buda (D) Cummins (D) Waukesha
"Humdinger"—See Ralph B. Carter Co.	
"Hyster"—See Willamette Hyster Co.	
Ingersoll-Rand Co. "Mobil-Air"—Portable Air Compressors	Waukesha
Insley Mfg. Corp. "Insley"—Type K Excavators	Buda
International Harvester Co. "International" — Motor Trucks, Stock Engines and Power Units	International
Jaeger Machine Co. "Jaeger"—Pumps, Hoists, Pavers, Mixers, Contractor's Equipment, etc.	Hercules Waukesha
Kalamazoo Coaches, Inc. "Pony Cruiser"—Motor Coaches	Ford-Mercury International
Kalamazoo Railway Supply Co. "Kalamazoo"—Rail Cars	Ford Hercules
Kenworth Motor Truck Corp. "Kenworth"—Buses	Buda Hercules Waukesha
Keystone Driller Co. "Keystone" — Excavators and Well Drilling Machines	Buda Hercules
Knickerbocker Co. "Knickerbocker"—Concrete and Plaster Mixers	Hercules Waukesha
Koehring Co. "Koehring"—Excavators (Shovels, Cranes and Draglines), Pavers, Mixers, Hauling Equipment, Mudjacks, Longitudinal Finishers and Wheel Dumptors	Buda Cummins (D) GMC (D) Waukesha
Kohler Co. "Kohler" — Electric Lighting Plants	Waukesha
R. G. Le Tourneau, Inc. "Le Tourneau"—Road Machinery	Buda (D) Cummins (D)
The Linn Mfg. Corp. "Linn"—Crawler Type Trucks or Tractors — Dirt Moving, Logging, etc.	Cummins (D) Hercules Hercules (D) Waukesha
Littleford Bros., Inc. "Littleford"—Road Maintenance Equipment	Ford
Love-Tractor, Inc. "Love-Tractor"—Tractors—Farm and Industrial	Chrysler‡ Ford
Mack Mfg. Corp. "Mack" and "Mack Jr."—Motor Trucks, Buses, Trackless Trolleys, Fire Trucks	Mack
Manitowoc Engineering Works "Manitowoc" — Cranes, Draglines and Shovels	Cummins (D) Hercules Hercules (D)
Marlow Pumps "Marlow" — Centrifugal, Diaphragm, Plunger and Sludge Pumps	Waukesha
Massey-Harris Co., Ltd. "Massey-Harris" — Reaper — Thresher, Combines and Farm Engines	Chrysler Continental Hercules Waukesha
"Mastercraft"—See General American Aerocoach Co.	
Maxim Motor Co. "Maxim"—Motor Fire Apparatus and Heavy Duty Trucks	Ford Hercules
Mercury Mfg. Co. Electrical Industrial Trucks and Tractors	Chrysler‡ Ford Waukesha
Michigan Power Shovel Co. "Michigan"—Truck Shovel and Crane and Crawler Shovel and Crane	Hercules
Mixermobile Mfg. "Mixermobile"—Motive Concrete Mixer "Buggymobile"—Concrete Carrier	Ford
"Mobil-Air" — See Ingersoll-Rand Co.	
"Multi-Foote"—See Foote Co., Inc.	
Municipal Supply Co. "South Bend Gutter-Snipe" — Pick-Up Street Sweepers	Continental
Northwestern Motor Co. "Northwestern"—Railway Motor Cars and Maintenance-of-Way Equipment	Ford

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‡See MoToR's Auto Repair Manual.